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Attitudes and Extent of Divergency and Convergency related to Performance of Saudi Pupils in Mathematics

by

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Thesis Submitted in Fulfilment of the Requirements of the Degree of Master of Science

University of Glasgow
August 2008

Abstract

In Saudi Arabia, many pupils complain of failure in mathematics and they seem to have a negative image about mathematics. Therefore, this study aims to investigate attitudes of pupils in relation to mathematics. A survey was applied with intermediate pupils (aged about 13- 15) during the early stages of adolescence. This is considered as a critical period when pupils can start to form their views and attitudes.

The study also looked at divergency and convergency in relation to pupil performance. Previous studies had indicated the important of the convergency and divergency learning characteristics in relation to science. Thus, this study aimed to explore the extent to which these characteristics are important in relation to mathematics.

The study reviews the literature relating to the importance of attitudes in learning, its different definitions and its targets. Then, it describes specifically how attitude can be relevant in relation to mathematics as well as reviewing work done to measure attitudes towards mathematics. The approaches in measuring attitudes are discussed. Finally, divergency and convergency, seen as learner characteristics, are discussed and how these can be related to learning in mathematics.

The survey was conducted in intermediate schools in Saudi Arabia. Because of the segregation system that Saudi Arabia adopts, two girls' and two boys' schools were selected from typical Saudi population. Around 669 boys and girls participated in the project and they were asked to complete a questionnaire to show their views about mathematics. They also completed convergency and divergency tests. Because this project was carried out at the beginning of the school year, pupils' final mathematics examination marks for the previous year were obtained.

Chi-square was used as a contingency test to explore the changes in attitudes with age and any gender differences. Pearson correlation was used to explore any relationships involving the tests of convergency and divergency, and examination marks. Kendall's Tau-b correlation looked at any relationships between responses to attitude questions and performance.

From the results of the convergency and divergency tests, it was found that being *both* convergent and divergent is an advantage in mathematics examination. Moreover, it was noticed that the pupils who perform well in convergent tests tend to do better in divergent tests as well.

Generally from questionnaire responses, it was found that pupils tend to have a positive attitude in the earlier stage of schooling then these attitudes deteriorate when they became older. However, there was no difference with age in pupils responses to some questions.

Gender comparisons show that boys and girls tend to have similar views in some questions such as their image of mathematician, reasons for going to university and reasons to study mathematics. However, they have different views in other questions such as questions about mathematics, their abilities in mathematics, future careers, preferences for general and mathematical activities

This study has offered an overview of the learning of mathematics in Saudi Arabia and it suggests some important issues for future work.

Acknowledgements

There are some persons that contributed and participated in this study and I want to express my appreciation to them. However, before I thank anyone, praise be to Allah who always exists with me in any happy and sad moments in my life.

First of all, I should like to express my special gratitude to Professor Norman Reid, my great supervisor, for his kind and persistent support, constant encouragements and valuable advice. I have learned from him during my study the real meaning of teaching and learning. Indeed, without him and his worthy suggestions, this study could not have been completed.

I am grateful to Professor Rex Whitehead for his great effort and volunteering to read my thesis in the final stage and his advice to improve my thesis.

I wish to thank all head of schools and teachers that I worked with and all participants for their help and giving me time. Particularly, I am thankful to my brother, Doctor Waleed Badgaish and my uncle, Sameer Badgaish for their cooperation in applying the survey in the boys' school.

My deepest thanks goes to my husband, AbdulKareem Bamaga, for his encouragement and companionship with me abroad, leaving his work. My faithful love goes to my beloved children, Dana and Firas, whose existence in my life are a source of my happiness and success.

Finally, I would like to tender my extreme love to my great mother, Noor Badgaish, for her encouragement to study and to be patient during years studying abroad. I am really indebted to her for her support, worry and prayers for me. Whatever I do and write, I can not give her what she deserved.

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Chapter 1

Introduction

1.1 The problem of mathematics

Mathematics can be considered an essential foundation for many other subject areas as well as many occupations in life. Many sciences depend on mathematics: physics, chemistry, biology and medicine. Furthermore, it is important and used in our daily life. Engineers need mathematics when they construct any building, merchants use arithmetic when they buy or sell goods, tailors use mathematics when they take the measurement for clothes, pilots use mathematics when they are flying. Although all these benefits come from mathematics directly or indirectly, many people still think that mathematics is useless and of little value in daily life.

Orton (1994) has argued that, "*for many years mathematics has suffered from a belief that 'when [it] is not directly useful, it has indirect utility in strengthening the power of reasoning or in inducing a general accuracy of mind'.*" With the inherent logic in the processes of mathematics, this seems plausible. It could simply be that those who possess good powers of reasoning thrive in the world of mathematics rather than a study of mathematics developing the reasoning ability.

Many questions emerge: Why is mathematics often seen as a difficult and unpopular subject by many pupils? Why do large numbers of pupils fail in mathematics? And who or what is responsible for that: is it due to an inappropriate curriculum, inappropriate teaching methods or just lack of commitment from the learners? The issues seem to be complicated and interrelated with each other. Whitney described the American school failure in mathematics:

> *"For several decades we have been seeing increasing failure in school mathematics education, in spite of intensive efforts in many directions to improve matters. It should be very clear that we are missing some thing fundamental about the schooling process. But we do not even seem to be sincerely interesting in this; we push for 'excellence' without regard for causes of failure or side effects of interventions; we try to cure symptoms in place of finding the underlying disease, and we focus on the passing of test instead of meaningful goals"*
>
> (Whitney, cited in Skemp, 1987: 3)

Unfortunately, these problems also exist in Saudi Arabia and may exist in other countries as well. Mathematics is seen as a meaningless subject for many pupils in school and university students (Buxton, 1981). In some countries (e.g. China), mathematics is compulsory to age 18 while, in others, the majority opt out after age 16 (e.g. England). In Scotland, mathematics is an option beyond age 16 but the Higher Grade course which starts at age 16 enjoys ever increasing popularity (Scottish Qualifications Authority, 1962-1995). Nonetheless, the general reported world trend is that the popularity of mathematics is at risk. The fundamental question is how to change the views of pupils as negative attitudes may often affect performance.

It is appears that attitudes are very important issues in school education. The effects may be two-way. Positive attitudes can encourage success and negative attitude can lead to failure. Similarly, success can lead to positive attitudes while failure can have the opposite effect. There is a real need for educators and teachers to have a deep look into this matter. Therefore, this study is conducted to explore attitudes relating to mathematics with Saudi school pupils and relate these to performance. The overall aim is to see what insights can be gained so that the attitudes and performance of pupils in learning mathematics can be improved.

Furthermore, the study will look to the differences between pupils in their way of thinking and how much is that correlated to their performance in mathematics. In other words, we need to know how higher mathematics achievers think in order to try to develop these ways in other students as well, assuming that is possible. Thus, the pupils' achievement in mathematics can be increased.

1.2 Education System in Saudi Arabia

Saudi Arabia adopts a gender segregation system in all years of schooling beginning from elementary until university, and even at university. There are **9** years compulsory school education. Six years in elementary school and three in intermediate school. In these 9 years, there is no big difference between the curriculum for girls and boys. After that, students move to secondary school for three years.

In the first year of the secondary school, students all follow the same courses. For the final two years, students have a very restricted choice, having to elect from three fields of study:

- Natural science
- Islamic and Arabic studies (for boys) or literate Sciences (for girls)
- Administration science (only for boys)

After finishing three years in secondary school, students can move into higher education by entering university, college or institute and chose the major that they wish.

The school years in Saudi Arabia consist of two semesters and same subjects are studied in both semesters. Each semester last around 18-20 weeks, including examination time.

Mathematics is considered a compulsory subject in elementary and intermediate and first year of secondary school for both girls and boys. However, in the second and third years of secondary, students who choose Islamic and Arabic study do not have mathematics while the others (who select natural science or administration science) have to study mathematics more intensively than in the previous years.

There are slight differences between the mathematics curriculum for boys and girls. Some topics are emphasized more for one gender or the other. This variation occurs in other subjects as well. These differences may because boys and girls schools are administered by different education departments and each one can organize the educational plans that they see suit each gender. However both of those departments are under the supervision of the same ministry (Ministry of Education). Nonetheless, in the university, there are no differences between the curricula for male and female students who specialise in mathematics in the same university, although the two genders are taught separately.

1.3 Approach to be adopted

Many studies have shown that a critical age for the development of positive and negative attitudes related to school studies is in the early years of adolescence (see, for example, Johnstone and Hadden, 1983a,b) Therefore, this study focuses on the age group from 13-15. In order to see the overall Saudi pupils view toward mathematics, a questionnaire was developed and applied to intermediate pupils aged about 13-15. The questionnaire contained 13 closed questions looking at attitudes toward mathematics, mathematicians, some part of mathematics, preferred activities in mathematics and so on. Most questions had several parts. Answering questionnaires only required ticking boxes to show opinions. This makes it easy for pupils to suit their level as well as making questionnaire completion quick in that access to pupils for extended periods of time is difficult. Indeed, any kind of interviewing or personal access is only possible to schools of one gender.

Previous studies had shown the importance of learner characteristics like extent of divergency (Danili and Reid, 2004; Hindal, 2007). Thus, divergency and convergency tests were applied to the same sample to measure pupils' ways of thinking. The former involved 6 timed sub-tests, all of which aimed to measure the creativity and the abilities of generating many ideas. This test has been widely used by many researchers (Bahar, 1999; Hindal, 2007; Danili, 2004). Pupils were given clear instruction before they started and they were asked to answer each question in the time given then all the class have to move to the next pages together. The latter (convergency test) was a relatively new test developed by Hindal (2007). It included 5 timed sub-tests that measured the pupils' abilities to find a solutions or conclusions to problems.

In order to gain a picture of pupils' performance in mathematics, the scores for the mathematics final examination marks for pupils for their previous year's study were gathered, these reflecting on an extended period of study. The outcomes of the various measurements were related to each other to look for patterns. It was also possible to compare the three years groups involved as well as looking for gender differences although any gender differences may be difficult to interpret in that boys and girls are educated separately.

1.4 The structure of this thesis

The literature on attitudes, their measurement and development is very extensive (see, for example, Chaiken and Eagly, 1993, where there are nearly 700 pages of text and over 70 pages of references). This study seeks to offer an overview of only the main issues: the place and nature of attitudes, especially in relation to mathematics. Firstly, it describes the importance of attitudes and different definitions, attitude targets and how attitudes can be developed and changed with time, The importance and relevance of attitudes in relation to mathematics are discussed. Finally, there is a review of the findings of previous work offering descriptions of some factors that might influence the development of attitudes in relation to mathematics. Attitude measurement is the theme of chapter 3 where the problems associated with such measurement are described. The chapter looks critically at the scaling approaches which are so often adopted and offers some methods which are more robust and useful.

Convergency and divergency are then discussed in chapter 4, focusing on how these learner characteristics can be measured and their possible importance in the study of mathematics.

The next three chapters describe the methodology used in this study and the results that were found. There are two statistical approaches used in analysing the data obtained: comparison and correlation. Comparison between year groups and gender are summarised in chapter six while the correlation between divergency, convergency and standard marks are discussed in chapter seven along with the correlation between questionnaire responses and marks.

The final chapter gives an overview of the complete thesis and the implications of the findings. Some of the strength and weakness points of this work are deduced and some suggestions that might help in future research have been made.

Chapter 2

Attitudes and Mathematics

Much effort is spent in considering the cognitive outcomes related to mathematics classroom learning: how well the learners can recall, understand or use their knowledge. Frequently skills are emphasized. However, attitudes related to mathematics are rarely studied and are not a major focus of interest for mathematics teachers. Many decades ago, Aiken (1970) noted the relative absence of papers on attitudes and mathematics although he saw things improving. More recently, Hannula (2002) stated that: *"A lot of research has been done on attitude toward mathematics, but theoretically the concept needs to be developed."*

,

However, Di Martino and Zan (2007: 166) note:

> *"For a description of a pupil's attitude towards mathematics, it is not enough to highlight his/her (positive / negative) emotional disposition towards the discipline: it is necessary to point out what vision of mathematics and what self-efficacy belief this emotional disposition is associated with."*

There are two important points. Firstly attitudes towards mathematics are likely to be highly multi-dimensional and not easily measured as a number, score or grade. Secondly, attitudes towards mathematics will almost certainly affect future learning while experiences in learning mathematics will generate attitudes related to mathematics. This chapter focuses on attitudes related to mathematics and how they can be developed.

2.1 Definition of attitude

Attitude is a complex issue. However, there have been many attempts to define it for many centuries. Thurstone (1929) described an attitude as "*the affect for or against the psychological object*". This definition appears to be ambiguous and it needs to be developed with more detail as it only focuses on the affective. In 1935, Allport defined an attitude as a "*mental and neural state of readiness to respond, organized through experience, exerting a directive and or/dynamic influence on behaviour*". This definition described attitudes in terms of behaviors and does not mention the cognitive and affective factors explicitly. Oppenheim (1992) summarized all the definitions above and described attitude in a way that might be "*acceptable to most researchers"* (Ramsden, 1998):

> "*Attitude is a state of readiness, a tendency to respond in a certain manner when confronted with certain stimuli… attitudes are reinforced by beliefs (the cognitive component), often attract strong feelings(the emotional component) which may lead to particular behavioural intents (the action tendency component)".*
>
> (Oppenheim, 1992:174- 175)

Although this definition encompasses the three components (emotional, cognitive and behavioural), it did not consider the evaluative dimension which distinguishes attitude from other mental states.

Eagly and Chaiken (1993) bring many of these features together in their description:

> "*Attitude is a psychological tendency that is expressed by evaluating a certain entity with some degree of favour or disfavour"*
>
> (Chaiken and Eagly, 1993)

This description has the advantage of being brief and precise as well as emphasizing the key features observed in many previous descriptions. It will be used here as the basis of the discussion. Evaluation is an important element in attitude formation. Humans consider events, ideas, objects and people all around. Inevitably, there is a tendency to evaluate. This may involve elements of knowing, feelings as well as experiences. In this way, attitudes are formed. This was brought together by Reid (1978):

> *"Attitudes are a network of cognitive, affective and behavioural elements with an evaluative dimension and they are learned and they can develop with new input of cognitive, affective or behavioural nature."*

Looking at mathematics, school students have some knowledge of what mathematics involves. They may develop feelings which are positive, negative or neutral. They have experienced mathematics in the sense that they have taken classes and undertaken many mathematics exercises. They may well evaluate all this and come to some attitude towards mathematics, its place in their program of study, the way it is taught and its usefulness or otherwise for their lives. Thus, attitudes towards mathematics involve a considerable range of perceptions, each with their own cognitions, feelings and experiences.

2.2 Attitude objects

Attitudes are a very important factor in the learning and teaching process. Reid (2006: 33) stresses that attitudes "*allow us to:*

- *Make sense of ourselves;*
- *Make sense of the world around us;*
- *Make sense of relationships."*

In a sense, the very large number of attitudes which a person holds about all kinds of things and people define the very essence of that person. They are the expression of how the person evaluates everything around in relation to himself or herself. This has immediate applications in learning mathematics. Attitudes in relation to mathematics allow the learner to make sense of what they are learning and how it relates to their lifestyles, needs and aspirations, whether it is important or not, and how to react to learning experiences in mathematics.

One very important insight is that attitudes must have some kind of target: a person, an event, an object, an experience, an idea. Thinking of science education, Reid (2006) suggested that there are four possible targets:

❖ ***Attitudes towards the subject being studied***

Jung (2005) emphasizes that a most important point here is how to increase student positive attitude towards a subject because, without positive attitudes, a student may not be stimulated to learn: "*What is to be taught and how it is taught might be the two major influences on student' attitudes*." (Jung, 2005)

❖ ***Attitudes towards the study itself***

"*There are skills for effective learning and it is necessary to look at attitudes towards learning these skills and using them"* (Jung, 2005). Some of the most useful research was conducted by Perry (1999) with university students at Harvard University. Although his sample was hardly typical, his work has offered a framework which is helpful. From his work, there are four areas where attitudes towards study are important and Reid (2006: 33) has summarised these:

"(1) Student's perceptions of the nature of knowledge;
(2) Student's perceptions of the role of the lecturer in their learning;
(3) Student's perceptions of their own role in learning
(4) Student's perceptions of the nature and role of assessment."

❖ ***Attitude towards the implications arising from themes being studied***

Generally, when students study any topics in mathematics, they will develop attitudes towards these and related themes. Thus, some students will be very positively disposed towards algebra but may not evaluate geometry so highly. However, it can be more subtle: they may have positive views about solving equations in algebra but, when faced with algebra story problems, their attitudes may be quite negative, possibly because they find them so difficult.

❖ ***The so-called scientific attitude.***

This may seem unrelated to education in mathematics but there are those who consider that mathematics teaches scientific thinking (Al- Enezi, 2008). The scientific attitude is a willingness to think scientifically. Byrne and Johnstone (1987) discussed three elements accompanied to scientific attitude.

> *"Group 1 General attitudes towards ideas and information, i.e. 'curiosity', 'open-mindedness', etc.*
>
> *Group 2 Attitudes related to the evaluation of ideas and information: such attitudes are often collectively labeled 'critical-mindedness' and include 'objectivity', 'caution in drawing conclusions', 'weighing evidence', etc.*
>
> *Group 3 Commitment to particular scientific beliefs, e.g. 'loyalty to truth', existence of cause and effect relationships', etc."*

Some of these attitudes clearly have their parallels in mathematics and this can be illustrated in Figure 2.1 bellow.

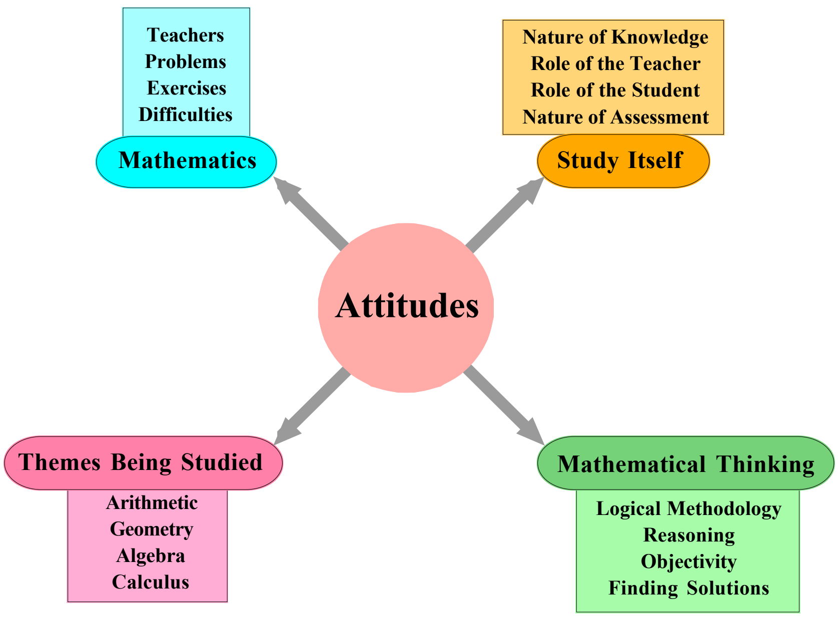


Figure 2.1 Attitudes Targets

2.3 Attitude Development

Johnstone and Reid (1981) used the word "development" rather than "change" when referring to attitudes in an educational context. Social psychologists usually refer to change but the argument of Reid and Johnstone was that this word has possible, although unintended, overtones of manipulation when used in education.

Suydam and Weaver (1975: 45) stress the importance of developing positive attitudes and their effect in student learning of mathematics:

> *"Teacher and other mathematics educators generally believe that children learn more effectively when they are interested in what they learn and that they will achieve better in mathematics if they like mathematics. Therefore, continual attention should be directed towards creating, developing, maintaining and reinforcing positive attitudes"*

Not only do the developments of attitudes help a person to make sense of the world around, they also bring benefits. Attitudes will not change or develop unless the changes are perceived, implicitly or explicitly, as bringing some kind of benefit. Nonetheless, attitudes tend to be remarkably stable with time. It is possible to summarise the findings of research by noting that attitudes tend to remain stable with time and will only change if there is a perceived benefit for the person. Possible benefits might include:

a) The person is enabled to make more logical sense of information
b) There is increased internal cognitive consistency
c) Fear and uncertainty are reduced
d) There is increased self-approval: the person feels more happy with him/herself
e) The person feels more acceptable socially.

Similarly, many years ago Kelman (1958) stated that, "*attitude changes must involve elements which are intrinsically satisfying or rewarding"*. This emphasizes that attitudes may develop if they help people make sense and understand the world around them in a more satisfactory and satisfying way.

2.4 Relevance to Mathematics

Furinghetti (1993) remarked that, "*Mathematics is a discipline that enjoys a peculiar property: everybody has some mental image of it"*. However, this seems to be not as unusual as he suggests. Other school and university subjects generate mental images. Nonetheless, the attitudes that a person develops in relation to mathematics have potentially far-reaching consequences. If a student develops negative attitudes towards the subject, then he or she may opt out of study at the later stages of school education. The choice not to study mathematics further may close many career opportunities for qualifications in mathematics are very important for large areas of study at university and for many career opportunities.

Thus, it is very important for the mathematics teacher to be aware of student attitudes toward mathematics and what are the student images. These might affect their choice of the subjects or their future study. Lime and Ernest (1998) note that,

> "*It is a matter of concern that ... negative images of mathematics might be one of the factors that has led to the decrease in student enrolment in mathematics and science at institutions of higher education, in the past decade or two ... the term 'image of mathematics' refer to a mental picture, view or attitude towards mathematics, presumably developed as a result of social experiences, though school, parents, peers, mass media or other influences."*

Morrisett and Vinsonhaler (1965) assert that students' attitudes toward mathematics may be drawn or established from their childhood experiences. However, we need to know who is responsible for these previous experiences and how can they build the student success. Banks (1964: 16-17) state that,

> *"An unhealthy attitude toward arithmetic may result from a number of causes. Parental attitude may be responsible ... repeated failure is almost certain to produce a bad emotional reaction to the study of arithmetic. Attitudes of his peers will have their effects upon the child's attitude. But by far the most significant contributing factor is the attitude of the teacher. The teacher who feels insecure, who dreads and dislikes the subject, for whom arithmetic is largely rote manipulation, devoid of understanding, cannot avoid transmitting her feelings to the children ... on the other hand , the teacher who has confidence, understanding , interest , and enthusiasm for arithmetic has gone a long way toward insuring success."*

There are those who, at least by implication, suggest that the fault of poor attitudes lies with the teachers. Thus,

> *"Most US children enter school eager to learn and with positive attitudes toward mathematics. It is critical that they encounter good mathematics teaching in the early grades. Otherwise, those positive attitudes may turn sour as they come to see themselves as poor learner and mathematics as nonsensical, arbitrary, and impossible to learn except by rote memorization. Such views, once adopted, can be extremely difficult to change"*
>
> (National Research Council, 2001: 132)

However, this view ignores the nature of mathematics itself, the curriculum over which teachers have little control as well as the kinds of textbooks and resources which are available. Nonetheless, the teaching and the teacher are extremely important and the National Council for Teaching Mathematics (2000) stress that teachers should be aware that:

> *"Students learn mathematics through the experience that teachers provide. Thus, students' understanding of mathematics, their ability to use it to solve problems, and their confidence in, and disposition toward mathematics are all shaped by the teaching they encounter in school. The important of mathematics education for all students requires effective mathematics teaching in all classrooms"*
>
> (National Council for Teaching Mathematics, 2000: 17)

Similarly, Gibson (1999: 1) stresses the importance of teachers in building student understanding:

> *"Developing in pupils an appreciation of things mathematical is a priority for mathematics teachers. Indeed, an absence of motivation and consequently interest in the subject on the part of pupils leads to a turn off in attitude and subsequent rejection of mathematics as an option choice in later secondary schooling."*

Although some researchers consider teachers an important element for developing negative attitude toward mathematics, some have noted that the nature of mathematics itself might affect student images of the subject. Thus, Orton and Wain (1994: 31) have noted that,

> *"It is not necessary to spell out the evidence that lead one to say that the public image of mathematics is a poor one. The tragedy is that, after having spent between eleven and seventeen years in full-time education, many intelligent people are still able to claim that mathematics has always been, and will always be, a meaningless activity. This is in spite of the fact that in eleven years of full-time education a person will have received something over 1500 hours of mathematics teaching."*

Perhaps it is the 1500 hours spent in mathematics classrooms which has caused the problem. If the student does not see how the mathematics he or she is asked to study can be relevant to their lives or to their futures, then it is almost inevitable that negative attitudes may form.

Indeed it may be comparison with other subjects which can cause a problem. Some of students may believe that mathematics is a subject which cannot be applied in life compared to other subjects like biology, chemistry or physics as well as subjects like history and language with their emphasis on human activity.

The science subjects have the added attraction of practical work. This allows more group activity, conversation and, perhaps, freedom. It can lead to satisfaction in learning Hofstein and Lunetta (1982: 212) stated that:

> *"The laboratory provides a unique medium for teaching and learning in science education, and science educators have suggested that rich benefits in learning accrue from its use."*

Nonetheless, the importance and significance of studies in mathematics cannot be underestimated although, perhaps, the kind of mathematics demanded of school students may be the problem. This can be illustrated:

> *"We live in a time of extraordinary and accelerating change. New knowledge, tools, and ways of doing and communicating mathematics continue to emerge and evolve. Calculators, too expensive for common use in the early eighties, now are not only commonplace and inexpensive but also vastly more powerful. Quantitative information available to limited numbers of people a few years ago is now widely disseminated through popular media outlets. The need to understand and be able to use mathematics in every day life and in the workplace has never been greater and will continue to increase."*
>
> (National Council for Teaching Mathematics, 2000: 3)

The practical aspects of learning mathematics have been considered. Some (Fennema, 1972; Friedman, 1978; Wilkinson, 1974) have suggested that primary children can learn mathematics better when the teachers uses manipulative materials during lessons. Tulock (1957) suggested that some 'games' and 'audio-visual aids' are useful in making mathematics meaningful and raising student interest in mathematics. As the result, he argued that the students might appreciate more of the meaningfulness and relevance of the subject.

However, the teacher is critical in seeking to create an atmosphere in mathematics lessons that may help the student to develop a positive attitude toward the subject. Orton & Wain (1994) claimed that, '*it is the teacher who develops the classroom environment in which the learning of mathematics flourishes or dies.*' Similarly, Haladyna *et al* (1983) assert that the teaching process and classroom environment affect students' attitudes toward mathematics. This is supported by the observation (NCTM, 2000: 18) that,

> *"Teachers establish and nurture an environment conducive to learning mathematics through the decisions they make, the conversation they orchestrate, and the physical setting they create"*

There are many studies which have indicated that student attitudes toward study and their achievement are influenced strongly by the relationship between teacher and student: Al-Enezi, 2008; Berndt and Hawkin, 1988; Fraser and Fisher, 1982; Hartmut, 1978)

Confrey (1990: 112) summarized the duties of the classroom teacher:

> *"An instructor should promote and encourage the development for each individual within his/her class a repertoire for powerful mathematical construction for posing, constructing, exploring, solving and justifying mathematical problems and concepts and should seek to develop in student the capacity to reflect on and evaluate the quality of their construction."*

However, this is not an easy task for teachers have to cope with many students and teach a curriculum over which they have little control. Thus, before the teacher is blamed for any student negative attitudes, it is necessary to explore if the curriculum helps or hinders teachers in creating a good environment in the class for effective, meaningful and satisfying learning. Some studies reveal that our 'traditional' curriculum which is based on demonstrating methods and procedures does not help students to develop their thinking and perhaps this contributes to the formation of more negative attitudes (Marshall, 2003; Hiebert, 1999).

There is some evidence which indicates that the most important factor which develops student negative attitudes toward mathematics is an emphasis on 'rote learning' methods (Bernstein, 1964). Thus,

> *"Children are often confronted in school with situations which few adult would tolerate. Day in and day out there is repetition of meaningless expressions, terms, and symbols. Eventually many children come to dislike arithmetic. Lack of understanding and skills in arithmetic is associated with personality maladjustment and delinquent behavior, including truancy and incorrigibility"*
>
> (Clark, 1961: 2)

Clark was writing many decades ago. While this may still be true in some classrooms, the way teaching and learning have developed suggests that it may not be a good picture for today.

Fennema et al. (1996) have argued that educators and policy maker should realize the need to reform mathematics learning based on building student thinking and understanding by offering them problem-solving methods and giving them freedom to explain, discuss any problem they face, asking questions and giving their opinion. However, there is no evidence that these approaches, of themselves, will generate more positive attitudes. Indeed, some of them may have the opposite effect in that it is possible that such approaches may expose student weaknesses in understanding and undermine confidence.

Furner and Berman (2003) assert that communication inside the classroom plays an important role in learning because it allows students to participate together, with opportunities to argue their case for their own answers. Yet again, there is no evidence offered that this will bring the desired benefits. However, some studies with university mathematics students demonstrate the importance of cooperative learning in building student interest and developing positive attitudes toward mathematics (Hill *et al*., 2003; Wood and Craft, 2000; Elliott *et al*., 2000) but this does not imply necessarily that the same will be true for schools which do not usually have classes made up of those who have elected to study mathematics.

Curtis (2006) argues that while the classroom can help students build a foundation of skills, the development of intellectual abilities to solve problems and develop positive attitudes toward the subject may help. Similarly, Brooks (1990) argues for constructivism. Curtis (2006: 4) goes on to say that,

> *"Learning based on constructivism uses lessons where exploration often precedes explanation. The teacher creates activities where students explore concept though the use of technology, manipulations, discussions, and drawings."*

In a parallel way, Caprio et al. (1998) stated that constructivism means that student have '*to work constantly, to think constantly, and to observe and reflect.*'

Much of this reveals very shallow thinking about constructivism and the label is often used as a kind of summary of what might simply be called good teaching. It is not easy to see how allowing students to construct their own understandings of mathematics (the core of constructivism) will either bring about better learning or more positive attitudes. The work of Kirschner et al. (2006) casts considerable doubt over the whole perspective of constructivism as a means to bring about improved learning.

The National Research Council (2001) recognizes that learners are seeking to make sense of the world around them. If the way mathematics is taught encourages this approach, then positive attitudes might well be encouraged as recent work in the sciences has suggested (Hussein, 2006 , Chu, 2008). Thus,

> *"Developing a productive disposition requires frequent opportunities to make sense of mathematics, to recognize the benefits of perseverance, and to experience the rewards of sense making in mathematics ... As students build strategic competence in solving non routine problems, their attitudes and beliefs about them selves as mathematics learners become more positive. The more mathematical concept they understand, the more sensible mathematics becomes"*
>
> (NRC, 2001: 131)

The role of the parents may also be important. Poffenberger and Norton (1959) state that parents play an important role in affecting their children's attitude development either by encouraging them, by their expectation of their children achievement and by their own attitudes. This may well be true at younger ages, but older school students tend to develop their own independent thoughts and are less influenced in this way by parents. Thus, for example, Reid and Skryabina (2002) found that parental influences in developing positive attitudes towards physics were marginal in Scotland, from age 10 onwards.

Shaprio (1961) found that elementary school children can be affected by peer attitudes, particularly among girls. On the other hand, other studies indicate that social factors and home environment are not important in terms of attitudes toward mathematics as much as in other verbal subject (Karas, 1964; Aiken, 1969).

2.5 Previous Work: Attitudes to Mathematics

A number of research studies have been carried in the domain of mathematics education and many of them focus on attitudes toward mathematics. Attitude can influence or can be influenced by other factors. There is some evidence indicating that student attitudes to any subject can significantly affect their choice of the subject (Dick and Rallis, 1991; Johnston, 1994).

Khan and Weiss (1973) considered the wide range of variables which might be involved in attitude development in a school setting (figure 2.1, overleaf).

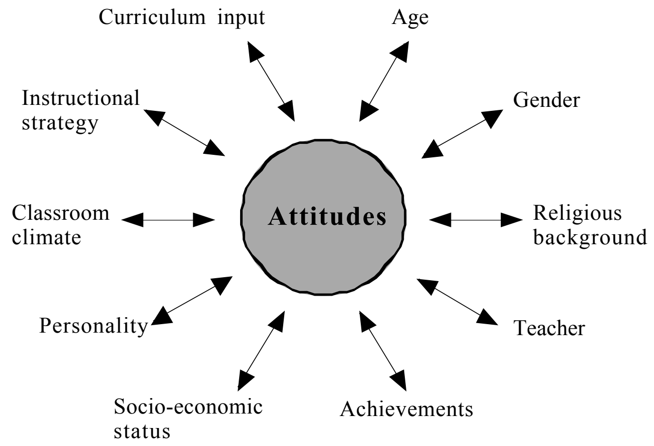


Figure 2.2 Attitudes and Other Factors (derived from Khan and Weiss, 1973)

It is possible to gather these factors under two sections:

- *Personal factors*: achievement, personality, sex and age.
- *Social factors*: teacher, classroom environment, parental influences, curriculum and instructional policy.

Some of the research carried is now discussed under these headings.

2.6 Attitude and Personal Variables

- **Attitude and achievement**

The relationship between attitude toward mathematics (ATM) and achievement in mathematics (AIM) is a major issue with many studies. Some studies claim that achievement in mathematics can be assisted by better attitudes toward mathematics (eg. Ethington and Wolfle, 1984, 1986; Lester *et al.*, 1989; Loebl, 1993; Marshall, 1989; Sherman, 1980). Brown and Abell (1965) studied the relationship between attitude and achievement related to some subjects and they found that the correlation between attitude and achievement with arithmetic was higher than with any other subject (eg. spelling, reading, or language). Dutton (1962) found that students' attitudes toward arithmetic in college are correlated positively with their arithmetic marks from elementary school but the correlation was not high. There is no further evidence supporting this finding.

Moreover, at high school level, Degnan (1967) measured attitudes and general anxiety level for 22 low mathematics achievers compared with 22 high mathematics achievers in grade eight (age ~14) and he found that high achievers held more positive attitude toward mathematics but they were more anxious than low achievers. This study concluded that attitudes are not the same variable as general anxiety.

There is some research focussing on the relationship between attitude toward mathematics (ATM) and achievement in mathematics (AIM) and some claim that achievement affects attitudes. Thus, Esenhardt (1977), who applied his research with 11- 16 years old student in USA in relation to some subjects (eg. Science, Mathematics, English and Social Studies, claimed that achievement affected attitude more than the reverse.

Furthermore, Keeves (1986: 148) proposed a chain for the causal relationship between attitude toward mathematics (ATM) and achievement in mathematics (AIM):

> *"initial achievement and initial attitudes => academic motivation => attentiveness => final achievement => final attitudes"*

However, Ethington and Wolfle (1984, 1986) offered an equation summarising the way in which attitude toward mathematics (ATM) causes achievement in mathematics (AIM). However, they go on to argue that the relationship may well be bilateral:

> *"Although it might be argued that enrolment in mathematics courses is likely to affect attitudes toward mathematics, an equally plausible argument may be made that these attitudes affect decisions to enrol in mathematics courses. Thus, specifying any unidirectional causal relationship between these factors would be inappropriate."*
>
> (Ethington and Wolfle, 1986: 66)

Many consider that attitude toward mathematics (ATM) and achievement in mathematics (AIM) influence each other. Thus, Mcleod (1992) conceives that ATM interacts with AIM and vice versa. Ma (2001: 222) states that, *"A reciprocal relationship seems to be able to capture the interactive nature of ATM and AIM."* Furthermore, Hayduk, (1987) points out that the reciprocal relationship between ATM and AIM can be illustrated as loop (see figure 2.2).

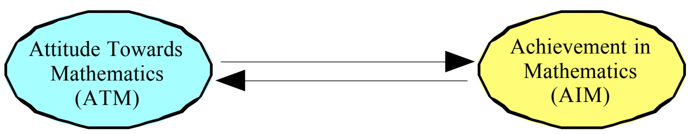


Figure 2.3 The Reciprocal Relationship Between ATM and AIM

The evidence from many studies which have looked at attitudes towards mathematics and achievement in mathematics do not offer a clear picture of causality. It is much more likely that achievement and attitudes influence each other continuously and probably in complex ways (Ma, 2001). Perceived success may enhance positive attitudes while positive attitudes may encourage work which leads to further success.

Some studies indicated that there are some factors which are suspected to affect the relationship between attitudes toward mathematics (ATM) and achievement in mathematics (AIM): for instance, gender, grade and ethnicity. In regard to gender, Aiken (1970a: 567) stated that,

> *"No one would deny that sex can be an important moderator variable in the prediction of achievement from measures of attitude and anxiety. The results of several investigations ... suggest that measure of attitude and anxiety may be better predictors of achievement of female rather than male."*

A few years later, Aiken (1976: 296) repeated again that, "*girls' mathematics marks are more predictable from their attitudes than boys' marks."* However, this may simply be because girls tend to be more accurate and careful than boys when filling out questionnaires.

However grade level may also be important as a factor in influencing the relationship between attitude toward mathematics (ATM) and achievement in mathematics (AIM). Thus, Aiken (1970) found that:

- *"The correlation between attitude and achievement, though statistically significant in instances, are typically not very large" (p. 559)*
- *"Achievement was also greater for students whose attitudes had remained favorable or had become more favorable since elementary school [at the senior high level]". (p.556)*

Six years later, Aiken (1976) stated that there is "*a low but significant positive correlation*" in elementary and secondary school levels. (p.295) also pointed out that "*the correlation between attitude and achievement varies… with grade level*" (p.296).

Ethnicity does not seem to be a major factor affecting the relationship between ATM and AIM. Aiken (1976) indicated that he found significant and positive correlations between ATM and AIM for all students wherever they are, although this correlation is not high. On the other hand, Ma and Kishor (1997: 41) state that "*the (ATM-AIM) relationship is significantly stronger for Asian student than for white and black student*". However the relationship between attitude toward mathematics (ATM) and achievement in mathematics (AIM) does appear to be ambiguous and delicate. (Gardner, 1983)

Although it was found that ATM-AIM relationship is not straightforward, some research results indicate that it is not important. Thus, Fraser (1982) suggested that, *"if teachers want to improve achievement, they would be well advised to concentrate on achievement "per se" instead of trying to improve achievement scores by improving attitudes."*

- **Attitudes and age**

Many years ago, Stright (1960) stated that the elementary school is an important stage in shaping attitudes toward arithmetic and student attitudes appear to be more positive in this level. In addition, there is some evidence which indicates that American children enter school with positive attitudes toward mathematics but this attitude declines as they become older (Carpenter *et al*., 1981; Dossey *et al*., 1988). However, McDermott (1956) found that the majority of student indicated that they was afraid of mathematics in elementary school because of frustration and the other stress that their feeling of difficulties in mathematics start when algebra (issue) was introduced in secondary school.

Aiken (1969) noted that, *"the result of a number of studies point to the persistence of negative attitudes toward mathematics as students ascend the academic ladder."* Foxman et al. (1981) found that "*pupils find mathematics more difficult, less useful and less enjoyable as they grow older.*" Similarly, Hadden and Johnstone (1982, 1983), working with the secondary school student aged (12-14) in Scotland, found that student positive attitudes toward science decrease over this age range but they found that the fall in attitudes relating to the sciences was much more when compared with mathematics and geography.

Nevertheless, while Stright (1960) observed that the percentage of pupils who hold negative attitudes toward arithmetic fell from third to sixth grade (roughly age 9-12). This may arise because students will become more consciousness of the importance of mathematics in their life as they get older (Aiken, 1969). There are also some studies finding that junior high school (roughly age 12-15) is an important stage in developing student attitudes toward mathematics irrespective of whether the curriculum can be described as traditional or modern (Dutton, 1968; Aiken, 1969).

- **Attitude and Gender**

Several studies have indicated that boys tend to have more positive attitudes than girls (Frost *et al*., 1994; Leder, 1995; Foxman *et al.,* 1981). Moreover, Foxman *et al.* (1981)

who applied attitude scales with students found that "*boys judged topics as easier than their success rate would indicate, while girls judged them as more difficult.*" McGraw et al (2006) found that, "*Female students still do not view themselves as "good at math" or "liking math" to the extent that male students do.*" Similarly, Aiken and Dreger (1961) and Dreger and Aiken (1957) found in their research with college students that boys have more positive attitudes toward mathematics.

On the other hand, Stright (1960) noted that girls tend to enjoy more elementary level arithmetic classes when compared to boys. Furthermore, the result of Dutton (1968) indicated that boy's attitude toward arithmetic appeared to be same as girls when they studied "new math". However, Foxman *et al.* (1982) measured the attitudes of 15 year old student toward mathematics, found that *"as a group, girls tend to believe, more than do boys, that mathematics is difficult; attitudes to individual problems suggest that boys tend to over-rate the ease of mathematics items, in comparison with girls."* In terms of girls, Foxman *et al*. (1981: 103) found that *"although they tended to look upon mathematics as less enjoyable and less useful a subject than did boys, the degree of difference was not great."*

The more negative attitude of girls may arise as a result of their lack of confidence in themselves. Boekaerts *et al.* (1995) and Foxman *et al.* (1982) hold the view that girls tend to be less confident than boys in their mathematical abilities. Thus, they feel that their success in mathematics cannot be achieved (Benenson and Dweck, 1986). However, confidence is not quite the same as attitude.

Although many studies support the view that girls tend to hold more negative perspectives toward mathematics, girls do tend to prefer particular topics in mathematics. Foxman *et al*. (1982: 117) measured student attitudes toward particular topic within mathematics and found that, "*Boys, as group, rate trigonometry, angles and formula more highly than girls in terms of usefulness. Girls, overall, perceive every day problems, decimals and fractions to be more useful than do the boys.*"

However, Geary (1994: 197-8) found that, *"in all, these studies indicate that beginning in the elementary school years and continuing into adulthood, boys often show an advantage over girls in the solving of arithmetical and algebraic word problems."* There is much evidence that girls' lack of interest in mathematics is due to the way that mathematics curriculum has been applied and taught, this often being more suitable for boys (Belenky *et al*., 1986; Damarin, 1990; Rogers & Kaiser, 1995).

Interestingly enough, although many studies emphasise that gender is an important factor in determining attitudes toward mathematics, various recent meta-analyses relating to attitudes toward mathematics or achievement in mathematics do not find sex differences (Friedman, 1989, 1994; Frost *et al*., 1994; Hyde *et al*., 1990).

Looking at the evidence overall, the effect of gender on attitudes towards mathematics is small and may reflect different levels of confidence as well as the perceived role and value of mathematics in future careers.

- **Attitude and teacher/ classroom's climate**

Teachers are at the core of the learning process. Thus, (s)he may form or improve student attitudes toward a subject as well as being able to create a good atmosphere inside classrooms in order to enable student to receive good learning. Aiken (1969) claims that, *"It is rather generally held that teacher attitude and effectiveness in a particular subject are important determiners of student attitudes and performance in that subject."*

Similarly, Ruffell et al. (1998, 1) suggested that the, *"Teacher's attitudes to mathematics is increasingly put forward as a dominant factor in children's attitudes to mathematics."* Furthermore, Aiken and Dreger (1961) found that college students who did not like mathematics claimed that their former teacher were responsible for this feeling because they were not patient with them and were strict; indeed, some indicate that the teacher was not familiar with subject. According to Aiken and Dreger's finding Aiken (1969: 23) state that, *"It is also true of course that students who do not do well in a subject may develop negative attitudes toward that subject and blame their teachers for their failure, even when the teachers have been conscientious."*

Aiken (1969: 40) state that,

> *"Although it is certainly unfair to implicate teachers too strongly as creators of negative student attitudes toward mathematics, the results of research have suggested that the teacher, perhaps even more than the parents, is an important determiner of student attitudes."*

Although many studies point out that teacher can affect student attitudes toward mathematics, teachers are also able to improve students' performance. Lester (1980) claimed that, *"It also seems obvious that the likelihood of improved problem-solving performance is increased if students see good problem-solving behavior exhibited by their teacher."* However, learning environment is considered an important factor and the role of the teacher in developing this climate may well be critical.

Curtis (2006) noted that, '*When students experience a different learning environment from traditional teaching, it can have a positive impact on student attitudes.'* This was related to the work of Boaler (1998) who found the nontraditional climate classroom enabled the students to develop a positive attitude toward mathematics.

- **Attitude and Parental Influence**

There are many studies emphasizing that parental participation plays an important role in affecting students' attitudes and achievement toward mathematics (Stevenson and Newman, 1986, Tocci and Engelhard, 1991). However, Poffenberger and Norton (1959) state that, *"The students' attitudes toward mathematics were positively related to how they rated their fathers' attitudes toward mathematics. The attitudes of the students were also related to their reports of the level of achievement in mathematics which their fathers and mothers expected of them."*

In particular, Ma (2001) found that, "*Fathers tend to have more influences on their children's achievement, whereas mothers tend to have more influence on their children's attitude*." Similarly, Hill (1967) applied a questionnaire with 35 boys from upper-middle-class backgrounds and also interviewed their parents. His results suggest that the attitude of the mother appeared to be the same as the attitude of her son and he stated that, *"The degree of similarity in attitudes between mothers and sons was related to maternal warmth, use of psychological control techniques, and low paternal participation in child rearing."*

Furthermore, there is some evidence indicating that parental educational level influence students' attitude and motivation. Ma (2001) stressed that, *"FAED had positive effects on their children's AIM"* whereas *"MOED had negative effects on their children's IM: the higher the mother's education level, the lower her child's perception of mathematics as important in one's life."* Then, he concluded that, *"The relationship between parental*

education and mathematics attitude may be more culturally diverse than the relationship between parent education and mathematics achievement."
[FAED = father's education ; MOED = mother's education]

Cao *et al*. (2006) supported Ma's conclusion, observing that, "*Parents from different cultural backgrounds and in different societies influence their student learning differently."* In their research carried out with Australian and Chinese students, they found that, *"Overall, and at each year level, students from China considered that their parents had a stronger influence on their mathematics learning than did Australian students."*

Some studies point out that in the parents' view, girls and boys appear to be different in their attitude and achievement. Levine (1972) stressed that, "*There was a slight tendency for parents to expect more from their sons than from their daughters in mathematics*." However, the findings of Cao (2006) suggested that, *"Parental encouragement, fathers' and mothers' attitudes and help, all become weaker with increasing years levels, although parental achievement expectation changes only slightly across years 5 and 9 among the Australians students."*

2.7 Conclusions

This chapter has considered the nature and purposes of attitudes and explored the importance of attitudes towards mathematics in its relationship with success in mathematics. There are many factors which may influence attitudes towards mathematics. However, most of these factors are outwith the control of teachers.

The way teachers present mathematics and the kind of climate in the mathematics teaching and learning situation will be important and teachers have great opportunities here. The curriculum to be taught and the assessment systems may well be determined outside the classroom. Assessment may be a very powerful factor in that perceived lack of success may undermine confidence and, thus, start to generate more negative attitudes towards mathematics and the learning experiences associated with it.

An important issue which must be addressed is how to measure attitudes. This is the theme of the next chapter.

Chapter 3

Measuring Attitudes

3.1 The Problem of Measuring Attitudes

Attitudes are not easy to measure and the measurements are open to criticism: are they credible, valid and reliable? Are the appropriate methods used for the age group and purposes intended?

Henerson (1987) states that,

> *"An attitude is not something we can examine and measure in the same way we can examine the cells of a person's skin or measure the rate of her heartbeat. We can only infer that a person has attitudes by her words and actions."*

Similarly, Reid (2006) stresses that attitudes cannot be measured directly but can only be deduced from behaviour. In the context of science education, he emphasized that *"This measurement must be able to offer an accurate and valid picture of learner attitudes to some specific aspect of the learning in the science subject."*

There are direct approaches to attitude measurement including self-report which include techniques like questionnaires, attitude scales, interviews, incomplete sentences, projective pictures, and essays. Indirect approaches include observation, or deduction of attitudes from some aspect of behaviour like decisions taken or performances achieved. Corcoran and Gibb (1961) discuss these approaches specifically in relation to mathematics. However, Brown and Abell (1965) consider that indirect methods are inappropriate in relation to mathematics. In fact, most research measuring attitudes toward mathematics use direct methods, especially questionnaire and interview.

Whether measurement is direct or indirect, Piazza (1980) claimed that, *"A good measure of an attitude must usually be based on more than one observation or one response to a questionnaire item."* He goes on to explain that, *"a respondent may answer a question in a certain way for a variety of reasons, not all of which maybe relevant to the matter being studied."* This principle is important although students may resent surveys which are too long and these take time to complete and mark.

Overall, the most important thing is to choose the method which is most appropriate for the aims of the research and which gives as much information as is needed in a reasonable time. One frequent approach is to use questionnaires with large samples and then interview small numbers to see to what extent the questionnaire responses are offering a valid picture. Questionnaire completion can be fairly rapid and enormous amounts of data obtained quickly. Interviews, by contrast, are time consuming to conduct and summarise. Bill (1973) argues that the questionnaire approach is better than interviews *"even with young adolescents of poor intellectual abilities."*

3.2 Questionnaires

Oppenheim (1966) described a questionnaire as follows:

> *"A questionnaire is not just a list of questions or a form to be filled out. It is essentially a scientific instrument for measurement and for collection of particular kinds of data, like all such instruments, it has to be specially designed according to particular specification and with specific aims in mind, and the data it yields are subject to error." (p. 2)*

Twenty-six year later, Oppenheim (1992) stated that, *"we should think of the questionnaire as an important instrument of research, a tool for data collection. The questionnaire has a job to do: its function is measurement."*

Based on analysis of many questionnaires, Reid (2006) noted that *"A well-constructed questionnaire can provide extremely accurate insights into how students think and the way they evaluate situations and experiences."* In order to develop a well-constructed questionnaire, Reid (2003, p. 41) suggested a series of instructions to help the process:

(a) "Write down as precisely as possible what you are trying to find out;
(b) Decide what types of questions would be helpful;
(c) Be creative and write down as many ideas for questions as you can;
(d) Select what seem the most appropriate from your list- keep more than you need;
(e) Keep the English simple and straightforward, avoid double negatives, keep negatives to a reasonable number, look for ambiguities, watch for double question;
(f) Pick the best, most appropriate and relevant questions, thinking of time available;
(g) Layout is everything!!
(h) Try your questionnaire out on a small sample of students (e.g. A tutorial group) – ask for comments, criticism. Check time required.
(i) *Make modifications and only then apply to larger group;*
(j) *Analyse each question on its own."*

When planning a questionnaire, it is important to be familiar with possible types of questions and to choose the types which suit the students who participate in this study. Basically, there are two kinds of question can be used. The first kind uses closed questions where the students have to select from a limited number of options. This approach is widely used by researchers, perhaps because it is easy for the student to answer rapidly, and analysis is relatively easy and comparisons between students are easy (Oppenheim, 1992). However, the approach has some shortcomings in that there is no opportunity for free responses. Possible answers are imposed and respondents may be frustrated and become annoyed (Oppenheim, 1992).

The second kind involves open questions where respondents are asked to answer questions by writing in their own words. Oppenheim (1992) noted that, although open questions are easy to design and the respondents have the freedom to answer them, it takes time and effort on the part of the respondents. In additon, answers which may prove difficult to analyse. Perhaps it is better to include both types: open and closed question. Interestingly, Oppenheim (1966, 1992) suggested that, "*sometimes, there may be good reasons for asking the same question both in open and closed form*." Yet, it is difficult when designing questionnaire to ask every question twice, even in two different forms.

While evidence shows the preference for using questionnaires with respondents at school levels (Oppenheim, 1992), it is vital to use high quality questionnaires to obtain clear results. These will involve questions with minimum ambiguity, clear instructions, with enough time given for completion. It is also essential that the students appreciate that their responses should be honest and that what they say will have no effect on any other aspect of their school studies. Even then, with younger students, there is always the possibility that students respond in terms of what they would *like* a situation to be rather than what it actually is.

Nonetheless, there are disadvantages with questionnaires. Henerson *et al*. (1987) stated that questionnaire "*do not provide the flexibility of interviews*." In other words, with questionnaires you will not be aware if the respondents understand your question in a different way. However with interview you can overcome this problem and you can explain questions, gain more information and explore new ideas (Henerson, 1987).

3.3 Interviews

Interviews are considered a useful method for gaining insights into student attitudes and they can offer much rich information. Interviewers can be more sure that questions asked are being understood as intended. The approach has been used in the mathematics field by Shapiro (1961) to assess student attitude towards arithmetic while many studies have used both questionnaires and interviews (Al-Enezi, 2008)

Reid (2006) noted that interviews, *"can be highly structured or totally open, but often interviews can be described as semi-structured."*

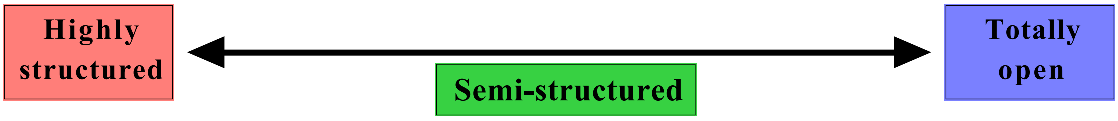


Figure 3.1 Types of Interview (from Reid, 2003)

Moreover, Oppenheim (1992: 81-82) stressed the aims of the interviews:

> *"They can give a prepared explanation of the purpose of the study more convincingly than a covering letter can; will more easily reach less well- educated respondents; help the ones with reading difficulties; offer standardized explanations to certain questions that arise; prevent many misunderstandings; and maintain control over the order or sequence in which the questions are answered."*

Furthermore, in order to develop an 'effective' interview, Henerson *et al.* (1987: 93) suggested nine steps:

1. *"Identify the attitude objective(s); determine what useful information the interview might provide about program effects.*
2. *Decide on the structure and approach of the interview.*
3. *Decide on the number and sequence of questions.*
4. *Draft questions and critique them.*
5. *Decide how you will summarize and report the interview data.*
6. *Add the introduction and probes, and choose a recording method.*
7. *Select the interviewer(s) and conduct a few tryouts.*
8. *Prepare the interviewer(s).*
9. *Make arrangements for the interviews."*

When developing interviews, Reid (2006: 30) has suggested some general principles:

"(1) Relate your questions tightly to your specified aims;
(2) Keep language straightforward and be prepared to ask questions in two or more ways;
(3) Have 'reserve' questions for shy interviewee;
(4) Seek a second opinion from a colleague on your questions;
(5) If possible, try the question out on a suitable 'guinea-pig'."

Although interviews can provide investigators with much useful information, there are some shortcomings as well. It can take a long time to interview students separately and the interviewer may influence the answers from the respondent, perhaps inadvertently (Henerson *et al.,* 1987). In addition, it is not easy to write a well-organized summary extracted from interviews (Reid, 2006).

3.4 Attitude Scales

The approaches of Likert and Osgood are often used to generate attitude scales. Having discussed questionnaires and interviews briefly in general terms, this section moves on to look critically at these scaling methods.

Attitude scales contain of numbers of statements (often between 6 and 24 statements) and respondents have to demonstrate their opinion by indicate the extent to which they agree or not agree with all statements. (Oppenheim, 1992)

However, in order to develop attitude scales, Hadden (1975: 15) noted two critical standards which should be considered:

(a) "The items must elicit responses that are psychologically related to the attitude being measured;
(b) *The scale should be capable of differentiating among individuals who are at different points along the dimension being measured and not merely between opposite extremes in attitude."*

There are numerous of attitude scales methods, each of them has its special style. Some of them have been widely used in measurement of attitude towards mathematics and science. Each of them is now described.

3.4.1 Thurstone's Method

Thurstone made a breakthrough by developing a method by which attitudes could be measured (Thurstone, 1929, Thurstone and Chave, 1929). The method involves gathering over 100 statements considered relevant to the attitude being considered. A large number of judges look at each statement and, each on their own, allocate to one of 11 categories defined from 'most favourable' to 'most unfavourable'. Statements where the judges agree on the category are then used in the questionnaire.

Oppenheim (1992) described Thurstone's method and this is summarized here:

(1) Collect a group of statements (around 100- 150).
(2) Find a group of judges (about 40- 60): any people who can give their opinion.
(3) Each of statements is copied on a separate card.
(4) Each judge places each statement (given randomly) into 1 of 11 categories: the first category will be extremely positive and category 11 will be extremely negative.
(5) Select statements where judges agree on the category. Where there is no agreement, statements are rejected.
(6) Each chosen statements is given a 'scale value' on the basis of the category agreed by the judges
(7) If candidate agrees with a given statement, then that candidate is given the 'scale value'.
(8) The 'scale values' of all the statements where the candidate expresses agreement are then added up to give the score of the candidate.

Suzuki (2007) noted that, in spite of being very cumbersome, Thurstone had offered a new way forward and opened the door for others to develop simpler approaches. Much earlier, Hadden (1975) had stressed that the method has two disadvantages:

(1) "The procedure is cumbersome and tedious……..
(2) Since an individual's final score is taken as the mean or median of the scale values of several items to which he has agreed, different <u>patterns</u> of attitudes may be expressed by the same score. This appears to be a valid criticism but one that no attitude scale can escape.
(3) Scale values are influenced by attitudes of the judges. Further refinements of procedure can, however, eliminate judges with extreme attitudes."

A few years later, Likert developed his method which tried to avoid the excessive work and time demand caused by the use of so many judges. His method is widely used in mathematics and science education. Long ago, Aiken (1969) stated that, "the Thurstone and Likert attitude-scale techniques are popular procedures for measuring attitude toward mathematics." However, nowadays the Thurstone method is seldom used and will not discussed further here.

3.4.2 Likert's Method

In his method, he omitted using judges and his major concern was that all statements should be developed to measure one issue (Oppenheim, 1966, 1992)

Likert method has easy and clear steps which are described as follows:

(1) *Collect a number of statements that relating to the issue you want to measure.*
(2) *Behind the statement create five scale positions from 'strongly agree' to 'strongly disagree'*
(3) *Chose a sample of respondents (about 100 at least).*
(4) *Each respondent are asked to show their opinion to each statement by ticking one of the five scale points.*
(5) *The five scale points are scored from 5 to 1 (or 1 to 5). Thus, for example, a 'strongly agree' might be credited with five points and a 'strongly disagree' with 1 point.*
(7) *Add up all the scores to get total sum that represents the respondent's attitude.*

(Derived from: Oppeneheim, 1992; Edwards & Kilpatrick, 1948)

When this approach is used, the normal procedure is then to correlate the responses for each question in turn with the total score to gain an estimate of how well each question reflects the underlying attitude (assumed to be what the total score measures). Questions which correlate poorly are then discarded to leave a smaller set of questions which is used to form the questionnaire.

Reid (2006) gave an example of the use of this type of question related to chemistry although this set of questions was not analysed by any scaling approach.

Think about your experiences in laboratory work in chemistry.
Tick the box which best reflects your opinion.

	Strongly Agree	*Agree*	*Neutral*	*Disagree*	*strongly Disagree*
(a) I believe that the laboratory is a vital part in learning chemistry	☐	☐	☐	☐	☐
(b) I prefer to have written instructions for experiments	☐	☐	☐	☐	☐
(c) I was unsure about what was expected of me in writing up my experiment	☐	☐	☐	☐	☐
(d) Laboratory work helps my understanding of chemistry topics	☐	☐	☐	☐	☐
(e) Discussions in the laboratory enhance my understanding	☐	☐	☐	☐	☐
(f) I only understood the experiment when I started to write about it afterwards	☐	☐	☐	☐	☐
(g) I had few opportunities to plan my experiments	☐	☐	☐	☐	☐
(h) I felt confident in carrying out the experiment in chemistry	☐	☐	☐	☐	☐
(i) I found writing up about experiments pointless	☐	☐	☐	☐	☐
(j) The experimental procedure was clearly explained in the instructions given	☐	☐	☐	☐	☐
(k) I was so confused in the laboratory that I ended up following the Instructions without understanding what I was doing	☐	☐	☐	☐	☐

Compared with the Thurstone scale, Oppenheim (1992) stated that the Likert scale has a high reliability. Furthermore, Reid (2006) emphasized that many studies which have used Likert scales reveal that respondents tend to be truthful provided that the respondents do not suspect any hidden agenda. He also shows that such questions are reliable in the sense that the same pattern of results will be obtained for each question if used on two more separate but similar situations.

Although this method is popular and widely used, there are a number of criticisms which can be raised against it. These criticisms all relate to the scoring method. The first shortcoming is this method is what is known as a deficiency of 'reproducibility'. That means it is possible for two candidates to obtain an identical total score for very different patterns of responses (Oppeneheim, 1992). Similarly, Gardner (1975) stated that, *"To add up the weight, the number of doors, the number of cylinders in a motor car to produce a single number would have little meaning."* The point Gardner was making was that, unless there is very clear evidence that questions are actually measuring the same thing, then adding up scores from these questions may give a meaningless total. High correlation does not ensure that the questions do, in fact, measure the same thing. After all, weight and height correlate highly in a population but the two measures certainly do not measure the same thing.

Reid (2006) has discussed the weakness of the scoring method in some detail. The fundamental issue is that ordinal numbers are being treated in an integer sense. Unless there is some evidence that the five points for all the questions are on the same scale and are measuring the same thing, the procedure is highly flawed. To gain evidence that the questions are, in fact, measuring the same construct, correlation is often used but this argument is flawed. Correlation measures that a high score on one measurement tends to relate to a high score on another. For example, height and weight correlate strongly but that does not imply they are the same measurement The weakness of this whole approach has been discussed in detail by Reid (2006).

3.4.3 Osgood's Method

Osgood *et al*. developed the method in 1957 and it was called the 'semantic differential'. The approach has been used widely in educational research, largely because of its ease of use, high reliability and validity (Heise, 1970). Heise (1970) went on to give some of the advantages of this method by noting that, *"Osgood's method is eminently suitable in terms* *of type of sample, administration, easy design, high reliability and validity when compared to other methods"*

The technique generally considers a bipolar rating scale with differentiating adjectives and between the adjectives there is a 7-point scale. The respondents are asked to tick one box in each line to reflect their view. Reid (2006) offers an example of the use of this method when looking at students' views of their chemistry laboratory. However, he used only six boxes and a scaling method was not used to analyse the data.

What are your opinions about your laboratory experiences in chemistry?
Tick ONE box on each line

Useful	☐	☐	☐	☐	☐	☐	Useless
Not helpful	☐	☐	☐	☐	☐	☐	Helpful
Understandable	☐	☐	☐	☐	☐	☐	Not understandable
Satisfying	☐	☐	☐	☐	☐	☐	Not satisfying
Boring	☐	☐	☐	☐	☐	☐	Interesting
Well organised	☐	☐	☐	☐	☐	☐	Not well organised
The best part of chemistry	☐	☐	☐	☐	☐	☐	The worst part of chemistry
Not enjoyable	☐	☐	☐	☐	☐	☐	Enjoyable

Although this method was not used by the example given by Reid (2006), very often the boxes are numbered from 1 to 6 and an overall score obtained by adding up. This approach has all the same problems associated with allocating ordinal numbers in the Likert method.

3.4.4 Problems with Scaling Techniques

The major problem of scaling methods lies in the scoring method. The methods developed by Likert (1932) and Osgood *et al.* (1957) are able to be used easily without using any scaling method. They have offered excellent insights (see Reid, 2003).

Mathematically, ordinal numbers cannot be added. It is impossible to be sure that responses to any two questions reflect a specific attitude: correlation does not indicate cause and effect, merely relationship. The same 'score' can be obtained from students who clearly hold very different attitudes. The problems associated with scaling were identified many decades ago (see Reid, 1978; Hadden, 1981) but it is strange that the approach still persists so widely.

Figure 3.1 demonstrates the adding up scores problem. It displays the responses of 6 questions which are answered by two students. Both of students have the same final score (17) although their answers to the questions are often very different.

	Strongly agree	*Agree*	*Neutral*	*Disagree*	*Strongly disagree*
Score	**1**	**2**	**3**	**4**	**5**
Question 1	O	X			
Question 2	X	O			
Question 3			X		O
Question 4		X		O	
Question 5		O			X
Question 6			O	X	
	Student 1 X		Student 2 O		

Figure 3.2 Two students' responses (imaginary) (from Reid, 2006)

The scaling method of scoring gives an overall total and, with large samples, this does give *some* reflection of the general attitudes held. However, the method masks important detail and, thus, does not offer any clear agenda for action. Osborne *et al.* (2003: 1057) makes this point when they stress that, "*Attitude scales … while they are useful in identifying the problem, they have been of little help in understanding it…*"

Another major disadvantage of a scaling procedure is that the gaps between points on the scale may not be equal. Indeed, there is no way of knowing the relative spacing between scale points (Oppenheim, 1992). Thus, ordinal numbers of uncertain value are being added, giving scores of uncertain significance and largely incapable of informing future action. The prospects for the approach are not good. Surprisingly, it is still used widely.

Reid (2006:14) summarized some of the number of problems associated with scaling methods:

(1) "We have no way of ensuring that steps on the scale are equally spaced. It is impossible to measure the spacing.
(2) Values on one question may not be comparable to those on another. Almost certainly, these are not and we have no way of knowing the relative values.
(3) Correlations do not necessarily imply direct relationship.
(4) Similar scores may be obtained for very different patterns of attitudes.
(5) There are problems associated with errors and 'softness' of categorical data. For an individual, this may be as large as 20%.
(6) Combining scores hides the rich detail arising from each question. The distribution in each separate question is what matters."

However, all these problems and obstacles that impede the measurement of attitudes can be overcome, at least in part. Some of the ways are now discussed.

3.5 Better Ways Forward

Attitudes are often highly multi-dimensional and attitudes towards mathematics are very likely to be complex, involving attitudes, for example, related to specific themes, ways of teaching, teachers, and the importance of mathematics, and so on. With questionnaires, a whole range of questions can give a rich set of insights into the detail of such attitudes. Adding up scores on individual items will tend to mask this rich detail. Indeed, the patterns of responses on individual questions frequently give distribution patterns which are far from normal, making the use of parametric statistics inappropriate (Reid, 2006).

Reid (2006) argues that each question should be analysed on its own. The response patterns of two different groups on each question can be compared, using a statistic like chi-square.

Reid (2006) points out two important principles:

(1) It is impossible to measure attitudes in any absolute sense. All that can be done is to compare attitudes of large groups of people.
(2) It is wrong to try to measure the attitude of an individual: the methods are too inaccurate and imprecise. All that can be done is look at groups of people and see patterns.

In all of this, one key point is to ask why attitudes are being measured. It has been established that attitudes are a very important aspect of the processes of learning (see chapter 2). It is important to gain insights into the attitudes of groups of learner so that problems can be identified and the educational process can be modified to generate more acceptable outcomes. For this, detail is needed. The scaling methods have too many weaknesses but, specifically, they fail to describe the detail needed. The approaches adopted in this study seek to uncover the rich detail to give a vivid picture of the learners' perceptions of their studies in mathematics.

Chapter 4

Learning Characteristics
Convergence/ Divergence

Learning characteristics have rarely been considered in research related to learning in mathematics. However, Dunn & Dunn (1987) argued from their studies that student achievement will significantly increase if they are taught in a way that suits their learning style. Moreover, Dunn and Dunn (1993) stressed that high achievers, rather than low achievers, can hold more variety of learning styles. The latter finding is important but the idea that a teacher can teach in line with the very diverse learning styles which are likely to be present in a typical classroom is perhaps not too realistic.

In the literature, many authors use the phrase ‘learning style’ although several other descriptions also exist. The phrase learner characteristic is perhaps more broad and useful. Nonetheless, in the discussion here, the language used by the author concerned will be adopted. Whatever language is used, the idea of learner characteristic or learning style seem important and this chapter offers a very brief review of the field, with special emphasis on the convergent and divergent characteristics. These are chosen in that there is more or less no work on them related to mathematics while there is some evidence from the sciences which suggest their importance in learning.

4.1 Learning style definition and its types

Learning style can be defined as *“the way in which a person sees or perceives things best and then processes or uses what has been seen. Each person’s individual learning style is as unique as signature”* (Le Fever, 1995). Similarly, Orhun (2007) describes learning style as *“a personally preferred approximation for collecting and processing information, forming an idea, decision- making, and attitude and interests.”*

Furthermore, Kolb (1984) defined learning style as *“the way we process the possibilities of each new emergent event which determines the range of choices and decisions we see, and the choice and decision we make, for some events to determine the events we live through which influence our future choices.”*

All these descriptions emphasise implicitly or explicitly that there is some element of choice for the learner. This is perhaps an assumption.

Kolb (1976) asserted that learning styles have four general groupings:

- concrete experience (CE) Preference for things seen, touched, tasted
- reflective observation (RO) Preference for thinking through what is observed
- abstract conceptualization (AC) Preference for thinking in terms of ideas
- active experimentation (AE) Preference to 'play with' ideas or experiment

Then he suggested that these four groupings can be represented along on two dimensions:

- active - to - reflective which (defined as doing-watching)
- concrete - to - abstract which (defined as feeling-thinking)

Then, Kolb (1985) classified individuals into four types according to the activities described above:

- Accommodators: this person appears to be more active and concrete
- Convergent: a person who is active but tends to be more abstract
- Assimilator: this person tend to be more reflective and abstract
- Divergent: the person who is reflective but tends to be more concrete.

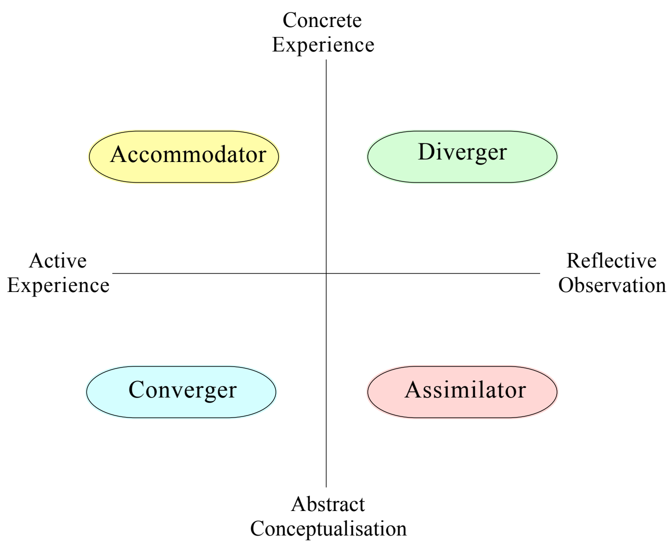


Figure 4.1 The Kolb Model (source: Orhun, 2007)

It has to be noted that Kolb's description of the converger and diverger are somewhat limited compared to the earlier descriptions offered by Hudson (1968). These are discussed later.

The Kolb's classification of learning styles as shown in figure 4.1 has some problems. The idea that the huge diversity of learner differences can be classified in this simple way is intrinsically unlikely. It assumes that a divergent person, say, is the opposite of a convergent person. This was not assumed by Hudson himself in his original work (1968) and Hindal et al. (2008) found that those who were divergent tended also to be convergent.

Hudson (1968: 91) noted that,

> *"No one was, or was ever expected to be, consistently convergent or consistently divergent "……" I have never seen why someone should not drift slowly over a period of years from divergence to convergence, or vice versa. Nor why someone should not be divergent in some moods and convergent in others. Nor why someone might not be convergent (or divergent)."*

From his experience, he differentiated between divergers, convergers and all-rounders, the last group being moderately good as divergers and convergers.

The convergent and divergent learning styles are now discussed in more detail.

4.2 Convergent/ Divergent

The notions of *convergency* and *divergency* was developed by Hudson when he discovered that, when people undertake intelligence tests, some parts of the test (diagrammatic questions) were often answered much better or much worse than other parts like verbal and numerical questions (Hudson, 1966). He then noticed that *"arts specialists usually had verbal biases of ability while scientists had numerical or diagrammatic ones."*

Generally speaking, convergent thinking means that persons have to concentrate on ideas to find the answer to some problem whereas divergent thinking means persons have to create possible answers and discover ideas. Figure 4.2 illustrates the differences between the two styles.

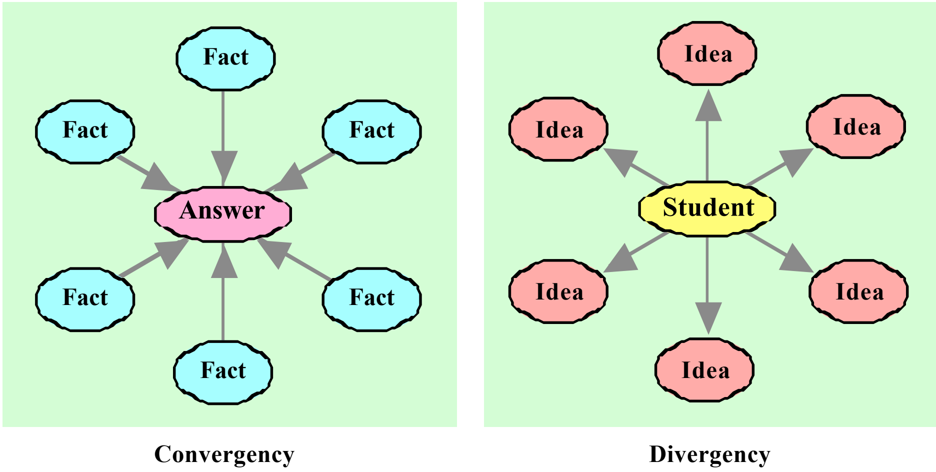


Figure 4.2 Convergency and Divergency (from Hindal, 2007)

Hudson (1966) found that convergers tend to do better than divergers in intelligence tests while, in the open-ended tests, divergers usually do better than convergers. He also stressed that, "*the convergence/ divergence dimension is a measure of bias, not a level of ability.*" In relation to performance at school, he noted that, "*young children specialize and flourish not in terms of the absolute level of their various abilities but in terms of their bias*" (1966: 46). This may reflect the importance of convergent/divergent style in the children's performance.

Marjoribanks (1978: 197) went on to expand and clarify the findings by observing that,

> *"In the conceptual perspective it is proposed that convergers tend to specialize in the physical sciences and perform particular well in mathematics, physics, and chemistry while divergers are attracted to the arts and perform with distinction in subjects such as English and modern languages."*

However, Danili and Reid (2006) found that divergers always seem to have advantages and they performed better in chemistry assessments. Strictly speaking, they found that convergers never outperformed the divergers, assuming that a low score in the test reflected convergency. Hudson (1966) had noted many years before that performance in subjects like biology and 'general arts' are similar for both convergers and divergers.

Hindal (2007) stressed that:

> *"In the context of the sciences, both being convergent and being divergent may have major advantages. Those who are good at the sciences (and other subjects) need to be good divergers to look for links and patterns and see how things relate to each other. Equally, after that, ideas need to be brought together to draw conclusions and see a clear pattern. The results here show that performance is related to characteristics of divergence and characteristics of convergence and this might offer an explanation."*

Although the results of Hudson and Marjoribanks were supported by some researchers, some research showed contrary results. Hartley and Greggs (1997) argued that their results illustrated that, in divergent tests, the scores that convergers got do not differ from those of divergers. However, the results of Field and Poole (1970) demonstrated that, among the convergers that specialized in science at university, divergers out-perform and achieve better than convergers in science.

There is some evidence to indicate that teachers and educational experience play a role in improvement of thinking style (Mackay and Cameron, 1968; Povery, 1970). Similarly, Hartley (1998) stated that:

> *"In general, it seems that members of staff react more favourably to convergent than to divergent student. To put it bluntly, teachers find divergent students difficult to deal with, and this may be especially true of teachers who are themselves convergent thinkers. Such teachers don't like guessing or playfulness, but prefer a more serious approach. If, however, divergent thinking does enhance creative output, then teachers need to be made aware of this and persuaded to encourage divergent thinking rather than to respond to such thinking with hostility".*

In the term of social attitudes, it is proposed that attitudes of divergers are not the same as attitudes of convergers, "*with convergers being conscientious and expressing conforming and conservative attitudes while divergers are likely to be more rebellious and intellectually independent and have more liberal and non authoritarian attitudes."* (Marjoribanks, 1978)

All the characteristics of convergers and divergers are summarized in table 4.1

Convergers characteristics	Divergers characteristics
• Higher performance in intelligence tests • Good at practical application of ideas • Specialized in physical science and classics • Prefer formal material and logical arguments • Ability to focus hypothetical- deductive reasoning on specific problems • Better in abstract conceptualization • Hold conventional attitudes • Like unambiguity • Emotionally inhibited	• Higher performance in open-ended tests • Fine at generating ideas and seeing things from different perspectives • Specialized in the arts • Better in concrete experience • Interested in people • Hold unconventional attitudes • Strong in imaginative ability • More likely to be witty

Table 4.1: General characteristics of convergent and divergent thinkers
(Source: Bahar, 1999)

Relating to Hudson's work on the relationship between the cognitive abilities of children and their performance in school, Marjoribanks (1978) proposed a number of hypotheses:

(1) Convergers scores are better than divergers in mathematics and physical science whereas the divergers do better in English and French;

(2) Those who are good in convergent *and* divergent abilities will tend to perform similarly in mathematics and physical science but those who are good in convergent *and* divergent abilities also perform as well as the divergent in English and French;

(3) In relation to biology, divergers, convergers and those good in both are all similar in their performances;

(4) Convergers and those who are convergers *and* divergers hold more positive attitudes towards school.

The findings of Marjoribanks supported some of the hypotheses mentioned above and contradicted others. Indeed, there seems to be some inconsistency in the findings from various research and this may simply reflect the measurement tools that each of them use in their measurement.

Now each of divergence and convergence characteristics is discussed separately in more detail. The test used by many to measure divergency is discussed and a relatively new test (the only one found) to measure convergency is described.

4.3 Divergency

Frasier and Carland (1982) reviewed some researchers' descriptions for divergence: they described one description as, "*The development of more than one possible response to a problem or question. Believed to be a central characteristic of creativity*." and another as as, "*mental activity directed to open-end kinds of problems for which there is no one correct answer; the more infrequent statistically a response is under these conditions, the more divergent is the thinking*".

Davis and Rimm (1998) proposed that the divergence style should contain these procedures: understanding and be familiar with problem, forming or suggesting hypotheses as well as modifying and reexamining these hypotheses and informing the results. Following this picture, Hindal (2007: 63) described processes that divergent thinkers need in order to express their learning characteristic:

- *"Exploring*
- *Questioning*
- *Experimenting*
- *Testing ideas*
- *Problem solving"*

It was suggested from some studies that divergent thinkers tend to be more 'witty' and enjoy to express and discuss their personal feelings or opinions about any issues (Hudson, 1966).

There is strong evidence which suggests that, in examinations of some subjects like sciences, mathematics, and technology, being divergent tends to be an 'advantageous' (Danili and Reid, 2006). In relation to mathematics, the divergent thinkers can have advantages because they are able to relate mathematical concepts, this being known to be important that mathematical ideas build on each other and form complex relationships. Looking at chemistry, Al-Naeme (1991) found that divergers gained better scores than convergers in some parts of chemistry. He remarked that:

> *"It seems that convergent thinking ability may not assist pupils in performing practical problem-solving in chemistry particularly when the practical tasks require a creative and imaginative thinking ability."*

Al- Qasmi (2006) found that those who did best in a test for divergency tended to connect ideas in their long-term memory more effectively. Al-Qasmi suggested some reasons for her findings:

> *"It could be because the working memory stores new information in the long term memory in such a way that many links are formed. It could simply be based on genetics – some people are born with a better brain architecture. It could even be a matter of choice: some people choose to link ideas more than others. Of course, it might be a combination of any two or all three."*

In order to measure the divergence for individuals, the test used by many is described by Bahar (1999). This test based on measuring the ability to create ideas and view things from different perspectives and doing well in open-ended questions. The test consists of six timed sub-tests. Students are given 20 minutes to answer the whole test.

Test 1: Students are asked to write as many words as they can that have the same meaning or similar to the words given but without repeating any word. They are given three words and have to answer them in 4 minutes.

Test 2: This contains two parts: each part contains 4 words. Students are asked to write as many different sentences as they can providing each sentence should include these four words without changing the form; they are given 4 minutes to complete the two parts.

Test 3: The students are given four words and they asked to draw as many pictures as they can that can represent each of these words. They are giving 5 minutes to answer the question.

Test 4: Students are asked to think of as many things as possible that have the same given adjective. Two minutes are allowed to complete answer.

Test 5: Students are asked to think quickly of as many words as they can that began with a specific letter and end with other specific letter, excluding the names of people and places; and they have 2 minutes to complete.

Test 6: Students are given a topic and they have three minutes to think of as many ideas as they can which relate to this topic.

4.4 **Convergency**

At times, there is a tendency to value divergent abilities highly (as these can lead to the creation of ideas) and almost implicitly suggest that convergent characteristics are less useful. Frasier and Carland (1982) offers a useful antidote when they quote Reismann (1962:79) who says,

> *"Convergent creativity: this is the kind of creativity that is called forth by our best examinations when they require the bringing together of ideas from many sources in order to answer the test question. At its best, this demand does stimulate the reorganization of concepts".*

Hudson (1966) described the converger as: *"the converger is the boy* (sic) *who is substantially better at the intelligence test than he is at the open- ended tests"*

Hudson (1966) clarified the two main characteristics that evidence shows are typical of the converger: "*This first is his concentration upon the impersonal aspects of his culture, both in school and out. The second, the caution with which he expresses his feeling."* It was been found that convergers not only tend to perform extremely well in physical science and mathematics but they are able to be successful in 'arts subjects' as well (Marjoribanks, 1978). This results seems to be contradicted by the work of Danili and Reid (2006) but this may reflect on how convergency is measured.

Marjoribanks findings revealed the importance of convergent thinking in the mathematics field. The nature of mathematical exercises require the kind of thinking where students bring ideas and facts together to gain access to answers or solutions. Hindal (2007) summarized some of the convergent skills: "*the convergent style learner tend to use, for example: determining cause and effect, analyze, reasoning by analogy, making inferences, determining relevant information, recognizing relationships and applying spatial relationships, deductive thinking skills, using logic and analyzing syllogism, spotting contradictory statements."*

In order to use these skills, convergers need the following 'processes':

- *"Uunderstanding relationships*
- *Collecting all the relevant information*
- *Organizing the information using a list, table, and graph*
- *Finding the relationship by looking for pattern or keyword"* (Hindal, 2007)

It was thought that a low score in a divergent test indicated convergence. However, Hindal et al. (2008) challenged this idea and suggested that convergence might be seen as a learner characteristic in its own right.

On this basis, it is possible for a student to be convergent, divergent, both or be strong in neither characteristic. As no test for convergence appeared to exist, they developed one. The test was built to the specifications which characterized convergence but was deliberately designed to have the same format, style and length as the established test for divergency. It contains five timed sub-tests. Each test has specific time and 20 minutes are allowed overall. The description of the test is illustrated in table 4.2

Specification of Convergency Test				
Section	***Item***	***Description***	***Aim***	***Time***
1	1	Given a number of countries and their capitals students are asked to classify them according to two ways	Find the relationship	5
	2	Gives letter in a random order, the student is required to form words.	Put in right order and understanding sequencing using words	
	3	Three sets of figures in each group there is a number missing. First is required to write the missing number, then write that the relationship between the figures, which led to take this figure specifically in the empty space	Understand sequencing using numbers. Seeing patterns and drawing a conclusion	
2	1	The student is required to read and then summarize the paragraph in three main ideas are in the paragraph then put it in the form of cognitive map	Picking out key ideas and leaving aside the less important	5
3	4	Gives students four sets of pictures of each group containing four forms required of a student to put on different format and give the reason	Finding the relationship; pattern seeking	3
4	2	Four graphs, ask the student to identify two aspects of the differences	Ability to identify common features presented in graphical form	2
5	2	Describe an itinerary of the person from starting point on to the end shown on a map. The students are require to draw the route on the map in the beginning Then write describing this as a way to indicate that to somebody who wants to go the same route.	Able to extract form a matrix of information the key essential features and place them in a coherent logical order.	5

Table 4.2 The Convergent Test Specification and Design
(from Hindal, 2007)

4.5 Some Conclusions

There are a variety of learning characteristics such as: field dependency/independency, visual-spatial and symbolic-linguistic abilities, convergency and divergency. The field dependency/independency construct has received attention from many researchers and there is a large number of studies in relation to sciences and mathematics as well (Witkin et al., 1977; Hindal, 2007; Al-Enezi, 2004). Visual-spatial abilities have not been considered in much research relating to mathematics. The concept has been discussed at some length (Silverman, 1989, 2002, 2003) but the only test found was that developed by Hindal (2007). However, space did not permit this characteristic to be discussed further here.

While convergency and divergency have also been much discussed, the work of Bahar (1999) and Hindal (2007) has indicated how important these characteristics are in relation to examination performance, especially in the sciences, while the work of Danili and Reid (2005) has explored the relationship between these characteristics and aspects of assessment. Therefore, this research aims to explore if these characteristics are related highly to performance in mathematics.

Chapter 5

Experiments Undertaken

This chapter discusses the methodologies of this study and the way that it was carried out. The method of data gathering and analysis are also described.

5.1 The purpose of research

This research aims to investigate the relationships between students' attitudes and their performance in relation to mathematics, and the relationship of certain learner characteristics to performance.

Attitudes are considered as very important in the educational area. Many previous studies have indicated that attitudes are an important factor in student achievement and there are numerous factors that influence student attitudes toward any subject (chapter 2). However, attitude can be developed and changed either to more positive or more negative under specific circumstances. In many countries, mathematics is a subject where students seem to complain about difficulties more than with other subjects and there is a considerable dislike of the subject. This attitude may hinder further learning.

It is important to understand the reasons for this negative feeling so that steps can be taken to minimise it. What are the key influences: school, teachers, peers, previous experience, failure, nature of subject, class environment and so on? All of this information can be obtained by measuring students' attitudes in relation to mathematics by using questionnaire or interviews or a combination of them. Therefore, this study was conducted to explore students' attitudes toward mathematics and seek the factors that affect them.

It has been noted that attitudes play an important role in relation to students' achievements. In addition, some previous work suggests the importance of various learner characteristics. The work of Danili and Reid (2004) showed the strong relationship between extent of divergency and performance in chemistry while the work of Hindal (Hindal, Reid and Badgaish, 2008)revealed that many learner characteristics related to performance in many subject areas, including mathematics. It was assumed that the convergent thinker tended to perform well and specialized in physical science and mathematics. However, the work of Hindal observed that the pupils who showed both convergent and divergent characteristics did better in the examinations, in the sciences, mathematics and in other areas. This surprising result needed further exploration.

5.2 The sample of the study

In this research, four intermediate public schools were chosen from different areas in Mecca city in Saudi Arabia. Because of the segregation system in all Saudi schools, this study was applied in two boys' schools and two girls' schools. In intermediate schools, there are three year groups (aged 13-15). Two classes from each level were selected randomly from each school. 669 pupils participated in this study. Table 5.1 illustrates the numbers of pupils involved in the project in relation to the level and gender.

	Boys	*Girls*	*Total*
Level 1 (age 13)	98	102	200
Level 2 (age 14)	119	119	238
Level 3 (age 15)	115	116	231
Total	332	337	669

Table 5.1 Samples Used

5.3 Methods used in the Study

The aim was to gain a picture of the way attitudes in relation to mathematics were changing with age and to see if there were any gender differences, recognising that boys an girls might well have very different experiences being educated separately. A questionnaire was designed with these aims in mind. In addition, the extents of convergency and divergency were measured using the tests which Hindal (2007) had used in her study.

5.3.1 Divergency and Convergency Tests

The two tests (divergency and convergency) are described first. The divergent test used in this study was the test used earlier by Bahar (1999). However, it was translated into Arabic with very minor modification to some words to fit Arabic language and idiom. The test aims to measures pupils' creative abilities to generate new ideas and make links between them. It contains six timed sub-tests and pupils were asked to answer each question separately in a specific time. Each class started each question and finished together on time, then they moved to the next page, and so on until the last questions. The test took 20 minutes to complete and was applied to students in a relaxed atmosphere where they were informed that the test will not affect their school marks in any way. The test was marked by giving 1 mark for each correct answer. The test is shown below (layout shortened). The test, as presented to the students, is shown in full in the appendix. Here each subtest (entitled test 1, 2 etc) was placed on a separate page.

TEST 1

When you are writing, it is often necessary to think of several different words having the same meaning, so that you do not have to repeat one word again and again. In this test you will be asked to think of words having meanings which are the same as or similar to a given word. The given words will be ones that are well known to you.

For example
If the word were SHORT you would write at least some of the words written below:

Short:	*brief*	*abbreviated*	*concise*	*momentary*	*little*	*limited*
	deficient	*abrupt*	*petite*	*crisp*	*compact*	

Now try the following words. You probably will not be able to fill in all the spaces, but write as many words as you can think of.

1. Strong:

....
....
....

2. Clear:

....
....
....

3. Dark:

....
....
....

4 Minutes

TEST 2

In this test you will asked to write as many sentences as you can. Each sentence should contain the four words mentioned and any other words you choose:

For example

TAKE FEW LAND LITTLE

1. Few crops take little land.
2. A few little boats supplies to land.
3. Could you take a few little people with you to see my green land?

All the four words are used in each sentence. The words must be used in the form that is given; for example, you cannot use ‘taking’ instead of ‘take’. Notice that the sentences may be of any length. All sentences must differ from one another by more than merely one or two changed words, such as different pronouns or adjectives.

Now try the following words. Remember to number each new sentence as was done in the example above.

1. WRITE WORDS LONG OFTEN

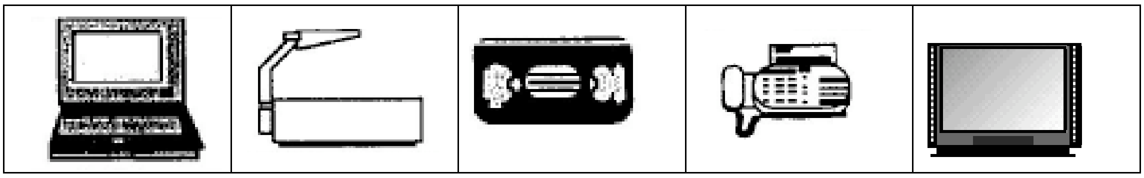
2. FRIEND MAN YEAR CATCH

4 Minutes

TEST 3

This is a test of your ability to think up a number of different symbols that could be used to stand for certain words or ideas.

For example
The word is ‘electronics’. This word could be represented by many symbols or drawings as shown below. As you know there are many other symbols that could represent the word ‘electronics’?



Now draw as many symbols as you can think of (up to five) for each word or subject below.
Each drawing can be a complicated or as simple as you chose. (No artistry required)

1. Energy

2. Happiness

3. Technology

4. Silence

5 Minutes

TEST 4

This is a test to see how many things you can think of that are alike in some way.

For example:
What things are always red or that are red more than any other colour? You may use one word or several words to describe each thing.

tomatoes bricks blood

Go ahead and write all the things that are 'round' or that are round more often than any other shape.

....
....
....

2 Minutes

Test 5

This is a test of your ability to think rapidly of as many words as you can that begin with one letter and end with another.

For example:
The words in the following list all begin with 'S' and end with 'N'.

Sun spin stain solution

Now try thinking of words beginning with 'G' and ending with 'T'. Write them on the lines below. Names of people or places are not allowed.

....
....
....

2 Minutes

TEST 6

This is a test to see how many ideas you can think of about a topic. Be sure to list all the ideas you can think about a topic whether or not they seem important to you. You are not limited to one word. Instead you may use a word or a phrase to express each idea.

For example: 'A train journey'. Examples are given below of ideas about a topic like this.

number of miles suitcases the railway stations people in the train

Now list all the ideas you can about 'working in laboratories'.

....
....
....

3 Minutes

Hindal (Hindal, 2007; Hindal, Reid and Badgaish, 2008) developed a test for convergency and this was used here, with very minor adjustments to suit the different audience. Hindal tried the test out with various groups of 13 year old students and talked to them afterwards. Her aim was to gain some evidence that the students were answering the questions in a way which reflected convergent behaviour. Despite this, she was not totally certain of the test validity although the interviews gave her strong grounds for confidence. Very recently, the test was used with 54 students, aged about 13, in Scottish schools and she interviewed the students afterwards in some detail (Chandi, *et al*., 2008). They reported that there was clear evidence that the first four sub-tests were measuring what was intended but they lacked unequivocal evidence about sub-test 5.

The test consists of five sub-tests. Each sub-test is oriented to measure the pupils' ability to find the solution or conclusion of problems. The whole test takes exactly 20 minutes and each question is given a specific time. It was giving an overall mark of 28. The test structure mirrors the well established test of divergency (Bahar, 1999). The whole test is now shown, again, with layout slightly adjusted. The test in the form used is shown in full in the appendix.

The validity and reliability of the divergency test are well established (B ahar, 1999) and the validity of the convergency test will be discussed later.

Test One

(1) Look at the table alongside:

Morocco	Iran	Oman	Qatar	Lebanon
Rabat	Karachi	Beirut	Masqat	Doha
Egypt	Pakistan	France	United Kingdom	Spain
Cairo	Teheran	Madrid	Paris	London

There are many patterns in the table which could link the names in the table together
Find two patterns and write them down.

Pattern 1……………………………..…………………….……………………..……
Pattern 2………………………………….………………………….………………….

(2) Put the letters in the right order to give a correct word.

- E O N T ………………………………………..
- R E N I D F ………………………………………..
- E A C P E ………………………………………..

(3) Here are several sets of numbers.
Add the next number in each sequence for each, and then explain why you chose the number.

- 2 …. 4 …. 8 …. ☐

Explain:……………………………………………….…………………………………

- 1 …. 3 …. 6 …. 10 …. 15 …. ☐

Explain:………………………………………………….…...……..……………………

- 1…..4….9….16…..☐

Explain……………………………………………………………………………..

Five minutes

Test Two

Here is a short piece of writing, Pick out the three main ideas.

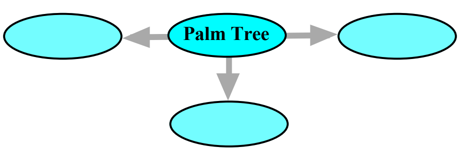
Read the topic and classify the three main ideas use the diagram.

The Palm Tree in Saudi Arabia

In the oases of Saudi Arabia, the date palm tree stand tall with their branches out stretched toward heaven and their roots anchored deep into the earth. Since ancient time, the date palm has been a source of food for inhabitants of the Arabian Peninsula, and its branches have granted him shade from the strong desert sun. In the Holy Qur'an and Hadith, many passages make mention of the important of it. In the Qur'an, it is referred to 29 times and is called "a blessed tree". In addition, dates are considered a main meal for Muslims during Ramadan, whereas the daily fast is broken with a few dates and then a few sips of water.

Dates are considered a nutritious staple of the Saudi diet and an excellent source of energy for the health conscious because they are Low in fat, cholesterol free, high in carbohydrates and contain fibre, potassium and vitamins. Furthermore, some studies indicate to the possible medicinal benefits that might be derived from dates, such as an analgesic or as a supplement for people who suffer from hypokalemia, a disorder involving too low levels of potassium.

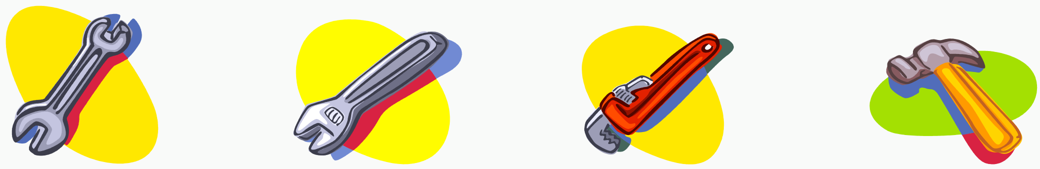
Before oil became Saudi Arabia's primary industry, date farming was a prevalent part of national economy .Today; the kingdom is the world's second producer of dates, supplying 17.6 percent of the world market. It has an enormous number of varieties of date grown in different region such as; khalas, ruzeiz,



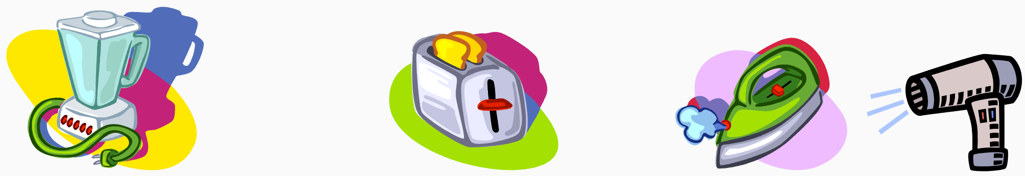
Five minutes

Test Three

- Picked out the different object, and then give a reason to select it.



Give a reason: ....



Give a reason: ....

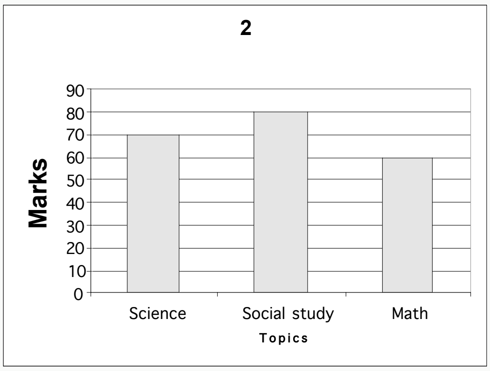
Give a reason: ....

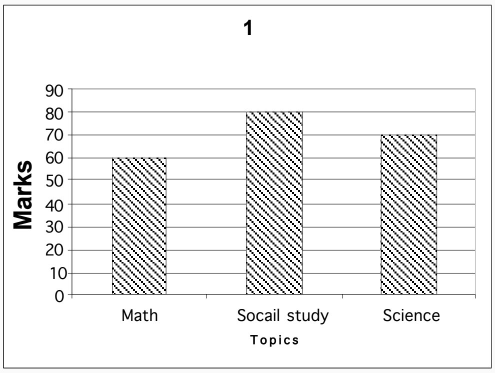
Give a reason: ....

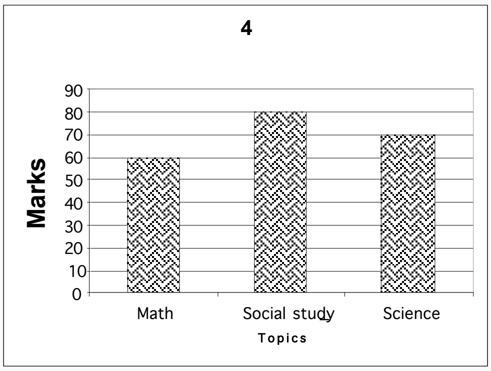
Three minutes

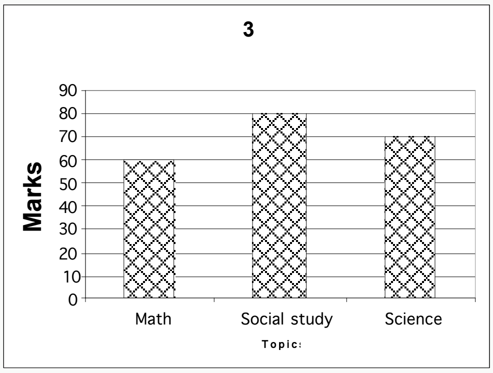
Test Four

- Here are four graphs showing how pupils performed in examinations.
- All have the same axes, labelled in the same way.
- Look at the four graphs carefully.
- Write down two things which are **true for all four** graphs.









1 ………………………………………………………………………………………

2 ………………………………………………………………………………………

Two minutes

Test Five

Read the test instruction first:

There is a man stands near the school (on the map start point). Help him to go to a nursery then to the supermarket (the end point) by drawing the way on the map.

1 Use a pen or pencil and mark the route clearly on the map

2 Write your description for the way you drew on the map.

Your description

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Five minutes

5.3.2 Questionnaire

In order to gain an insight into students' attitudes and perceptions of mathematics, a questionnaire with 13 questions was developed. Many of the questions contained several items. Four of these questions were developed in semantic differential format (Osgood et al, 1957) and one was in Likert format (Likert, 1932). Other format used included:

- Questions where pupils asked to tick as many boxes as they wished or the three or two that considered most important for them
- Yes/ No questions
- Filling gaps question, where student asked to write the word that in their opinion suit each description written.

The goals of these three types of question are to obtain a lot of information about different aspect of the learning of subject, the reason for studying mathematics, the reason for liking or disliking mathematics, the reason for going to university, the most interesting activities in the class or lesson and so on.

The questionnaire was developed, and then discussed with experienced colleagues and adjusted in the light of their comments. It was then translated into Arabic and the translation checked by an experienced Arabic teacher. Then it was given to both girl and boy pupils, aged 13- 15. Before the pupils filled in the questionnaire, they were told that this questionnaire will not be seen by any one except the researcher and will not affect their marks in any way. They were asked to answer honestly and were allowed 15 minutes. The questionnaire is shown overleaf.

What do you think about mathematics?

*Please answer **ALL** the questions below - most answers only require you to tick boxes.*
*Your answers do **NOT** count for examinations in any way.*
Please be as honest as you can!!

quick	✓	☐	☐	☐	☐	☐	slow
important	☐	☐	✓	☐	☐	☐	unimportant
safe	☐	☐	☐	☐	✓	☐	dangerous

The positions of the ticks between the word pairs show that you consider it as <u>very</u> quick, slightly more important than unimportant and <u>quite</u> dangerous.

Use the same method for the following questions

(1) Think about **mathematics**.
Tick one box on each line.

Does not involve hard work	☐	☐	☐	☐	☐	☐	Does involve hard work
Important	☐	☐	☐	☐	☐	☐	Not important
Leads to many jobs	☐	☐	☐	☐	☐	☐	Does not lead to many jobs
Is not easily understood	☐	☐	☐	☐	☐	☐	Is easily understood
Is abstract	☐	☐	☐	☐	☐	☐	Is concrete
Easy	☐	☐	☐	☐	☐	☐	Difficult

(2) Think about **yourself and mathematics.**
Tick one box on each line.

I feel I am NOT coping well	☐	☐	☐	☐	☐	☐	I feel I am coping well
I do NOT wish to learn mathematics	☐	☐	☐	☐	☐	☐	I wish to learn mathematics
I am obtaining a lot of new skills	☐	☐	☐	☐	☐	☐	I am NOT obtaining a lot of new skills
I am getting better at mathematics	☐	☐	☐	☐	☐	☐	I am getting worse at mathematics
It is definitely "my" subject	☐	☐	☐	☐	☐	☐	It is definitely NOT "my" subject
I find mathematics boring	☐	☐	☐	☐	☐	☐	I find mathematics interesting

(3) Here are ways to describe **mathematicians.**
Tick one box on each line

Mathematicians are:

Hardworking	☐	☐	☐	☐	☐	☐	Not hardworking
Not practical people	☐	☐	☐	☐	☐	☐	Practical people
Good fun	☐	☐	☐	☐	☐	☐	Boring
Useful	☐	☐	☐	☐	☐	☐	Not useful
Well paid	☐	☐	☐	☐	☐	☐	Badly paid
Popular	☐	☐	☐	☐	☐	☐	Unpopular
Low status	☐	☐	☐	☐	☐	☐	High status

(4) Here are several **reasons** why school pupils might need to study mathematics.
*Tick the **THREE** which are most important for you.*

- ☐ Teaches me to think clearly
- ☐ Can be applied in life
- ☐ Can solve problems in the world
- ☐ Is a useful way of thinking
- ☐ Leads to many jobs
- ☐ Is essential for many other subjects
- ☐ Is very logical
- ☐ Is fun

(5) Here are several statements.
Tick one box on each line to show your view.

		Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly Disagree*
(a)	I look forward to mathematics classes each week	☐	☐	☐	☐	☐
(b)	Geometry is the worst bit of mathematics	☐	☐	☐	☐	☐
(c)	I cannot solve equations easily.	☐	☐	☐	☐	☐
(d)	The mathematics textbook is boring.	☐	☐	☐	☐	☐
(e)	Mathematics is used in our daily life.	☐	☐	☐	☐	☐
(f)	I cannot see why I have to study mathematics	☐	☐	☐	☐	☐
(g)	I find mathematics ideas very interesting	☐	☐	☐	☐	☐
(g)	There are too many ideas to hold in my mind at once in mathematics	☐	☐	☐	☐	☐
(h)	My mathematics teacher is very important to enable me to understand	☐	☐	☐	☐	☐

(6) Would you like to study more mathematics next year?

- Yes, because ………………………………………………………………………………
- No, because ……………………………………………………………………………….

(7) Different pupils **prefer different things**.
Tick one box on each line your preference.

Algebra	☐	☐	☐	☐	☐	☐	Geometry
Solving equations	☐	☐	☐	☐	☐	☐	Solving geometry problems
Drawing geometry shapes	☐	☐	☐	☐	☐	☐	doing arithemetic
Mathematics	☐	☐	☐	☐	☐	☐	Social Studies
Science	☐	☐	☐	☐	☐	☐	Mathematics
Arithmetic	☐	☐	☐	☐	☐	☐	Algebra
Mathematics	☐	☐	☐	☐	☐	☐	Arabic

(8) What do you **enjoy a lot** in your mathematics lessons.
Tick as many as you like.

- ☐ Solving everyday problems
- ☐ Solving different exercise
- ☐ Drawing geometry shapes
- ☐ Measuring angles
- ☐ Counting numbers
- ☐ Getting right answers
- ☐ Listening to teacher explanation
- ☐ Doing homework
- ☐ Doing multiplication exercises
- ☐ Approximation numbers

(9) Suppose you were thinking of going to university.
Here are several reasons for going to university.
Tick as many as you like to show your views.

- ☐ I get a subsidy
- ☐ My parents want me to go
- ☐ All my friends will probably go
- ☐ I like new challenges
- ☐ I shall get an interesting job in the future
- ☐ It is the normal thing to do after finishing school
- ☐ I am good at school level

Which subject might you study at university? ……………………………………………

(10) Fill in **the school subject** that you think **best** fits each description below:

(a) ……………… is most interesting.
(b) ………………… is most important.
(c) ……………… is most enjoyable.
(d) ………………… is most boring.
(e) ……………… is mostly suitable for girls.
(f) ………………… is mostly suitable for boys.
(g) ……………… is useless for girls.
(h) ………………… is useless for boys.

(11) Which of these do you think is going to be most interesting to do in intermediate school?
Tick as many as you like

- ☐ Playing in a school sport team
- ☐ Doing mathematics exercise
- ☐ Painting pictures
- ☐ Learning English
- ☐ Cooking
- ☐ Reading stories

(12) Which of these do you think you are going to be after you leave school?
Tick two boxes.

- ☐ an artist
- ☐ a businessman/woman
- ☐ a nurse
- ☐ a football player
- ☐ a mathematics teacher
- ☐ a doctor
- ☐ an aircraft pilot
- ☐ a lawyer
- ☐ an engineer
- ☐ a housewife

(13) I became interested in mathematics thanks to …..
Tick as many as you like.

- ☐ television
- ☐ my teacher
- ☐ exhibition, demonstration, festivals
- ☐ mathematics lessons
- ☐ my friends
- ☐ my parents
- ☐ other (please indicate) ……………………………………………………………………………

5.3.3 The Methods of Data Analysis

In relating to the questionnaire's data, each question was analysed separately by using chi-square contingency test to evaluate the significant differences in pupils' answers: the aim was to compare responses by age and compare responses for boys an girls. All statistical calculations were based on the frequencies.

To look for any relationship between two variables, , correlation coefficients were calculated. The variables involved were:

Attitudes and learning characteristics (convergency/ divergency)
Attitudes and performance
Learning characteristics and performance

Two methods of correlation were applied. The first one is the Kendall's tau-b procedure for the ordinal data and the other is the Pearson correlation to find the correlation between divergency, convergency and performance.

The studies carried out in the October 2007, the semester starting in September. The mathematical performances of the pupils were judged from their final mathematics (from 100marks) in the previous years. However, Pupils' semester examination marks for current years were also gained.

Chapter 6

The Analysis of Data
(Questionnaire)

6.1 Introduction

The questionnaire was used with three year groups in schools from Saudi Arabia. Two girls and two boys' school were selected from different areas in Mecca. From each school two classes were chosen randomly from each level. The overall sample participating in the study was 669. The sample was selected in such a way that it reflected the population of pupils at these ages in Saudi Arabia.

The questionnaire aims to offer an overview of pupils' image about mathematics and specific mathematical topics. However, of greater importance was to see how pupils' views changed with age and whether boys and girls held different views, given that they are educated completely separately.

The responses for each part of each question are summarised for each age group and gender. The data are presented as percentages for clarity but all statistical calculation are based on frequencies.

In the actual questions, the polarity of questions was random. However, in each table, the positive statement is shown on the left, again for clarity. Color coding is used to highlight the comparisons which are significant. Significance was checked using chi-square as a contingency test.

This chapter discusses firstly the images and views of pupils' school toward mathematics and how these views develop or change with age in Saudi Arabia. Secondly, it discusses the differences' between boys and girls attitudes towards mathematics.

6.2 Comparing Year Groups

The responses for the three year groups are now compared. All data are presented as percentages, the total sample being 669. A very small number of pupils failed to answer some questions and, therefore, totals do not always add up exactly to 100%.

(1) Think about mathematics	Age	Responses						χ2	df	p
Does involve hard work	*13*	23	9	6	7	21	33	53.8	10	$p < 0.001$
	14	19	17	13	8	16	24			
	15	43	15	7	8	11	15			
Important	*13*	74	12	5	1	1	6	29.7	8	$p < 0.001$
	14	65	17	7	2	2	5			
	15	56	16	6	5	6	13			
Leads to many jobs	*13*	51	16	10	5	4	12	11.9	8	n.s.
	14	41	17	12	9	7	9			
	15	38	21	11	6	9	14			
Is easily understood	*13*	50	11	5	6	10	16	48.1	10	$p< 0.001$
	14	32	16	7	10	6	24			
	15	20	19	8	7	15	31			
Is abstract/is concrete	*13*	24	6	9	6	8	36	14.0	10	n.s.
	14	24	8	8	10	13	28			
	15	22	10	12	13	10	27			
Easy	*13*	43	21	5	6	5	17	52.3	8	$p < 0.001$
	14	28	17	7	13	10	21			
	15	17	14	9	11	15	34			

Table 6.1 Data question 1

In general, their views are fairly positive although there is some polarisation of view with a tendency to be very positive or very negative. As they become older, they appreciate that mathematics involves more hard work, is less easy and less easy to understand. These differences with age are quite marked.

While they see mathematics as very important, this does fall with age slightly. Interestingly, the extent of abstractness of mathematics is not seen as a major issue. Abstractness and difficulty are sometimes equated but abstractness of itself is perhaps not the problem. Only when abstractness generates working memory overload, difficulties will arise (Al-Enezi, 2008:44, 58).

(2) Think about yourself and mathematics.	Age	Responses						χ2	df	p
I feel I am coping well	*13*	54	14	9	6	5	13	21.0	10	$p < 0.05$
	14	45	18	9	6	4	14			
	15	32	24	8	7	8	19			
I wish to learn mathematics	*13*	67	10	7	2	5	10	53.5	8	$p < 0.001$
	14	52	10	13	8	4	9			
	15	32	24	11	7	6	17			
I am obtaining a lot of new skills	*13*	61	17	7	4	3	9	21.9	10	$p < 0.05$
	14	50	16	12	7	3	6			
	15	41	19	10	6	7	13			
I am getting better at mathematics	*13*	67	15	9	1	1	6	25.8	8	$p < 0.01$
	14	52	13	12	6	2	8			
	15	44	23	8	6	4	11			
It is definitely "my" subject	*13*	35	15	7	6	5	29	31.0	10	$p < 0.001$
	14	25	14	13	9	9	25			
	15	14	15	11	10	8	40			
I find mathematics interesting	*13*	46	15	10	9	9	12	27.1	8	$p < 0.001$
	14	40	18	15	7	6	11			
	15	21	20	12	10	11	23			

Table 6.2 Data question 2

This question explores how they see themselves in relation to their studies in mathematics. In general, their views are fairly positive although there are some polarisations of view with a tendency to hold highly positive or highly negative views. As they become older, their views toward mathematics become more negative. This is most marked in their responses to 'I wish to learn mathematics' and seeing mathematics as 'definitely my subject'. This is a matter of concern in that it suggests that pupils are feeling driven away from mathematics as they become older.

(3) Here are ways to describe mathematicians	Age	Responses						χ2	df	p
Hardworking	*13*	57	14	6	2	3	17	7.7	10	n.s.
	14	56	15	11	3	4	11			
	15	55	16	6	4	5	13			
Practical people	*13*	61	12	4	3	4	13	7.5	10	n.s.
	14	55	14	7	2	8	11			
	15	54	16	7	3	5	12			
Good fun	*13*	53	21	5	4	3	14	4.5	8	n.s.
	14	53	15	11	4	4	12			
	15	45	18	10	7	3	16			
Useful	*13*	78	10	3	2	2	5	21.9	8	$p < 0.01$
	14	74	8	7	4	1	4			
	15	58	17	9	5	3	7			
Well paid	*13*	54	17	11	3	2	7	14.1	10	n.s.
	14	46	22	15	3	1	5			
	15	38	23	16	7	2	8			
Popular	*13*	48	15	12	4	2	15	7.4	8	n.s.
	14	43	14	13	8	6	11			
	15	40	20	13	6	6	14			
High status	*13*	50	12	8	5	6	15	13.7	10	n.s.
	14	48	16	11	8	5	8			
	15	42	21	12	7	5	10			

Table 6.3 Data question 3

Although asked about mathematicians, the answers to this question may largely reflect their view of their mathematics teachers in that they may have few other mathematicians. In general, their views tend to be positive while polarisations are evident in all cases. There are almost no differences in their view as they become older but there is a slight fall in their view of mathematicians as useful. If this is a picture of how they see their mathematics teachers, then it does suggest that, for most pupils, their teachers are not the source of any rejection of mathematics which seems to grow with age (as suggested by question 2).

In his study of attitudes relating to education from age 12 to 20 in Libya, Alhmali (2007) found very marked polarisation of views in many areas related to mathematics while such polarisation was rarely evident in other subject areas. He deduced, in simple terms, that learners either 'liked' or 'hated' mathematics. It is a matter of concern that a sizeable minority hold such negative views in this subject area, mathematics holding a powerful position in the overall curriculum. There is a need to look at these students and seek to find out what are the key factors which have generated such strong perceptions.

In this question, pupils were asked to select the *three* reasons which they felt were most important for them. The percentage choosing each reasons for each year is shown. The chi-square is calculated by relating the frequencies across age groups for those selecting or not selecting each reason.

(4) Reasons to study mathematics	Age	%	$\chi 2$	df	p
Teach me to think clearly	*13*	53	10.5	2	$p < 0.01$
	14	51			
	15	39			
Can be applied in life	*13*	45	0.8	2	n.s.
	14	45			
	15	49			
Can solve problems in the world	*13*	29	6.2	2	$p < 0.05$
	14	37			
	15	27			
It is a useful way of thinking	*13*	49	1.9	2	n.s.
	14	42			
	15	44			
Leads to many jobs	*13*	38	0.1	2	n.s.
	14	38			
	15	39			
It is important for many other subject	*13*	37	4.3	2	n.s.
	14	33			
	15	28			
It is very logical	*13*	18	6.8	2	$p < 0.05$
	14	27			
	15	28			
It is fun	*13*	37	15.8	2	$p < 0.001$
	14	40			
	15	24			

Table 6.4 Data question 4

In general, the majority of students see the reason to study mathematics is to teach them to think clearly but there is a slight fall of this perception as they become older. Of course, there is little evidence that mathematics does, in fact, help learners to think clearly. Perhaps, mathematics does give opportunities to use this ability.

A much larger fall is observed in their view that mathematics is fun and their view that mathematics can solve world problems rises and then falls, perhaps reflecting specific syllabus topics. On the other hand, there is increase in their views that mathematics is very logical. Overall, views are widely scattered and no reason stands out clearly. The three reasons with the highest overall number of responses are: 'thinking clearly', 'applied to life', useful way of thinking'. It is possible that the lack of clarity of reasons for studying mathematics is a problem or, perhaps, the variety reflects that mathematics serves many purposes. This needs further exploration.

(5) Show your view		Age	SA	A	N	D	SD	χ2	df	p
a	I look forward to mathematics classes each week	*13*	29	25	28	10	10	27.1	8	p < 0.001
		14	20	31	30	9	10			
		15	11	23	36	14	16			
b	Geometry is the worst bit of mathematics	*13*	12	10	18	25	34	10.5	8	n.s.
		14	13	12	25	23	27			
		15	14	17	19	23	25			
c	I cannot solve equations easily.	*13*	18	17	21	26	13	8.9	8	n.s.
		14	15	27	20	21	17			
		15	21	22	21	19	17			
d	The mathematics textbook is boring.	*13*	15	10	23	19	29	26.2	8	p < 0.001
		14	13	13	22	23	31			
		15	25	20	18	20	17			
e	Mathematics is used in our daily life.	*13*	39	24	14	11	7	7.9	8	n.s.
		14	39	25	19	7	10			
		15	32	24	20	11	11			
f	I cannot see why I have to study mathematics	*13*	17	13	20	17	29	8.1	8	n.s.
		14	18	15	22	18	26			
		15	20	19	24	17	19			
g	I find mathematics ideas very interesting	*13*	39	21	17	8	10	40.9	8	p < 0.001
		14	37	23	18	8	13			
		15	17	22	23	21	17			
h	There are too many ideas to hold in my mind at once in mathematics	*13*	37	27	14	9	10	12.6	8	n.s.
		14	36	25	20	9	9			
		15	30	36	15	13	5			
i	My mathematics teacher is very important to enable me to understand	*13*	50	18	13	7	9	7.1	8	n.s.
		14	56	24	9	4	9			
		15	58	23	7	7	7			

Table 6.5 Data question 5

As they become older their interest in mathematics lessons decreases (although this might also be true for other subjects). The oldest groups are much more critical of textbooks and they also say that they find ideas in mathematics much less interesting.

The sad observation is the general decline in positive attitudes with age.

(6) Would you like to study more mathematics next year? Give reason?					
	No	**%**		**Yes**	**%**
1	Boring, not exciting	19	***1***	I love it, best subject, exciting	13
2	Difficult, complex, not understood easily	17	***2***	Easy	2
3	Time allocation enough	9	***3***	Time allocation not enough	0.5
4	Not important for me	3	***4***	Useful for other work and subjects	13
5	Teacher problem!!	1	***5***	Teacher successes	1
6	I cannot hold a lot of information at one time	4	***6***	It develops my brain and thinking	11
7	Other	2	*7*	Other	2

Table 6.6 Data question 6

Categories were created on the basis of the pupil answers. These are shown in table 6.6. It is clear that the 'love-hate' view of mathematics is an important factor. Those who want more mathematics in the following year see its value for careers as well as considering that it helps their thinking. Perhaps, mathematics allows those who think logically to show their skills. The perceived difficulty is a large factor in repelling learners. It is interesting that the teacher is not seen as an important factor in wanting or not wanting more mathematics.

(7) Different pupils prefer different things.	Age	Responses						χ2	df	p
Algebra …… Geometry	*13*	22	6	6	5	6	46	9.8	10	n.s.
	14	13	6	9	7	7	45			
	15	21	7	7	6	11	41			
Solving equations …… Solving geometry problems	*13*	42	9	9	7	6	19	13.2	10	n.s.
	14	35	13	12	9	5	16			
	15	36	15	7	6	7	24			
Drawing geometry shapes …… Doing arithmetic	*13*	41	8	6	4	3	31	6.2	8	n.s.
	14	35	5	5	8	7	28			
	15	39	10	6	6	8	26			
Mathematics …… Social Studies	*13*	46	5	3	10	5	24	33.9	10	$p < 0.001$
	14	33	8	8	5	8	27			
	15	25	7	7	5	9	42			
Science …… Mathematics	*13*	43	8	7	6	3	27	10.1	10	n.s.
	14	44	5	4	7	5	22			
	15	42	11	6	5	8	21			
Arithmetic …… Algebra	*13*	54	9	7	4	3	16	14.8	10	n.s.
	14	45	11	13	2	5	11			
	15	46	13	9	7	4	13			
Mathematics …… Arabic	*13*	38	4	7	5	6	35	16.9	10	n.s.
	14	26	5	6	6	7	37			
	15	21	6	5	6	10	46			

Table 6.7 Data question 7

As might be expected, there are very considerable polarisations in all cases: their views of various subjects and topics within mathematics are held strongly. Looking at comparisons of activities and topics within mathematics, the picture is somewhat confusing but does not change with age. Compared to other subject areas, mathematics loses ground to social subjects with age (and it seems also to be the same for Arabic although not significant) but, interestingly, does not lose ground to the sciences. This might reflect a general and similar antipathy towards both mathematics and the sciences.

Pupils could tick as many options as they wished.

(8) What do you enjoy a lot in your mathematics lessons	Age	%	χ2	df	p
Solving everyday problems	*13*	26	5.2	2	n.s.
	14	27			
	15	19			
Solving different exercise	*13*	47	3.7	2	n.s.
	14	56			
	15	49			
Drawing geometry shapes	*13*	43	0.4	2	n.s.
	14	41			
	15	44			
Measuring angles	*13*	38	1.6	2	n.s.
	14	41			
	15	35			
Counting numbers	*13*	42	1.4	2	n.s.
	14	46			
	15	41			
Getting right answers	*13*	50	6.7	2	$p < 0.05$
	14	61			
	15	51			
Listening to teacher explanation	*13*	46	6.4	2	$p < 0.05$
	14	57			
	15	48			
Doing homework	*13*	44	8.3	2	$p < 0.05$
	14	51			
	15	38			
Doing multiplication exercise	*13*	47	1.2	2	n.s.
	14	49			
	15	44			
Approximating numbers	*13*	26	4.9	2	n.s.
	14	31			
	15	22			

Table 6.8 Data question 8

In general, the table shows few differences with age although the age 13 group seem to be slightly different in three areas: getting right answers, listen to the explanation for the teacher, doing homework all rate more highly in terms of enjoyment. While the last of these is puzzling (why should pupils enjoy homework?), the differences may simply reflect different syllabus emphases. In many cases, the middle year group (age 14) seems different (higher or lower) than the other two.

Thinking of reasons for going to university, pupils could select as many as they wished.

(9) Reasons for going to university	Age	%	χ2	df	p
I get a subsidy	*13*	33	3.3	2	n.s.
	14	35			
	15	27			
I shall get an interesting job in the future	*13*	65	3.0	2	n.s.
	14	69			
	15	72			
It is normal thing to do after finishing school	*13*	27	1.2	2	n.s.
	14	32			
	15	28			
I am good at the school level	*13*	37	6.0	2	$p < 0.05$
	14	44			
	15	33			
My parents want me to go	*13*	39	0.7	2	n.s.
	14	40			
	15	36			
All my friends will probably go	*13*	33	7.8	2	$p < 0.05$
	14	35			
	15	24			
I like new challenges	*13*	46	0.9	2	n.s.
	14	50			
	15	49			

Table 6.9 Data question 9

There are few differences with age but, in two areas, the age 14 group tend to be slightly higher: being good at school and all my friends will go. Two reasons stand out as the most important: ‘interesting job’ and ‘new challenges’. This reveals a fairly utilitarian – but realistic – view: qualifications can open career opportunities. In many cases, the middle year group (age 14) seems different (higher or lower) than the other two.

Question 9 – last part

In looking at their choices of broad areas for study at university, the responses were divided into four broad groups. The percentages opting for each area are shown in table 6.10. The year groups are similar and are shown together.

Broad Subject Areas Chosen	%
Mathematics	6
Physical Sciences	26
Biomedical Sciences	39
Arts	29

Table 6.10 Data question 9 (the last part)

The table shows that biomedical sciences were the most popular option. This may because it offers many jobs opportunities whereas mathematics received the lowest percentage. However, pupils in the stage are young and their answers could be unrealistic. However, 6% choosing mathematics is quite encouraging given that this is one subject area.

	Age 13	***Age 14***	***Age 15***	$\chi 2$	***df***	***p***
10) *Mathematics is ….*						
Most interesting	21	14	8	15.1	2	< 0.001
Most important	27	16	10	21.9	2	< 0.001
Most enjoyable	16	15	6	14.6	2	< 0.001
Most boring	12	10	22	13.5	2	< 0.001
Mostly suitable for girls	6	5	2	*With low percentages, chi-square is not calculated.*		
Mostly suitable for boys	6	9	5			
Useless for girls	8	8	8			
Useless for boys	6	6	3			

Table 6.11 Data question 10

With age, mathematics becomes less interesting, less important, less enjoyable and more boring. However, mathematics is not seen as having a strong gender bias.

(11) The most interesting activities in secondary school	**Age**	**%**	**χ2**	**df**	**p**
Playing in a school sport team	*13*	48	4.5	2	n.s.
	14	58			
	15	54			
Doing mathematics exercise	*13*	30	16.0	2	p < 0.001
	14	30			
	15	16			
Painting pictures	*13*	40	13.7	2	p < 0.01
	14	42			
	15	27			
Learning English	*13*	55	3.6	2	n.s.
	14	46			
	15	48			
Cooking	*13*	26	3.9	2	n.s.
	14	34			
	15	27			
Reading stories	*13*	41	1.8	2	n.s.
	14	47			
	15	42			

Table 6.12 Data question 11

There are few differences with age but the age 15 group, perhaps understandably, are much less enthusiastic about ‘doing a mathematics exercise’. However, they are also less enthusiastic about painting pictures.

Pupils were invited to tick two boxes.

(12) which of these careers do you think that you would have got it after finishing study.	Age	%	χ2	df	p
An artist	13	25	9.2	2	$p < 0.01$
	14	27			
	15	16			
A businessman/woman	13	15	5.4	2	n.s.
	14	20			
	15	23			
A nurse	13	20	3.0	2	n.s.
	14	21			
	15	15			
A football player	13	25	2.2	2	n.s.
	14	22			
	15	19			
A mathematics teacher	13	16	2.4	2	n.s
	14	15			
	15	11			
A doctor	13	38	0.3	2	n.s.
	14	36			
	15	36			
An aircraft pilot	13	14	0.5	2	n.s.
	14	16			
	15	15			
A lawyer	13	7	4.1	2	n.s.
	14	8			
	15	4			
An engineer	13	11	0.2	2	n.s.
	14	11			
	15	12			
A housewife	13	14	1.7	2	n.s.
	14	19			
	15	18			

Table 6.13 Data question 12

There are more or less no changes with age, suggesting that general career directions have not moved much with age. This may simply reflect that they are all too young to have moved to the complex stage where decisions have to be made and their views now are simply aspirations, some of which may be somewhat unrealistic.

As might be expected, choices are quite scattered. The patterns of responses are, at times a little unexpected. For example, it is not obvious why so many are interested in becoming an artist, and aspirations to become footballers are totally unrealistic. On the other hand, the difficulties in becoming lawyers or engineers are reflected in low uptakes – very realistic. The high proportion for doctors, despite the demands of this career, perhaps reflects something of the glamour of this career. In this general pattern, the proportions aspiring to be mathematics teachers are remarkably high.

Pupils were invited to tick as many boxes as they saw applying to themselves.

(13) I become interested in mathematics thanks to …	Age	%	χ2	df	p
Television	*13*	16	5.7	2	n.s.
	14	22			
	15	14			
My teacher	*13*	58	4.2	2	n.s.
	14	63			
	15	53			
Exhibition, demonstration, festivals	*13*	14	0.8	2	n.s.
	14	12			
	15	11			
Other	*13*	11	2.8	2	n.s.
	14	16			
	15	13			
Mathematics lessons	*13*	40	55.6	2	$p < 0.001$
	14	43			
	15	35			
My friends	*13*	26	3.0	2	n.s.
	14	34			
	15	29			
My parents	*13*	50	2.4	2	n.s.
	14	45			
	15	43			

Table 6.14 Data question 13

In general, there are few differences with age but the influence of mathematics lessons does seem to vary, perhaps reflecting the specific recently completed topics. Of greatest importance is the very high numbers selecting their teacher (averaging at 58 %(. The mathematics lessons are also rated highly as a powerful influence. This is consistent with the findings of Skryabina in relation to physics in Scotland (Reid and Skryabina, 2002). However, the data in table 6.11 also reveals the powerful influence of parents (not seen in the Skryabina study). This probably simply reflects Saudi social structures.

6.3 Gender Comparisons

The responses for boys and girls are now compared. The data are presented as percentages for clarity but all statistical calculation are based on frequencies. Again, the positive statement is shown on the left for clarity. Color coding is used to highlight the comparisons which are significant. Many of the gender differences may arise simply because boys and girls are educated totally separately.

(1) Think about mathematics	Age	Responses						χ2	df	p
Does involve hard work	*g*	24	20	8	6	19	22	36.8	5	p < 0.001
	b	34	6	11	10	12	26			
Important	*g*	66	17	4	3	3	8	7.8	5	n.s.
	b	65	12	8	3	3	8			
Leads to many jobs	*g*	40	24	10	7	9	10	14.3	4	p < 0.01
	b	47	11	12	7	4	13			
Is easily understood	*g*	36	19	5	6	13	19	29.7	5	p < 0.001
	b	29	11	9	10	7	30			
Is abstract/is concrete	*g*	20	9	9	7	13	36	21.6	5	p < 0.001
	b	27	7	10	13	7	23			
Easy	*g*	29	23	5	8	14	21	34.3	5	p < 0.001
	b	29	11	11	11	5	28			

Table 6.15 Data question 1

In most questions, the boys and girls do not hold identical views. Compared to the girls, boys tend to less polarised in terms of hard work and easiness, understand less well, see mathematics as more abstract, but see the place of mathematics for jobs more clearly.

(2) Think about yourself and mathematics.	Age	Responses						χ2	df	p
I feel I am coping well	*g*	43	25	7	4	7	13	25.5	5	p < 0.001
	b	44	11	11	8	4	18			
I wish to learn mathematics	*g*	50	17	11	3	6	13	7.0	4	n.s.
	b	49	12	10	10	4	11			
I am obtaining a lot of new skills	*g*	49	22	8	5	6	9	12.2	5	p < 0.05
	b	51	12	11	7	3	10			
I am getting better at mathematics	*g*	56	23	6	3	4	6	34.8	5	p < 0.001
	b	52	10	13	7	1	11			
It is definitely "my" subject	*g*	27	18	10	8	8	31	7.8	5	n.s.
	b	21	11	11	10	7	33			
I find mathematics interesting	*g*	35	20	13	6	9	15	6.1	5	n.s.
	b	36	16	11	11	7	16			

Table 6.16 Data question 2

In most questions, the boys and girls do not hold identical views, with boys tending to be less positive in coping well with mathematics and getting better at mathematics and obtaining new skills. With pupils taught separately, the girls appear to hold more positive views.

(3) Here are ways to describe mathematicians	Age	Responses						χ2	df	p
Hardworking	*g*	58	17	5	2	6	13	9.0	4	n.s.
	b	54	12	11	5	3	15			
Practical people	*g*	59	18	5	2	6	9	15.2	5	p < 0.01
	b	56	10	8	4	6	15			
Good fun	*g*	51	22	8	3	4	14	9.2	4	n.s.
	b	51	13	11	8	2	15			
Useful	*g*	66	12	7	4	2	5	1.0	5	n.s.
	b	55	9	5	3	2	5			
Well paid	*g*	50	28	10	2	1	3	68.5	3	p < 0.001
	b	29	8	15	6	2	8			
Popular	*g*	46	21	13	5	6	9	21.5	5	p < 0.001
	b	44	11	14	8	4	19			
High status	*g*	49	20	9	5	7	9	16.9	5	p < 0.01
	b	47	13	13	10	4	14			

Table 6.17 Data question 3

In most questions, the boys and girls tend to hold positive views regarding mathematicians. However, it has to be recognised that this might simply reflect their views of their mathematics teachers. Compared to the boys, the girls see mathematicians as more practical people, well paid, more popular and with a higher status. It is likely that this simply reflects their teachers.

(4) Reasons to study mathematics	Age	%	χ2	df	p
Teaches me to think clearly	*g*	52	4.1	1	p < 0.05
	b	44			
Can be applied in life	*g*	52	8.3	1	p < 0.01
	b	41			
Can solve problems in the world	*g*	32	0.0	1	n.s.
	b	31			
It is a useful way of thinking	*g*	47	1.2	1	n.s.
	b	43			
Leads to many jobs	*g*	38	0.1	1	n.s.
	b	39			
It is important for many other subjects	*g*	37	7.9	1	p < 0.01
	b	27			
It is very logical	*g*	26	0.7	1	n.s.
	b	23			
It is fun	*g*	38	6.0	1	p < 0.05
	b	29			

Table 6.18 Data question 4

Although views are similar, compared with boys, girls see mathematics as more applied in life, more important for other subjects, more fun and improve their thinking more. This is not easy to interpret but perhaps reflects different emphases in the gender separated schools in Saudi Arabia.

(5)	Show your view	Age	SA	A	N	D	SD	χ2	df	p
a	I look forward to mathematics classes each week	*g*	20	28	31	9	13	3.1	4	n.s.
		b	19	25	32	13	11			
b	Geometry is the worst bit of mathematics	*g*	13	12	19	26	30	3.5	4	n.s.
		b	13	14	23	20	27			
c	I cannot solve equations easily.	*g*	17	20	21	24	18	6.5	4	n.s.
		b	20	26	21	19	13			
d	The mathematics textbook is boring.	*g*	17	15	22	19	28	3.5	4	n.s.
		b	19	14	20	23	22			
e	Mathematics is used in our daily life.	*g*	37	26	19	8	10	2.3	4	n.s.
		b	38	23	16	11	9			
f	I cannot see why I have to study mathematics	*g*	18	14	23	19	25	2.0	4	n.s.
		b	19	17	21	16	23			
g	I find mathematics ideas very interesting	*g*	31	22	20	11	15	2.7	4	n.s
		b	31	22	19	14	11			
h	There are too many ideas to hold in my mind at once in mathematics	*g*	36	32	16	9	8	2.6	4	n.s
		b	33	26	18	11	7			
i	My mathematics teacher is very important to enable me to understand	*g*	58	23	10	4	7	8.2	4	n.s.
		b	51	20	9	8	10			

Table 6.19 Data question 5

In all questions, the boys and girls have similar views.

(7) Different pupils prefer different things.	Age	Responses						χ2	df	p
Algebra …… Geometry	*g*	18	8	8	6	11	41	14.3	5	p < 0.05
	b	19	5	6	7	4	48			
Solving equations …… Solving geometry problems	*g*	39	17	9	6	7	17	18.5	5	p < 0.01
	b	36	7	9	9	5	23			
Drawing geometry shapes …… Doing arithmetic	*g*	38	9	4	5	8	30	6.8	4	n.s.
	b	38	7	8	7	4	26			
Mathematics …… Social Studies	*g*	38	9	6	5	9	26	22.9	5	p < 0.001
	b	30	4	7	8	5	38			
Science …… Mathematics	*g*	48	9	3	4	6	23	14.0	5	p < 0.05
	b	38	6	8	8	5	23			
Arithmetic …… Algebra	*g*	49	14	11	3	4	11	13.0	5	p < 0.05
	b	48	7	8	6	4	15			
Mathematics …… Arabic	*g*	32	7	4	5	11	35	9.2	4	n.s.
	b	23	3	8	6	4	45			

Table 6.20 Data question 7

The most interesting feature is that boys are more interested in social subjects compared to mathematics than are the girls. Geometry is also held in higher regard by the boys reflecting the known gender difference. Hanna (1989) compared between boys and girls achievement in five parts of mathematics in 20 countries. In looking at the geometry part, it was found that boys tended to outperform the girls markedly. Rather surprisingly, girls were found to perform better at arithmetic compared to algebra.

(8) What do you enjoy a lot in your mathematics lessons	Age	%	χ2	df	P
Solving everyday problems	*g*	21	4.2	1	$p < 0.05$
	b	27			
Solving different exercise	*g*	59	20.1	1	$p < 0.001$
	b	42			
Drawing geometry shapes	*g*	47	5.7	1	$p < 0.05$
	b	38			
Measuring angles	*g*	40	1.6	1	n.s.
	b	36			
Counting numbers	*g*	48	5.7	1	$p < 0.05$
	b	38			
Getting right answers	*g*	57	2.1	1	n.s.
	b	52			
Listening to teacher explanation	*g*	58	16.2	1	$p < 0.001$
	b	43			
Doing homework	*g*	40	4.3	1	$p < 0.05$
	b	48			
Doing multiplication exercises	*g*	55	16.4	1	$p < 0.001$
	b	39			
Approximating numbers	*g*	25	0.6	1	n.s.
	b	28			

Table 6.21 Data question 8

In most questions, boys and girls do not have identical views. In mathematics lessons, girls enjoy more in solving exercise, drawing geometry shapes, counting numbers and listening to teacher's explanation. On the other hand, boys enjoy solving everyday problems and doing home work.

(9) Reasons for going to university	Age	%	χ2	df	P
I get a subsidy	*g*	30	0.5	1	n.s.
	b	33			
I shall get an interesting job in the future	*g*	79	34.1	1	$p < 0.001$
	b	58			
It is the normal thing to do after finishing school	*g*	35	11.8	1	$p < 0.001$
	b	23			
I am good at the school level	*g*	40	1.8	1	n.s.
	b	35			
My parents want me to go	*g*	35	3.4	1	n.s.
	b	42			
All my friend will probably go	*g*	33	1.6	1	n.s.
	b	28			
I like new challenges	*g*	54	9.2	1	$p < 0.01$
	b	43			

Table 6.22 Data question 9

In most questions, girls and boys hold slightly similar views for going to the university. However, compared to the boys, girls tend to like challenges, looking for future jobs and they consider going to the university as a normal thing after finishing school.

(11) The most interesting activities in secondary school	Age	%	χ2	df	p
Playing in a school sport team	*g*	49	4.8	1	$p < 0.05$
	b	58			
Doing mathematics exercise	*g*	23	1.7	1	n.s.
	b	28			
Painting pictures	*g*	42	8.8	1	$p < 0.01$
	b	31			
Learning English	*g*	56	11.6	1	$p < 0.001$
	b	43			
Cooking	*g*	49	127.1	1	$p < 0.001$
	b	9			
Reading stories	*g*	55	38.4	1	$p < 0.001$
	b	31			

Table 6.23 Data question 11

In general, boys and girls like different activities and this is to be expected. Girls tend to do a lot of activities, for instance, painting pictures, learning English, cooking and reading stories. However, as might be expected, boys are more interested playing in a school sport team. Looking at the responses overall, it is clear that the girls responded much more frequently: 1.37:1.

(12) Which of this do you think is going to be after you leave school	Age	%	χ2	df	P
An artist	*g*	24	0.4	1	n.s
	b	22			
A businessman/woman	*g*	23	4.1	1	$p < 0.05$
	b	17			
A nurse	*g*	23	7.6	1	$p < 0.01$
	b	15			
A football player	*g*	1	Calculation invalid but responses very different*		
	b	43			
A mathematics teacher	*g*	16	1.5	1	n.s.
	b	12			
A doctor	*g*	48	38.2	1	$p < 0.001$
	b	25			
An aircraft pilot	*g*	1	Calculation invalid but responses very different*		
	b	30			
A lawyer	*g*	1	Calculation invalid but responses very different*		
	b	12			
An engineer	*g*	1	Calculation invalid but responses very different*		
	b	22			
A housewife	*g*	33	Calculation invalid but responses very different*		
	b	1			

Table 6.24 Data question 12

In general, boys and girls have different views for their future career. Compared to boys, girls would like to be doctors, housewives, nurses and businesswomen. However, boys prefer to be football players, pilots, lawyers and engineers. This is much as to be expected.

* The chi-square values obtained when the frequency in any category falls too low can often tend to be highly inflated and lead to misleading conclusions. It is accepted here that a minimum of 10 or 5% (whichever is more critical) is required to generate a valid chi square value.

(13) I become interested in mathematics thanks to…	Age	%	χ2	df	p
Television	*g*	15	4.6	1	$p < 0.05$
	b	21			
My teacher	*g*	69	30.6	1	$p < 0.001$
	b	47			
Exhibition, demonstration, festivals	*g*	12	0.0	1	n.s.
	b	12			
Others	*g*	19	15.9	1	$p < 0.001$
	b	8			
Mathematics lessons	*g*	43	3.2	1	n.s.
	b	36			
My friends	*g*	39	24.2	1	$p< 0.001$
	b	21			
My parents	*g*	51	7.9	1	$p < 0.01$
	b	40			

Table 6.25 Data question 13

In general, girls perceive that their friends and parents have a greater effect in their interests in mathematics. This reflects the more social nature of girls at this age. The most important difference lies in the effect of the teacher. While teachers show the strongest effect of all for the boys, the impact of the teacher is even more marked for girls. With single gender schools, the role model of their mathematics teachers is extremely powerful. The greater impact of teachers in attracting students towards physics was also shown for girls in the work of Skryabina (Reid and Skryabina, 2002).

6.4 Conclusion

The comparison between three years groups shows in general that younger pupils tend to have more positive view toward mathematics, the mathematics curriculum and lessons and these favourable views decrease as they become older. However, there are no big differences in their attitudes towards mathematicians as they grow but there is a small fall in their view of the usefulness of mathematics teachers.

Although it appears that the tendency is for all to prefer science more than mathematics, there are no major differences as they became older in their preference either for some topics of mathematics or any other subject. However, as they grow they tend to prefer social subjects and Arabic more than mathematics. Furthermore, no major changes with age were found in the reasons for going to university, in the choice of career, the enjoyable activities in mathematics class. However, 15 years old pupils are less interested in doing mathematics exercise.

Despite being educated separately, in many questions boys and girls hold similar views. However, girls tend to be more polarised in their view about the easiness and the hard working, understanding and the abstractness of mathematics whereas boys believe that mathematics leads to many job although both groups consider mathematics as important.

Furthermore, boys and girls prefer different topics. While boys are more interested in social subjects and geometry, girls prefer arithmetic. In addition, girls and boys prefer different activities in mathematics lessons. While girls enjoy exercises, drawing geometry shapes, counting numbers and listening to teachers' explanation, boys are more interested in doing homework and solving daily problems. Girls and boys also like different general activities and they are choosing different careers. Girls more than boys are affected by their friends, parents and teachers views. These are to be expected reflecting natural gender differences. In addition the Saudi systems and role of the segregation between boys and girls may also play a role in these different views.

By contrast, boys and girls hold similar views on some points, including the reasons for going to university, reasons to study mathematics and their description of mathematicians. However girls' views tend to be more positive than boys in some cases.

It is clear that attitudes are changing with age over the three years studied. It is not certain if this reflects a continual attitude change over a wider age range or whether it is possible that many of the pupil attitudes towards mathematics are well formed before they reach intermediate schools in Saudi Arabia and then change during these critical years. It is highly likely that their attitudes in relation to mathematics will reflect the very conformist nature of Saudi society.

Chapter 7

Correlations between Measurements

7.1 Introduction

Correlation is important in exploring any relationships between variables or measurements. There are three common methods used to calculate correlation coefficient:

- Pearson method: when the data that got from measurements are integer and expected to demonstrate approximation to normality.
- Spearman method: handles most kinds of data where normality cannot be guaranteed.
- Kendall's tau-b method: when data are ordinal and does not assume the normality, especially when there are limited numbers of categories.

This chapter discusses two issues. First of all, all correlations relating convergency test scores, divergency test scores and standardized mathematics marks for each year group are considered. Pearson correlation is used as the data are integer in nature. Secondly, Kendall's tau-b correlation explores the relationship between pupil's perceptions related to mathematics questionnaire and standardised marks.

Although the overall sample is 669, some of pupils were not available to complete the convergent or divergent tests. Therefore the actual sample is 632.

Because Pearson correlation assumes that the distributions of variables are approximately normal, the distribution of the scores for each year group are now shown in Figure 7.1, 7.2, 7.3, illustrating the approximate normality of the data from both the convergent and divergent tests.

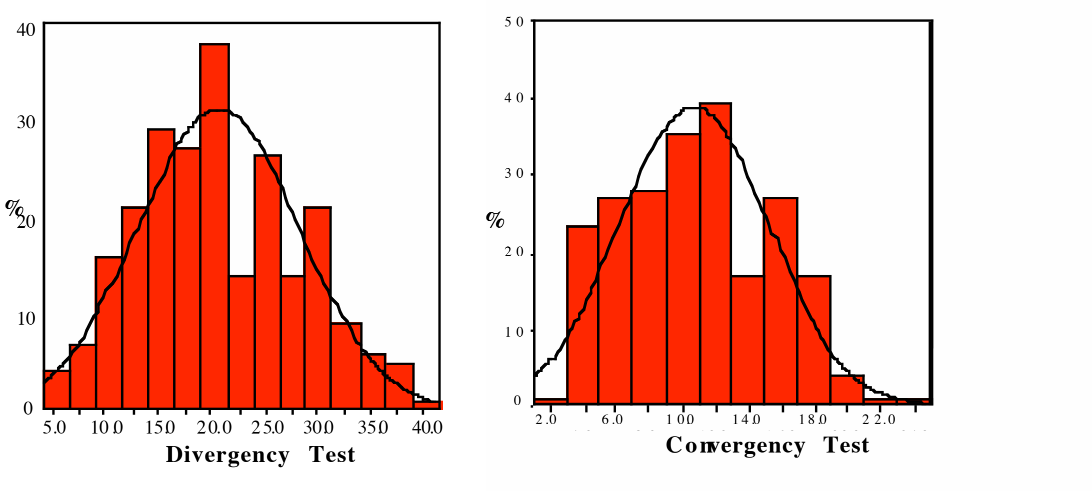


Figure 7.1 The distribution of divergency and convergency test for years 13

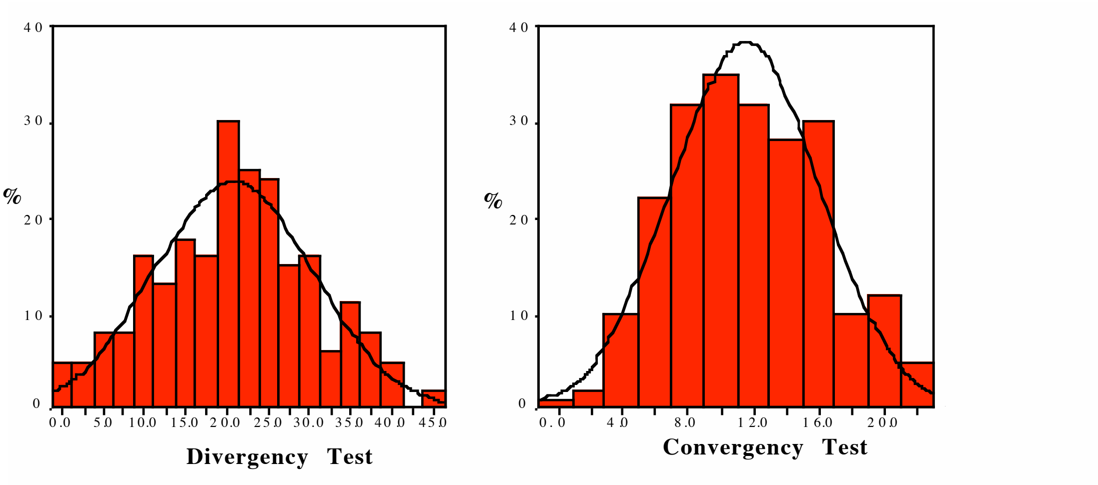


Figure 7.2 The distribution of divergency and convergency tests for years 14

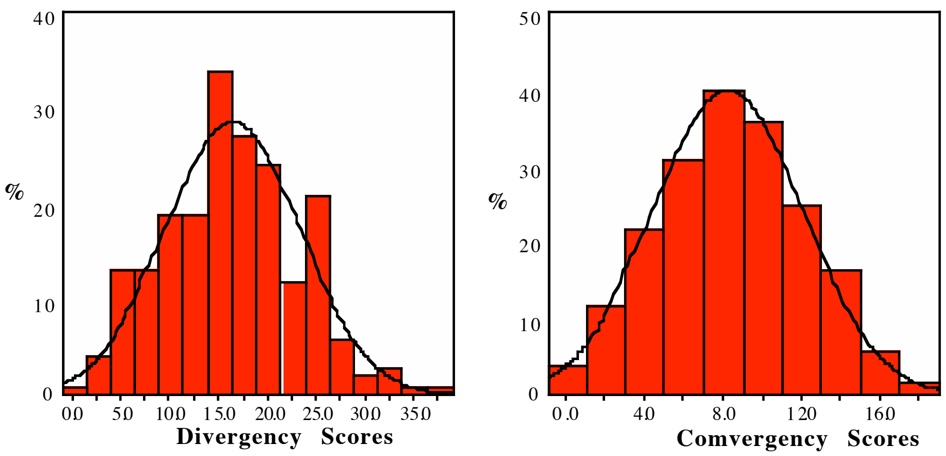


Figure 7.3 The distribution of divergency and convergency tests for years 15

7.2 Correlation Data for Tests

Table 7.1 shows high correlations between divergent test scores, convergent test scores and standardised examination marks, for all three year groups.

		Pearson Correlation Values	
N= 632	***Level***	***Standardised Mathematics Score***	***Divergent Test Score***
Divergent test scores	13	0.49	Correlations all significant at $p < 0.001$
	14	0.58	
	15	0.55	
Convergent test scores	13	0.45	0.45
	14	0.49	0.60
	15	0.57	0.65

Table 7.1 Correlation between divergency, convergency and performance

The outcomes shown in table 7.1 mean that being *both* divergent and convergent is an advantage in the mathematics examination. This is totally consistent with the findings of Hindal (2007) in relation to many subjects, included mathematics. It might be expected that being convergent is an advantage in that mathematics examination questions are seeking for one right answer: analysis, reasoning, thinking and deduction are all important processes. Convergency means bring ideas together (from different sources; much may be stored in long term memory) to the working memory space where we do our thinking and concentrating on problem to find a conclusion or solution.

Hudson (1966) tended to conceptualise divergency as an ‘opposite’ characteristic to convergency although he did admit that a person might operate in different ways in different contexts. Perhaps, the unexpected result is that those who are more divergent also tend to do better in mathematics. Hudson (1966) found about 40% of his sample were what he called ‘all-rounders’.

Al- Qasmi (2006) measured extent of divergency and found that, in the context of biology problem solving, those who were divergent also tended to perform better in such problems. She interpreted this relationship by suggesting that the divergent have an advantage of having many “pathways” that link between knowledge and ideas stored in long term memory, these pathways helping in finding answers and recalling information. Divergent pupils may be able to link between previous mathematical ideas, procedures and methods that store in the long term memory therefore they have an advantage in mathematics examinations in recalling the ideas from their long term memory easily.

However, the most interesting finding that both divergent and convergent tests correlated highly and significantly with each other. Again, this is exactly similar to the finding of Hindal (2007) who obtained a Pearson correlation of 0.52.

This supports the idea that divergent tend to be convergent in the same time (assuming the validity of the test). Although Hindal has explored the test validity, it was possible to explore this further by running the test, in its English form, with several groups (N = 53) of 13 year students in Scotland. After completing the test, there was a considerable period of discussion when pupils, mainly in groups, were asked to explain how they obtained their answers. It was very clear, from these discussions, that in the first four questions, the pupils were responding in line with the original intentions of Hindal (2008). However, there was inadequate evidence relating to the final question. Nonetheless, overall, validity was strongly supported.

It is normally *assumed* that convergency and divergency are opposite characteristics: people tend to be either one or the other. This can be illustrated:

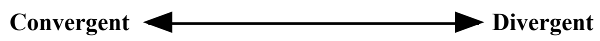


Figure 7.4 The traditional view of convergency-divergency

However, the overall correlation coefficient (for all three year groups together) between divergency test scores and convergency test scores was found to be 0.61 and it can be illustrated as a geometrical model (figure 7.5). The correlation can be found mathematically as the cosine of the angle between two lines (Reid, 2006). This illustrates the fact that, although the correlation is high, the divergent test and the convergent test are making measurements in directions which are in quite different directions.

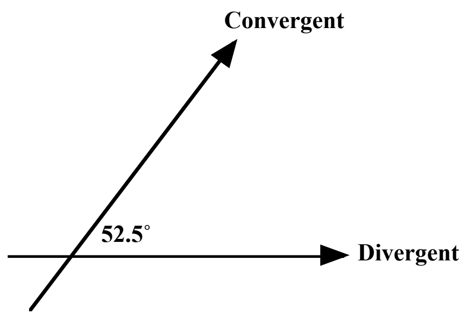


Figure 7.5 Geometry of correlation

7.3 Interpretation of the Data

It is useful to consider the nature of convergency and divergency by considering the information processing model developed by Johnstone (1997).

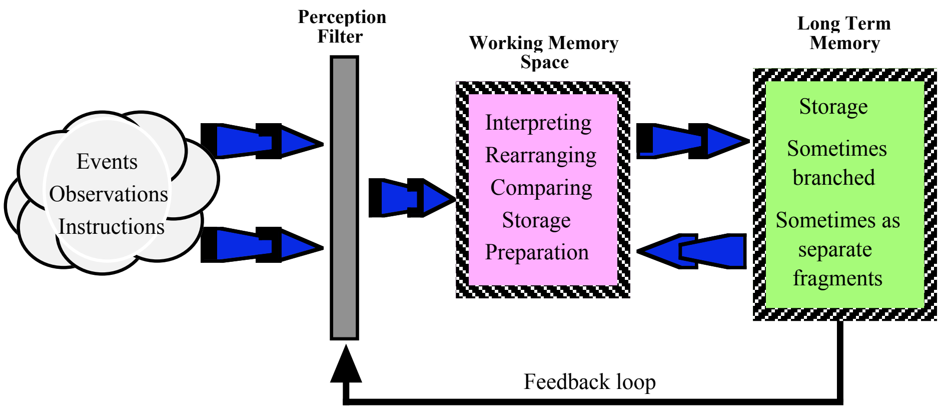


Figure 7.6 Information Processing (after Johnstone, 1997)

A divergent pupil is more able to link ideas and, indeed, to take one idea and move off in numerous directions. A convergent pupil is more able to bring ideas together to come to some kind of answer or conclusion. Described in this way, there is no reason why a pupil cannot be both divergent and convergent.

Ideas are stored in long term memory. The divergent person has stored ideas in such a way that there are more usable links. It is uncertain whether this happens because of the brain architecture in long term memory or because the working memory tends to control the storage in this way. If there are more links, then the chance of the working memory being able to find a pathway through long term memory to the appropriate answer or conclusion is increased. However, it is not clear why this should be so important in mathematics examinations in that gaining good marks tends to reflect abilities in applying learned procedures correctly.

If the convergent ability is a skill which enables the pupil to focus down on the key ideas in order to reach an answer, then the value of this in mathematics examinations is obvious. However, this focusing ability must be controlled by working memory in some way and it is not clear how and why working memory can operate in this way more effectively in some pupils than in others.

Of even greater significance, if both skills related to convergency and skills related to divergency are powerful correlates of success in mathematics examinations, is this cause and effect, and, if so, can the teacher control or change these abilities in the pupils in order to increase performance? Teachers may be able to do that in the early stages of school. Perhaps, the teacher can teach their pupils how to be creative and innovate many idea and link between them as well as they can also teach pupils the way of solving problem that involve bringing ideas from different sources in order to find the solution to the problem. Generally speaking, to increase the achievement, both thinking procedures (convergent, divergent) are important either in learning and assessment of mathematics in particular and for other subjects as well.

This whole area needs much more research. It could simply be that the correlation reflects no cause and effect relationship at all. Perhaps those who are good at mathematics examinations tend also to be more convergent and divergent. This is similar to the observation that those who are taller tend also to weigh more. It is even possible that the results reflect in part the possibility that those who are good at any kind of test are also good at other tests – some kind of generic test technique ability. This was explored by Al-Qasmi (2006) briefly and she concluded that only about 0.15 of any inter-test correlation could be attributed to this.

7.4 The correlation between questionnaire questions and performance

Questions Numbers	Description of question	Kendall's Tau-b
Q1A	Does involve hard work	0.12
Q1B	Important	0.11
Q1C	Leads to many jobs	0.04
Q1D	Is easily understood	0.11
Q1E	Is abstract/is concrete	0.14
Q1F	Easy	0.17
Q2A	I feel I am coping well	0.24
Q2B	I wish to learn mathematics	0.08
Q2D	I am getting better at mathematics	0.20
Q2E	It is definitely "my" subject	0.14
Q2F	I find mathematics interesting	0.11
Q3A	Hardworking	0.03
Q3B	Practical people	0.05
Q3C	boring	0.07
Q3F	Popular	0.01
Q3G	High status	0.08
Q5A	I do not look forward to mathematics classes each week	0.14
Q5C	I cannot solve equations easily.	0.11
Q5D	The mathematics textbook is boring.	0.07
Q5E	Mathematics is not used in our daily life.	0.08
Q5F	I cannot see why I have to study mathematics	0.11
Q5G	I find mathematics ideas not very interesting	0.10
Q5H	There are not too many ideas to hold in my mind at once in mathematics	0.08
Q5I	My mathematics teacher is not very important to enable me to understand	0.16
Q6	I do not like to study more mathematics next years	0.07
Q7A	Geometry …… Algebra	0.11
Q7B	Solving geometry problems …… Solving equations	0.16
Q7C	Drawing geometry shapes …… Doing arithmetic	0.12
Q7D	Mathematics …… social studies	0.16
Q7E	Science …… Mathematics	0.08
Q7F	Algebra …… Arithmetic	0.02
Q7G	Arabic …… Mathematics	0.08

Table 7.2 Correlation between questionnaire questions and performance

In order to find the relationship between responses to the questions in relation to attitude toward mathematics and the performance in mathematics examinations, the Kendall's tau-b correlation coefficients were calculated. This method is appropriate when data are ordinal, with a high level of 'ties', and the distribution is not normal.

The correlation between attitude toward mathematics and performance in mathematics is shown in table 7.2. The table shows that no high correlations are found between the questionnaire items that measure student attitude toward mathematics and standard marks of mathematics.

However, there are 6 out of 32 questions that correlate to mathematics marks with correlation $r \geq 0.15$ (marked in yellow colour in the table). These are now discussed. At this point, correlations are significant at $p < 0.001$. The reason for only considering values above 0.15 derives from the analysis of Al-Qasmi (2006) who suggested that correlations up to 0.156 were probably arising from generic tests skills.

As seen in table 7.2, pupils with high mathematics marks tend to see mathematics as being easy, they are coping well, getting better in mathematics and tend to prefer mathematics than social subjects and they perform better in solving equations rather than in geometry. These are expected and normal views that might be expected to relate to the higher mathematics performance. However, the correlation here is low. They also appreciate the importance of mathematics teachers in enable them to understand. This confirms that teachers play an important role in building pupil's success. G H Hardy said: "A mathematician, like a painter or poet, is a master of pattern. The mathematician's patterns, like the painter's and poet's must be beautiful…" (cited in Cross, 1990).

Chapter 8

Conclusions

8.1 Overview of project

Mathematics is considered an important and essential subject in the educational provision of most countries although some people do not enjoy their studies in mathematics and cannot see any usefulness in it. Mathematics is fundamental for many sciences such as engineering, physics, chemistry and biology and so on. Many problems in many areas of life can be solved using mathematical equations or simply by applying arithmetic. Nonetheless, some pupils complain of difficulties and find their studies unattractive. These difficulties can cause the pupils to be unsuccessful in examinations, often leading to rejection of the subject. Their attitudes towards mathematics and images of mathematics tend to be negative.

Attitudes are important in learning in that they often have strong relationships with achievement and performance and some evidence suggests that this relationship is reciprocal. In others words, a positive attitude can build towards students' success while success can encourage positive attitudes. Similarly, a negative attitude can lead to failure while failure can cause attitudes to become steadily more negative.

However, while attitudes affect and influence performance which in turn can influence attitudes, there are other learning characteristics which are related to performance. Working memory capacity is well know as a limiting factor in success in mathematics while field dependency, convergncy and divergency can relate to performance as well. Working memory capacities and field dependency have received many researchers' attention whereas convergency and divergency have received little attention in relation, specifically to mathematics.

This study has tried to fill the gap in research by exploring the development of attitudes relating to mathematics, considering in particular development with age (from age 13-16) and any gender differences. In addition the whole area of convergency and divergency has been considered to see how these characteristics relate to performance in mathematics.

The study was undertaken with intermediate schools (age 13-15) in Saudi Arabia (in Mecca). Because of the segregation system that Saudi Arabia followed, two boys and two girls' schools from different areas in Mecca participated in the project. From each school three classes (one class for each level) was randomly selected. The overall sample is 669 and it was chosen from typical population of Saudi Arabia.

Convergency and divergency tests were applied to pupils to measure their ways of thinking and a questionnaire was used to draw pictures of their attitudes towards mathematics. The final mathematics marks from the previous year were gathered so that their performance could be related to the extent of divergency and convergency. A well established test of divergency was used while a relatively new test of convergency was employed although careful checks did suggest considerable confidence in its validity.

The data was summarized using SPSS and correlations carried out involving the test data form the tests of convergency, divergency and the mathematics marks. To compare the responses to the attitude survey, chi-square as a contingency test was used.

8.2 Findings and implications

From pupils responses to questionnaire items, It was found in general that, in many questions, younger pupils (age 13) tend to have more positive views about mathematics than the older pupils. Thus, positive views decline with age. This reflects the idea that National Research Council (2001) suggested that pupils have positive attitude when they enter school and these views tend to change with time when they face any obstacles in mathematics learning. Nonetheless, some questions show that there are no significant differences with age: pupils view about mathematics, reason to study mathematics, preferred subjects, reason to go to university and the big influences in pupils being interested in mathematics.

When the pupils asked which activities that they are interested to do in the secondary school, doing mathematics exercises had the lowest percentage and age 15 appears to be less enthusiastic in it than age 13 and 14. This shows again that the older group have negative image of mathematics and tend to avoid it. In addition the pupils' responses reveal the influences of teachers, parents and mathematics lesson in making Saudi pupils interested in mathematics. Generally it was expected that teacher and their explanation method in classes has great effect into pupils feeling of the subject in any societies not only for Saudi pupils (the same result was found by Reid and Skryabina (2002) in relation to Scottish pupils in physics). However, Saudi parents also have a large effect on their children' interest in mathematics. This effect appears to fall slightly with age, and this perhaps reflect the Saudi strong social conformity while countries in the West tend to have a more individualistic culture. Some previous studies supported the influences of parents depend on the countries' culture. The result is consistent with that of Cao *et al*. (2006) who showed that the parents have great influences on attitudes of Chinese pupils toward mathematics and this was not seen with Australian pupils. In addition, the work of Reid and Skryabina (2002) in relation to physics in Scotland showed that parents do not have a big influence in their childrens' attitudes especially from aged 10 forward.

It might be expected that boys and girls would hold very different views relating to their studies in mathematics in that they are educated totally separately and there are very different career openings for boys and girls in Saudi Arabia. These differences are reflected in their responses in some areas. Despite this, in many areas they held quite similar views.

Interestingly, it appears that girls see that mathematics leads to many jobs and they see the importance for studying at university in their future job. Boys are less convinced and this is surprising given the male dominated nature of work in Saudi Arabia. Moreover, it was expected that boys should be more concerned about their future job because, in Saudi society, men have to take all responsibilities for proving for families and women are not obliged to work if they do not want.

Boys and girls have different views about mathematics, their mathematical aptitude, preferred activities either in secondary school in general and in mathematics lesson in particular, careers and favourite subjects However, girls tend to be more positive and polarized in their views. These differences in images are expected because both of them have special abilities and needs which suit their structures.

However, boys and girls are similar to some extent in their views about mathematicians though girls tend to be more positive. Both girls and boys agree that their teachers have a great effect in their interest in the mathematics whereas girls are also influenced by their friends and parents, reflecting the tendency of girls for greater social influence. However, no big differences in boys and girls views were found about reasons for going to university.

All of the findings above are describing the comparisons between year groups and gender comparisons of the responses to the questionnaire items. Perhaps the most interesting results were found from the calculating of correlation coefficients between convergency, divergency tests and examination marks.

Interestingly, the result of the convergency and divergency tests showed that those who are both convergent and divergent tend to do better in mathematics examinations. In others words, the person who is able to link between mathematical ideas and concepts and has ability to recall them in examinations and at the same time they are good at concentrating on any mathematics problems and bring ideas together in order to find the solution have an advantage in mathematics exams. This finding contradicts the previous thought that convergency is the opposite of divergency.

Surprisingly, the two tests are correlated highly with each other. This means that the pupils who do better in the convergent test also tend to achieve higher in the divergent test as well. The correlation outcomes are totally consistent with those obtained by Hindal *et al.* (2008). This suggests that the whole nature of convergency and divergency and the relationships between these two characteristics and examination performance needs much more study.

The questionnaire items were correlated with standardised marks to explore any relationships between them. Very few significant correlations were found and, indeed, all the correlations were very low. As might be expected, questions relating to the perceived easiness of mathematics, perceptions of coping well, getting better at mathematics and the importance of the teacher in understanding it, as well as preferences for mathematics rather than social subjects were all significant, although very low.

8.3 Strengths and weaknesses of work

While the reliability of the tests for convergency and divergency as well as the questionnaire are well assured with the very large samples and the conditions of use, it is less certain that the validity is good. Much work on reliability only offers evidence of internal consistency and, as all the tests and questionnaires used tested numerous aspects, such internal reliability is unhelpful. The validity of the questionnaire depended heavily on the opinions of experienced teachers. However, it is impossible to know if the pupils were honest in answering each question. For better result, it is recommended to interview numbers of pupils to be assured of the validity of questions. Time and pupil access prevented this taking place.

The validity of the test of divergency poses little problem in that this test has been used extensively and subjected to much checking. However, the convergency test is a relatively new test: developed by Hindal (2007). She deliberately created it along the same lines and structure as the established divergency test. Recently, the validity of this test was checked with 13 years old pupils and there is now evidence that the first four questions are doing what was intended by Hindal. There is a lack of evidence supporting the fifth question.

Of course, this study was conducted in one country (Saudi Arabia). There is no certainty that the findings of this study may be generalized for other countries. However, there is no obvious reason why the outcomes would not be transferable.

8.4 Future work

There are number of suggestion would be helpful for future work:

- It would be useful to interview number of pupils to be assured of the validity of each question which was difficult to do in this research.
- This survey was applied to only 13 to 15 years old pupils. It would be useful to run the survey with secondary pupils (age 16-18 years). They may able to express their thoughts more accurately.
- It was stated that teachers are considered an important factor in forming student attitudes toward the subject. Thus, it might be helpful to measure teachers' attitudes toward mathematics and see if they influence their student image of the mathematics.

- It is better to measure pupils' attitude more than one time in different periods to see how can they developed or change but there was not enough time to apply this method in survey.
- This study did not find clear reasons for pupils' rejection of mathematics so more work should be done to uncover what is beyond this negative attitude.

8.5 Final Conclusion

The purpose of this study was to discover why many Saudi pupils face difficulties in learning mathematics and reject it. The best method to do that is to measure or to draw picture of their attitudes toward mathematics, the issues that might be ignored in Saudi education.

Some teachers and educators do not realise how attitudes are important in building pupils' success. Teaching not only involves instructions, assignments and examinations. Teaching involves the development of young people: their knowledge, understanding, skills as well as their personal development in equipping them for their lives and for their future. Of course, teachers must be familiar with their students' abilities and their strengths and weaknesses and try to improve skills that help them to perform well in mathematics.

It is hoped that they work in this study has made a contribution in understanding how pupils relate to their studies in mathematics and that this will assist in future developments for the benefit of future learners.

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Appendix A

Divergency test

Name: ………………………………………………………………………………..

School: ………………………………………………………………………………

A TEST OF THINKING - 1

These tests aim to measure your ways of thinking.

The results will NOT affect your academic work or exams in any way.

The test is timed.
Do NOT open the booklet until told to do so.
You will be told when to move to each page

Centre for Science Education, University of Glasgow
Scotland

TEST 1

When you are writing, it is often necessary to think of several different words having the same meaning, so that you do not have to repeat one word again and again. In this test you will be asked to think of words having meanings which are the same as or similar to a given word. The given words will be ones that are well known to you.

For example
If the word were SHORT you would write at least some of the words written below:

Short: *brief* *abbreviated* *concisemomentary* *little* *limited*
deficient *abrupt* *petite* *crisp* *compact*

Now try the following words. You probably will not be able to fill in all the spaces, but write as many words as you can think of.

1. Strong:

....
....
....

2. Clear:

....
....
....

3. Dark:

....
....
....

4 Minutes

TEST 2

In this test you will asked to write as many sentences as you can. Each sentece should contain the four words mentioned and any other words you choose:

For example

TAKE FEW LAND LITTLE

1. Few crops take little land.
2. A few little boats supplies to land.
3. Could you take a few little people with you to see my green land?

All the four words are used in each sentence. The words must be used in the form that is given; for example, you cannot use 'taking' instead of 'take'. Notice that the sentences may be of any length. All sentences must differ from one another by more than merely one or two changed words, such as different pronouns or adjectives.

Now try the following words. Remember to number each new sentence as was done in the example above.

1. WRITE WORDS LONG OFTEN

....

....

....

....

2. FRIEND MAN YEAR CATCH

....

....

....

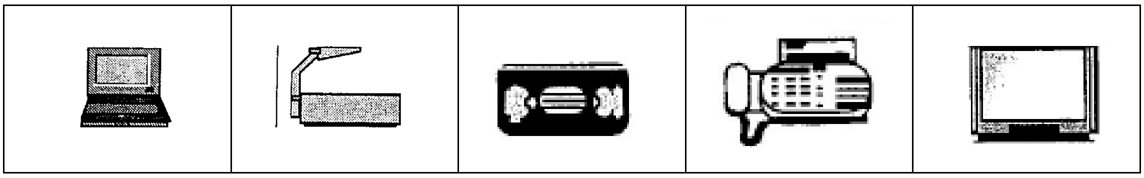
....

4 Minutes

TEST 3

This is a test of your ability to think up a number of different symbols that could be used to stand for certain words or ideas.

For example
The word is ‘electronics’. This word could be represented by many symbols or drawings as shown below. As you know there are many other symbols that could represent the word ‘electronics’?



Now draw as many symbols as you can think of (up to five) for each word or subject below.
Each drawing can be a complicated or as simple as you chose. (No artistry required)

1. Energy

2. Happiness

3. Technology

4. Silence

5 Minutes

TEST 4

This is a test to see how many things you can think of that are alike in some way.

For example:
What things are always red or that are red more than any other colour? You may use one word or several words to describe each thing.

tomatoes bricks blood

Go ahead and write all the things that are 'round' or that are round more often than any other shape.

....	....	....	....
....	....	....	....
....	....	....	....

2 Minutes

Test 5

This is a test of your ability to think rapidly of as many words as you can that begin with one letter and end with another.

For example:
The words in the following list all begin with 'S' and end with 'N'.

sun	spin	stain	solution

Now try thinking of words beginning with 'G' and ending with 'T'. Write them on the lines below. Names of people or places are not allowed.

....	....	....	....
....	....	....	....
....	....	....	....

2 Minutes

TEST 6

This is a test to see how many ideas you can think of about a topic. Be sure to list all the ideas you can think about a topic whether or not they seem important to you. You are not limited to one word. Instead you may use a word or a phrase to express each idea.

For example:

'A train journey'. Examples are given below of ideas about a topic like this.

number of miles suitcases the railway stations people in the train

Now list all the ideas you can about 'working in laboratories'.

....	....	....	....
....	....	....	....
....	....	....	....

3 Minutes

END OF TESTS

الاسم: ……………………………………………………………………………

المدرسة:…………………………………………………………………………………

الصف:……………………………………………………………………………………

اختبار التفكير)1(

الطالبة \عزيزي الطالب
أداة للبحث العلمي لقياس طريقتك في التفكير, من المهم أن تعرف أنة ليس كالنموذج الذي بين يدي
له تأثير على
تعاونك في الإجابة على هذا النموذج وفقا ا لن يطلع عليه احد سوى الباحث . لذا أرجو , وأنه درجاتك
للتعليمات التالية :

ابدأ الإجابة عندما يخبرك الباحث بذلك .-1
حاول قدر الإمكان الاستفادة من الوقت المسموح لك به .-2
لفقرات .انتقل إلى فقرة أخرى عندما تواجهك صعوبة في أي من ا-3
إلتزم بالوقت المحدد لكل نموذج ووضع القلم عندما يطلب منك ذلك .-4
تذكر أن الوقت المسموح به 20 دقيقة .-5

السؤال الأول

عندما تكتب من الضروري أن تفكر في الكلمات المختلفة والتي لها نفس المعنى،لذلك يجب عليك أكثر من مرة و يجب عليك أيضا أن تفكر في الكلمات التي تحمل نفس المعنى أو عدم تكرار الكلمة لمات المعطاة سوف تكون معروفة لك.

على سبيل المثال:
(ربما قد يكون بامكانك أن تكتب بعض الكلمات كا مختصر إذا أخذنا الكلمة)
ناه والتي تحمل نفس المعنىلمكتوبة أد:

: موجز قصيرة وجيز مجمل محدودمختصر
قصير الأمد قليل غير كاف نحيلة هش

را على ملأ جميع الفراغات الآن حاول في الكلمات الآتية من المحتمل أن لا تكون قاد

1. قوي:

....
....
....

2. واضح:

....
....
....

3.غامق:

....
....
....

4 دقائق

السؤال الثاني

في هذا السؤال يجب عليك كتابة عدد من الجمل الممكنة بقدر استطاعتك. كل جملة يجب أن تحتوي على تارها.الأربعة الكلمات المذكورة ادناة وأي كلمات أخرى تخ

على سبيل المثال:

أرض صغير يأخذ قليل

1.المحاصيل القليلة تأخذ أو تحتل أرض صغيرة.
2.القليل من القوارب الصغيرة تأخذ المؤونه للأرض.
3.هل تستطيع أن تأخذ القليل من الناس معك ليروا أرضي الخضراء الصغيرة؟

في كل جملة.الكلمات يجب أن تستخدم على النمط المعطى؛ مثلا,أنت لا كل الكلمات الأربعة مستخدمة تستطيع أن تستخدم كلمة "أخذ" كاسم بدلا من"يأخذ" كفعل.لاحظ بأن الجمل ربما تكون أطول, وكل الجمل يجب أن تختلف عن بعضها البعض بأكثر من كلمة أو كلمتين متغيرة على الأقل كالضمائر أو الصفات المختلفة.
الآن جرب الكلمات الآتية. تذكر ترقيم كل جملة جديدة كما فعل في المثال أعلاه.

1. يكتب كلمات طويلة اغالب

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

2. صديق رجل سنة يمسك

……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………………

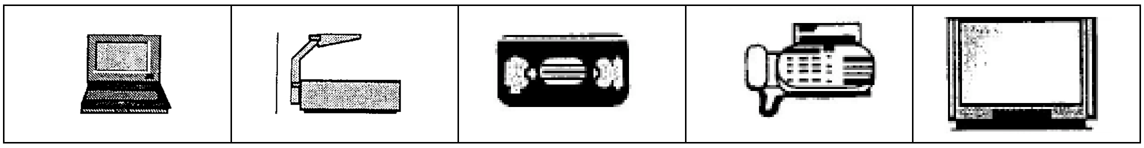
4 دقائق

السؤال الثالث

هذا السؤال يختبر قدرتك على التفكير بعدد من الرموز المختلفة والتي تمثل بعض الكلمات أو الأفكار المحددة.

<u>على سبيل المثال</u>

لعديد دناة. كما تعلم يوجد اد من الرموز والرسومات المعروضة ألالكلمة "كهرباء". هذه الكلمة قد تكون ممثلة بالعدي
من الرموز الأخرى التي تمثل الكلمة "كهرباء"؟



الآن أرسم عدد من الرموز بقدر استطاعتك) كحد أقصى خمسة رموز (لكل كلمة أو موضوع أدناه
كل رسمه يمكن أن تكون معقدة أو مبسطة بحسب اختيارك.

1. الطاقة

2. السعادة

3. التكنولوجيا

4. الصمت

5 دقائق

السؤال الرابع

هذا السؤال ليختبر كم عدد الأشياء التي تستطيع التفكير فيها والتي تتشابه في بعض النواحي.

<u>على سبيل المثال:</u>

د تستخدم كلمة واحدة أو ما هي الأشياء التي تكون دائما حمراء أو تكون أكثر احمرارا من الألوان الأخرى؟ ق
. أكثر لوصف هذه الأشياء

طماطم طوب دم

فكر وأكتب كل الأشياء التي تكون "مستديرة" أو التي تكون دائما أكثر استدارة من الأشكال الأخرى.

....
....
....

دقيقتين

السؤال الخامس

هذا السؤال لاختبار قدرتك على التفكير بشكل سريع بعدد من الكلمات التي تبدأ بحرف وتنتهي بحرف آخر.

على سبيل المثال:

الكلمات في القائمة التالية جميعها تبدأ ب "س" وتنتهي ب "ة"

سيارة	سفينة	سلحفاة	سحابة

الآن حاول التفكير بكلمات تبدأ بحرف "م" وتنتهي بحرف "ة" واكتبهم في الفراغات الموجودة ادناة. أسماء الناس والأماكن غير مسموح بها ؟

....	....	....	....
....	....	....	....
....	....	....	....

دقيقتين

سالسؤال السادس

هذا السؤال ليختبر كم عدد الأفكار التي تستطيع التفكير بها عن الموضوع. كن متأكدا أنك سجلت جميع الأفكار المرتبطة في إعتقادك بالموضوع سواء أكانت مهمة أو غير مهمة بالنسبة لك . أنت غير لتعبر عن كل فكرة.ستخدام كلمة أو عبارةمقيد بكلمة واحدة بل يمكنك إ

سبيل المثال:على

" رحلة القطار" . الأمثلة المعطاة أدناة عبارة عن أفكار لنفس الموضوع.

عدد الأميال الحقائب محطة السكة الحديدية الناس في القطار

لآن سجل جميع الأفكار التي يمكنك التفكير فيها عن "العمل في المعامل".آ

....	....	....	....
....	....	....	....
....	....	....	....

3 دقائق

انتهى الاختبار

Appendix B

Convergent test

Name: ……………………………………………………………………………………..

School: ………………………………………………………………………………………

A TEST OF THINKING - 2

These tests aim to measure your ways of thinking.

The results will NOT affect your academic work or exams in any way.

The test is timed.
Do NOT open the booklet until told to do so.
You will be told when to move to each page

Centre for Science Education, University of Glasgow
Scotland

Test One

Some Unusual Problems

These tests look at the way you try to solve problems

1- Look at the table alongside:

Morocco	Iran	Oman	Qatar	Lebanon
Rabat	Karachi	Beirut	Masqat	Doha
Egypt	Pakistan	France	United Kingdom	Spain
Cairo	Teheran	Madrid	Paris	London

There are many patterns in the table which could link the names in the table together
Find two patterns and write them down.

Pattern 1……………………………………………………………………………………
Pattern 2……………………………………………………………………………………

2- Put the letters in the right order to give a correct word.

- E O N T ………………………………………….
- R E N I D F ………………………………………….
- E A C P E ………………………………………….

3- Here are several sets of numbers.
Add the next number in each sequence for each, and then explain why you chose the number.

- 2 …. 4 …. 8 …. ☐

Explain:……………………………………………………………………………………

- 1 …. 3 …. 6 …. 10 …. 15 …. ☐

Explain:……………………………………………………………………………………

- 1 …. 4 …. 9 …. 16 …. ☐

Explain:……………………………………………………………………………………

Five minutes

Test Two

Here is a short piece of writing, Pick out the three main ideas.

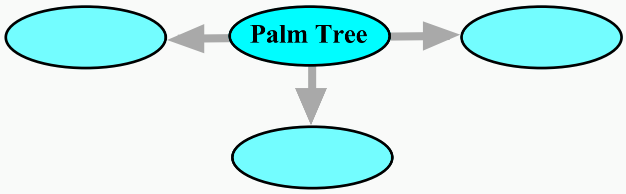
Read the topic and classify the three main ideas use the diagram.

The Palm Tree in Saudi Arabia

In the oases of Saudi Arabia, the date palm tree stand tall with their branches out stretched toward heaven and their roots anchored deep into the earth. Since ancient time, the date palm has been a source of food for inhabitants of the Arabian Peninsula, and its branches have granted him shade from the strong desert sun. In the Holy Qur'an and Hadith, many passages make mention of the important of it. In the Qur'an, it is referred to 29 times and is called "a blessed tree". In addition; date considers a main meal for Muslims during Ramadan, whereas the daily fast is broken with a few dates and then a few sips of water.

Dates are considered a nutritious staple of the Saudi diet and an excellent source of energy for the health conscious because they are Low in fat, cholesterol free, high in carbohydrates and contain fibre, potassium and vitamins. Furthermore, some studies indicate to the possible medicinal benefits that might be derived from dates, such as an analgesic or as a supplement for people who suffer from hypokalemia, a disorder involving too low levels of potassium.

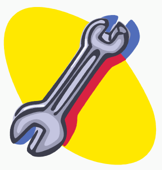
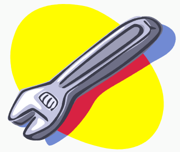
Before oil became Saudi Arabia's primary industry, date farming was a prevalent part of national economy .Today; the kingdom is the world's second producer of dates, supplying 17.6 percent of the world market. It has an enormous number of varieties of date grown in different region such as; khalas, ruzeiz,



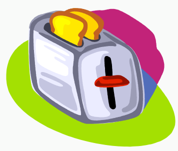
5 minutes

Test Three

- Picked out the different object, and then give a reason to select it.

Give a reason: ....

Give a reason: ....

Give a reason: ....

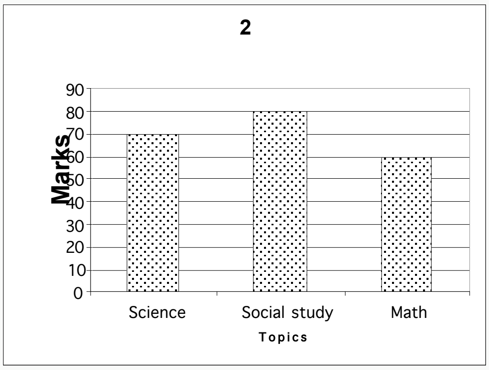
   

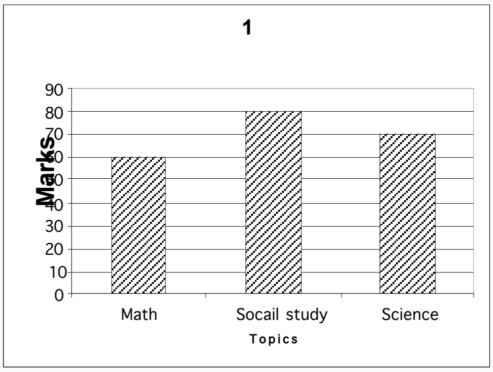
Give a reason: ....

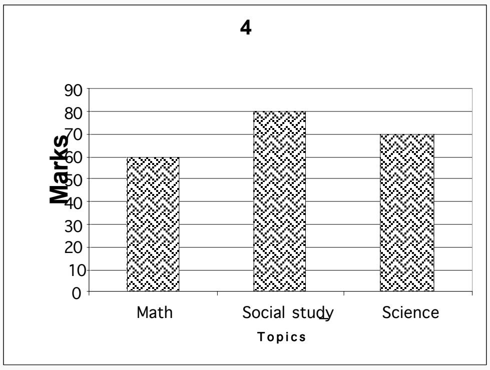
Three minutes

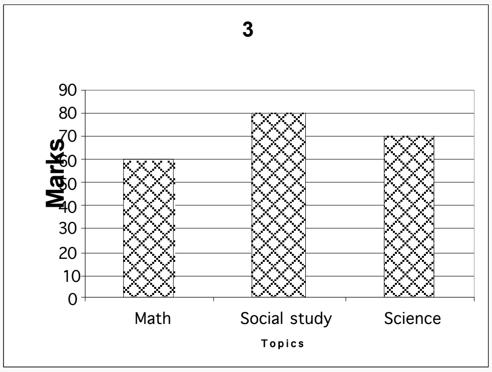
Test Four

- Here are four graphs showing how pupils performed in examinations.
- All have the same axes, labelled in the same way.
- Look at the four graphs carefully.
- Write down two things which are **true for all four** graphs.









1 ……………………………………………………………………………………

2 ……………………………………………………………………………………

Two minutes

Test Five

Read the test instruction first:

There is a man stands near the school (on the map start point). Help him to go to a nursery then to the supermarket (the end point) by drawing the way on the map.

1 Use a pen or pencil and mark the route clearly on the map

2 Write your description for the way you drew on the map.

Your description

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

Five minutes

Appendix C

Attitude Questionnaire

What do you think about mathematics?

*Please answer **ALL** the questions below - most answers only require you to tick boxes.*
*Your answers do **NOT** count for examinations in any way.*
Please be as honest as you can!!

quick	✓	☐	☐	☐	☐	☐	slow
important	☐	☐	✓	☐	☐	☐	unimportant
safe	☐	☐	☐	☐	✓	☐	dangerous

The positions of the ticks between the word pairs show that you consider it as <u>very</u> quick, slightly more important than unimportant and <u>quite</u> dangerous.

Use the same method for the following questions

(1) Think about **mathematics**.
Tick one box on each line.

Does not involve hard work	☐	☐	☐	☐	☐	☐	Does involve hard work
Important	☐	☐	☐	☐	☐	☐	Not important
Leads to many jobs	☐	☐	☐	☐	☐	☐	Does not lead to many jobs
Is not easily understood	☐	☐	☐	☐	☐	☐	Is easily understood
Is abstract	☐	☐	☐	☐	☐	☐	Is concrete
Easy	☐	☐	☐	☐	☐	☐	Difficult

(2) Think about **yourself and mathematics.**
Tick one box on each line.

I feel I am NOT coping well	☐	☐	☐	☐	☐	☐	I feel I am coping well
I do NOT wish to learn mathematics	☐	☐	☐	☐	☐	☐	I wish to learn mathematics
I am obtaining a lot of new skills	☐	☐	☐	☐	☐	☐	I am NOT obtaining a lot of new skills
I am getting better at mathematics	☐	☐	☐	☐	☐	☐	I am getting worse at mathematics
It is definitely “my” subject	☐	☐	☐	☐	☐	☐	It is definitely NOT “my” subject
I find mathematics boring	☐	☐	☐	☐	☐	☐	I find mathematics interesting

(3) Here are ways to describe **mathematicians.**
Tick one box on each line

Mathematicians are:

Hardworking	☐	☐	☐	☐	☐	☐	Not hardworking
Not practical people	☐	☐	☐	☐	☐	☐	Practical people
Good fun	☐	☐	☐	☐	☐	☐	Boring
Useful	☐	☐	☐	☐	☐	☐	Not useful
Well paid	☐	☐	☐	☐	☐	☐	Badly paid
Popular	☐	☐	☐	☐	☐	☐	Unpopular
Low status	☐	☐	☐	☐	☐	☐	High status

(4) Here are several **reasons** why school pupils might need to study mathematics.
*Tick the **THREE** which are most important for you.*

- ☐ Teaches me to think clearly
- ☐ Can be applied in life
- ☐ Can solve problems in the world
- ☐ Is a useful way of thinking
- ☐ Leads to many jobs
- ☐ Is essential for many other subjects
- ☐ Is very logical
- ☐ Is fun

(5) Here are several statements.
Tick one box on each line to show your view.

		Strongly Agree	*Agree*	*Neutral*	*Disagree*	*Strongly Disagree*
(a)	I look forward to mathematics classes each week	☐	☐	☐	☐	☐
(b)	Geometry is the worst bit of mathematics	☐	☐	☐	☐	☐
(c)	I cannot solve equations easily.	☐	☐	☐	☐	☐
(d)	The mathematics textbook is boring.	☐	☐	☐	☐	☐
(e)	Mathematics is used in our daily life.	☐	☐	☐	☐	☐
(f)	I cannot see why I have to study mathematics	☐	☐	☐	☐	☐
(g)	I find mathematics ideas very interesting	☐	☐	☐	☐	☐
(h)	There are too many ideas to hold in my mind at once in mathematics	☐	☐	☐	☐	☐
(i)	My mathematics teacher is very important to enable me to understand	☐	☐	☐	☐	☐

(6) Would you like to study more mathematics next year?

- Yes, because ………………………………………………………………………………
- No, because ……………………………………………………………………………….

(7) Different pupils **prefer different things**.
Tick one box on each line your preference.

Algebra	☐	☐	☐	☐	☐	☐	Geometry
Solving equations	☐	☐	☐	☐	☐	☐	Solving geometry problems
Drawing geometry shapes	☐	☐	☐	☐	☐	☐	doing arithemetic
Mathematics	☐	☐	☐	☐	☐	☐	Social Studies
Science	☐	☐	☐	☐	☐	☐	Mathematics
Arithmetic	☐	☐	☐	☐	☐	☐	Algebra
Mathematics	☐	☐	☐	☐	☐	☐	Arabic

(8) What do you **enjoy a lot** in your mathematics lessons.
Tick as many as you like.

- ☐ Solving everyday problems
- ☐ Solving different exercise
- ☐ Drawing geometry shapes
- ☐ Measuring angles
- ☐ Counting numbers
- ☐ Getting right answers
- ☐ Listening to teacher explanation
- ☐ Doing homework
- ☐ Doing multiplication exercises
- ☐ Approximation numbers

(9) Suppose you were thinking of going to university.
Here are several reasons for going to university.
Tick as many as you like to show your views.

- ☐ I get a subsidy
- ☐ My parents want me to go
- ☐ All my friends will probably go
- ☐ I like new challenges
- ☐ I shall get an interesting job in the future
- ☐ It is the normal thing to do after finishing school
- ☐ I am good at school level

Which subject might you study at university? ……………………………………………

(10) Fill in **the school subject** that you think **best** fits each description below:

(a) ……………… is most interesting.
(b) ………………… is most important.
(c) ……………… is most enjoyable.
(d) ………………… is most boring.
(e) ……………… is mostly suitable for girls.
(f) ………………… is mostly suitable for boys.
(g) ……………… is useless for girls.
(h) ………………… is useless for boys.

(11) Which of these do you think is going to be most interesting to do in intermediate school?
Tick as many as you like

- ☐ Playing in a school sport team
- ☐ Doing mathematics exercise
- ☐ Painting pictures
- ☐ Learning English
- ☐ Cooking
- ☐ Reading stories

(12) Which of these do you think you are going to be after you leave school?
Tick two boxes.

- ☐ an artist
- ☐ a businessman/woman
- ☐ a nurse
- ☐ a football player
- ☐ a mathematics teacher
- ☐ a doctor
- ☐ an aircraft pilot
- ☐ a lawyer
- ☐ an engineer
- ☐ a housewife

(14) I became interested in mathematics thanks to …..
Tick as many as you like.

- ☐ television
- ☐ my teacher
- ☐ exhibition, demonstration, festivals
- ☐ mathematics lessons
- ☐ my friends
- ☐ my parents
- ☐ other (please indicate) ………………………………………………………………………………

Thank you for answering
All the best in your studies