THE EFFECTS OF A STRUCTURED TEACHING METHOD ON MATHEMATICS ANXIETY AND ACHIEVEMENT OF GRADE EIGHT LEARNERS

by

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Summary:
The hypothesis that a structured, sequenced, approach to mathematics learning, based on the application of learnt facts, decreases mathematics anxiety and increases mathematics achievement is tested. A literature study and an empirical investigation were conducted with respect to the relationships between maths anxiety, maths achievement and teaching methods. A qualitative research design which focussed on the cross-case analysis of different case studies was used.

The qualitative case study involves multiple methods such as interviews, observations and a pretest, posttest design. It analyses and compares the effects of the Kumon method, used as the intervention programme, on maths anxiety and maths achievement of an experimental group and a control group.

The results of this research indicate that learners on the intervention programme who showed a decrease in anxiety, showed an increase in achievement. This has implications for the teaching methods used in South Africa.

Key words:
Mathematics anxiety; mathematics achievement, teaching methodology, Kumon method, outcomes-based education, OBE, study orientation questionnaire, SOM, Kumon diagnostic test, grade 8, South African learners

CONTENTS

CHAPTER 1

INTRODUCTORY ORIENTATION

1.1 INTRODUCTION

Many learners experience mathematics anxiety in our schools today. Reported consequences of being anxious toward mathematics include the avoidance of mathematics and the decline in mathematics achievement (Hembree 1990:34). A further consequence involves the interference with conceptual thinking and memory processes (Skemp 1986:54). There is increasing concern about the number of learners who drop mathematics in the latter years of high school. Barnes (1984:14) notes that this avoidance is the result of a complex set of interacting factors, affecting boys and girls differently, but the main cause, for both sexes is the anxiety which mathematics arouses in many students.

In an international study involving forty one countries, the competency of grade seven and grade eight learners in the fields of mathematics and science was tested. South Africa scored lowest in both mathematics and science proficiency (*Sunday Times*, 24 November 1996:1). In a further report by Unesco, Unicef and the South African Department of Education, (*Sunday Times*, 16 July 2000:1) amongst twelve countries in Africa, a sample of grade four South African learners scored lowest in numeracy skills on the continent. These results will affect the number of learners having the skills required for future careers in the fields of science and technology in South Africa. A decrease in tertiary studies in the fields involving mathematics and science will negatively impact on South Africa's technological developments and economy.

Because of the importance attached to mathematics at all levels of education, there is a need to study the cognitive and affective implications of mathematics teaching. Teaching methods need to be developed to determine which programmes would be appropriate for those with deficits in mathematics skills and varying amounts of mathematics anxiety (Kostka 1986:533). Wu (1999:1) states that the problem is not in the lack of ability of students, but in the teaching method. In most cases, the precision and fluency in the

execution of the skills are the requisite vehicles to convey the conceptual understanding (Wu 1999:1).

Mathematics, by its nature involves both cognition and affective effects. Sutton (1997:44) argues that the glory of mathematics lies in the fact that maths does not come easily to anyone. It is in the struggle to understand and the manner in which this is met, that one learns life skills. Research is needed in the areas of both mathematics anxiety and instructional techniques for the reduction and prevention of anxiety (Hadfield 1988:82).

Since Sheila Tobias (1978) wrote about mathematics anxiety in her book *Overcoming math anxiety*, an awareness of the problem of mathematics anxiety was created. Learners and adults began to identify and talk more freely about their fears, feelings of helplessness and panic at being confronted by an apparently insolvable problem (Maree 1992:55). Mathematics anxiety and its related causes, effects and solutions have since then been limitedly addressed.

1.2 AWARENESS OF THE PROBLEM AND STATEMENT OF THE PROBLEM

This research topic arose in response to observations and investigations during ten years of teaching science and mathematics in the senior high school phase and nine years of involvement with the Kumon educational institute in South Africa.

In 1995 the teaching methodology in South Africa changed from a "traditional" approach to an "outcomes based" approach, known as curriculum 2005. Since then, curriculum 2005 has been revised four times and finally in June 2000 phased out completely to be replaced by curriculum 21. Outcomes-based education remains at the centre of the new approach (Coetzer 2000:77). Curriculum 21 will focus on the teaching of mathematics and science with seventy percent of classroom time spent on mathematics and language teaching in grades one to three, and fifty percent from grade four onwards. This replaces the curriculum 2005 approach that reading and mathematics should not be specifically taught (*Sunday Times*, 4 June 2000:22).

An increasing number of students are experiencing mathematics problems. The national pass rate for mathematics was 49,5 % in 1996, dropping to 46,3 % in 1997 and to 42,1%

in 1998 (*Pretoria News*, 11 July 2000:6). More recent statistics with respect to pass rates for mathematics have not been officially published. Coetzer (2001:87) notes that progressive schools in the United States of America that followed a curriculum similar to curriculum 2005 showed similar results, especially as regards instruction and results in mathematics and natural sciences. Merseth (1993:553) emphasises that attention needs to be given to the lessons learned from the debacle of "new maths".

Ma (1999:520) found that the relationship between mathematics anxiety and mathematics achievement is significant. It was also found that once maths anxiety takes shape, its relationship with maths achievement is consistent across grade levels. A high level of anxiety is associated with a lower level of achievement (Quilter & Harper 1988:121). Barnes (1984:14) states that one of the main causes for the avoidance of mathematics in the latter years of high school is the extreme anxiety which mathematics arouses in many students.

The need for more studies on the prevention of mathematics anxiety and the need for teachers to be more aware of how maths anxiety is engendered and how it can be prevented was noted by Dossel (1993:4). Barnes (1984:14) noted the increasing swing away from mathematics in the latter years of high school and concludes from his research on mathematics anxiety that teachers need to develop teaching methods which will keep the general level of anxiety in the classroom low. Kostka (1986:533) concluded from her research that future studies are needed to compare various combinations of components designed to increase mathematical skills and reduce anxiety.

From the above investigations and observations it can be asked whether there is a link between the unstructured, changing curriculum and lower levels of mathematics achievement and numeracy. Has the move away from a factually based, "drill and practise" approach led to increased understanding or a lack of a secure mathematics foundation in which basic arithmetical skills are known? Does an outcomes based approach to mathematics decrease or increase understanding of maths concepts, and how does it affect mathematics achievement? How does teaching methodology affect mathematics anxiety? The hypothesis that a structured, sequenced, approach to maths learning based on the application of learnt facts will decrease maths anxiety and increase achievement is tested in this study.

1.3 DELIMITATION OF THE RESEARCH

This research refers to the following concepts:

- Literature study: A literature study was done covering the nature and related effects of mathematics anxiety, mathematics achievement and teaching methodology and techniques. This study investigates the nature of the relationship between maths anxiety and maths achievement. It also investigated the nature of the relationship between maths anxiety and teaching methods.
- An empirical investigation involving a qualitative case study was limited to the supervision and continuous assessment of five learners on an intervention programme, using a structured approach to address mathematics achievement and mathematics anxiety. A control group of five learners was monitored for descriptive evaluation.
- Learners were in their grade eight year of schooling. They were all from the same school, were taught by the same teacher and are from the same socio-economic area.
- Participating learners were identified as having high mathematics anxiety.
- Mathematics anxiety was identified from the Study Orientation questionnaire in Maths (SOM). The field of mathematics anxiety comprises fourteen questions within the total of seventy six (Maree 1997:7).
- Mathematics achievement was assessed by analysing classroom progress within the grade and the results of the Kumon mathematics diagnostic test (level P4). The results before the intervention programme (the Kumon programme) and the results after the five month intervention on the Kumon programme are evaluated and analysed with those of a control group.

1.4 AIMS OF THE RESEARCH

There are several general aims with regard to the literature study and the empirical investigation. The aim of the literature study includes gathering information and analysing previous research in the areas of maths anxiety, maths achievement and teaching

methods. The general aim of the empirical investigation is to investigate the relationship between maths anxiety, maths achievement and different teaching methods.

1.4.1 Literature study

The main aim of the literature study is to gather information about previous research and gain insight into:

- Mathematics anxiety
- Mathematics achievement
- Teaching methodology

The study investigates the nature of the relationship between mathematics anxiety and mathematics achievement. It also investigates the nature of the relationship between mathematics anxiety and teaching methods.

1.4.2 Empirical investigation

A further aim of this research is to use the Kumon method as a structured intervention programme in a qualitative case study aimed at the following:

- To investigate the relationship between mathematics anxiety and mathematics achievement
- To investigate the relationship between mathematics anxiety and different teaching methods.
- To investigate whether a structured approach to teaching mathematics will affect fluency in basic arithmetical skills, which will have an effect on mathematics anxiety.

The specific aim of this research is to test the following hypothesis:
A structured teaching method that increases the fluency of basic mathematical skills, results in a decrease in mathematics anxiety and an increase in mathematics achievement.

1.5 RESEARCH METHOD

Two methods are involved in this research: a literature study and an empirical investigation. An outline of these two methods is discussed.

A literature study was conducted to clarify concepts, definitions and the nature of mathematics anxiety. Details of previous research into aspects of mathematics anxiety and its relationship to achievement are discussed. Both cognitive and affective effects of anxiety are researched and detailed. The literature study also includes the nature of different teaching methodologies in mathematics and how these affect achievement and anxiety.

A qualitative case study using the Kumon method as an intervention programme was done with five learners. The participating learners were selected from a group of grade eight's who completed a Study Orientation Maths (SOM) questionnaire. From the resulting diagnostic profiles, ten learners were identified as having high maths anxiety. Of these learners, five participated in the intervention programme, using the Kumon method, for a period of five months and the other five learners, not participating in the programme, were used as a control group. All learners participating in the case study were tested for maths achievement and a record of their maths progress through this period was analysed. This allowed for a description and explication of the phenomena arising around maths anxiety and achievement.

All learners participating in the case studies were from the same school. This allowed for the teaching methodology and curriculum content taught at school to be constant between learners participating in the programme and the control group, increasing the reliability of the study.

For the purpose of clarity, certain concepts need to be expanded on. Concepts used in this research are outlined below.

1.6 CLARIFICATION OF CONCEPTS

In this research specific concepts will be focussed on. These include mathematics anxiety, teaching method and intervention programme, learner achievement and case study.

1.6.1 Mathematics anxiety

Mathematics anxiety is defined as involving feelings of tension and anxiety that interfere with the manipulating of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations (Richardson & Suinn 1972:551). In this research, both the cognitive understanding and the affective effects of mathematics anxiety are detailed. The effects of the changing curriculum, the mastery of basic skills and concept formation impacts on a learner's understanding of mathematics and his feelings of adequacy.

1.6.2 Teaching method and intervention programme

For the purposes of this dissertation, two differing teaching methodologies are described. The one approach is a structured, systematic approach, which focuses on algorithms being taught and then practised until the skill is acquired. The second method is based on a discovery, creative approach whereby students are encouraged to solve language based problems using their own understanding and thought processes.

The intervention programme was the Kumon method. The Kumon method, based on the philosophy of the late Japanese educator and founder of the Kumon Educational Institute, Toru Kumon, focuses on calculation ability. The method promotes individualised, self-learning through a set of highly structured worksheets which begin at pre-school and progress through to levels beyond high school. The focus is on mastery of "every step" which is assessed through speed and accuracy. The student works individually, and repetition and practise is required to master each level of Kumon study. The premise of the method is that the ability to calculate leads the way to creativity (Kumon 1996:18).

1.6.3 Learner achievement

For this study, achievement is used in the context of performance in tests and is defined in the Heritage dictionary (1973:11) in terms of achievement test as the measurement and comparison of skills in various fields of vocational or academic study. Previous research involving the relationships between achievement and anxiety is analysed.

1.6.4 Case Study

For the purposes of this research, "case study" is defined as the description, evaluation and analysis of the results of the intervention programme, the Kumon method, as applied to five identified grade eight learners with mathematics anxiety. The analysis includes the methodology and its effects on mathematics.

1.7 RESEARCH PROGRAMME

The dissertation comprises four chapters as outlined below:

1.7.1 Chapter 1: Introductory orientation

In this chapter detail of an awareness of the problem and statement of the problem is discussed. The delimitation of the research, involving a literature study and empirical investigation involving a qualitative case study is outlined. Concepts used have been clarified and the research programme detailed.

1.7.2 Chapter 2: Literature study

The literature study focuses on the following:

1.7.2.1 Mathematics anxiety

a) Definitions and nature of mathematics anxiety.
b) The causes of mathematics anxiety.
c) The consequences of mathematics anxiety.
d) Treatment of mathematics anxiety.
e) Measurement of mathematics anxiety.

1.7.2.2 Mathematics achievement

a) Relationships between achievement and anxiety.

b) Relationships between achievement and teaching methods.

c) Attitudes to mathematics achievement.

d) Reasons for poor achievement.

1.7.2.3 Teaching methodology

a) Traditional teaching approaches.

b) Outcomes-based teaching approach.

c) Kumon method of instruction.

d) Causes and effects of instructional methods.

e) Learning styles.

f) Parent involvement.

1.7.3 Chapter 3: Empirical investigation

A qualitative case study, using the Kumon method as an intervention programme was conducted. Five grade eight learners participated in the Kumon programme. The learners were identified using diagnostic profiles, obtained from the SOM questionnaire as having high maths anxiety. Another group of five learners, also identified as having high maths anxiety was used as a control group. Levels of maths achievement were monitored, before, during and after the structured, intervention programme which continued for five months. Analysis and conclusions are made on the effects of the Kumon method on mathematics anxiety and achievement. Although quantitative results were obtained, the analysis is qualitative in nature.

1.7.4 Chapter 4: Findings and recommendations

A summary of the literature study is presented. Findings and recommendations of previous research done with respect to teaching methodology, mathematics anxiety and mathematics achievement is analysed and noted.

The results of the empirical study are analysed and summarised in terms of the effect of the intervention programme on both mathematics anxiety and mathematics achievement.

From this analysis, recommendations are made for future research on the effects of teaching methodology for learners experiencing mathematics anxiety and achievement with particular reference to South African learners.

1.8 CONCLUSION

The aim of this research is to test whether Kumon, as a structured teaching method decreases mathematics anxiety and increases mathematics achievement. This was done by firstly conducting a literature study and analysing the findings. Secondly, an empirical investigation in the form of a case study was conducted. The findings of this study are analysed and the hypothesis tested. Findings and recommendations based on this result are made.

In the next chapter the results of the literature study with respect to mathematics anxiety, mathematics achievement and teaching methodology will be detailed.

CHAPTER 2

MATHEMATICS ANXIETY, ACHIEVEMENT AND METHODOLOGY

2.1 MATHEMATICS ANXIETY

In this section the definitions and nature of mathematics anxiety are discussed. The causes and consequences of mathematics anxiety as described by various researchers are detailed. Different treatments of mathematics anxiety including psychological treatments are discussed. The section concludes with an outline of various instruments used for the measurement of mathematics anxiety.

2.1.1 Definitions and nature of mathematics anxiety

Anxiety in general is used in response to a perceived threat to an individual (Barnes 1984:16). The threat may be real or imagined and for those who are unable to avoid the threat, feelings of distress, confusion and fear are experienced (Barnes 1984:16). Maths anxiety has been defined as the feeling of tension, helplessness, mental disorganisation and dread one has when required to manipulate numbers and shapes and the solving of mathematical problems (Ashcraft & Faust 1994:98). The special characteristics of maths anxiety can be described as 'the feelings of uncertainty and helplessness in the face of danger (May 1977:205).

Maths anxiety has been related to teachers and the classroom setting. Maths anxious children often show signs of nervousness when the teacher comes near, freezing and stopping work or covering it up to hide it (Barnes 1984:16). One of the findings of Newstead (1998:66) is that children between the ages of nine and eleven reported a significant amount of anxiety about the social, public aspects of doing mathematics in the presence of their teachers and peers in the classroom.

Maths anxiety has been explained in terms of a chain reaction or cycle. Spielberger (1972:482) conceptualised anxiety as a state, trait and a process. As is described by Spielberger (1972:482), anxiety is a result of a chain reaction that consists of a stressor, a perception of threat, a state reaction, cognitive reappraisal and coping. Mitchell (1987:43)

described a maths anxiety cycle and stated that maths anxiety experienced in the present has its roots in the past. Anxiety is perpetuated through negative self-talk manifesting in beliefs which cause anxiety. This leads to physical symptoms, an inability to think and avoidance which, in turn, leads to the inability to perform, causing anxiety and more negative self-talk, and the continuation of the maths anxiety cycle (Mitchell 1987:33). This cycle leads to negative educational and societal maths attitudes which often become a self-fulfilling prophecy, and generally leads to maths avoidance (Williams 1988:96).

Gierl and Bisanz (1995:142) distinguish between two forms of maths anxiety being:

- Mathematics test anxiety defined as feelings of nervousness associated with past, present and future mathematical situations.
- Mathematics problem-solving anxiety defined as feelings of nervousness associated with situations in and out of school that require learners to solve maths problems and use the solutions in some way.

Results of studies conducted showed that learners become more anxious about maths testing situations as they progress through school (Gierl & Bisanz 1995:139).

From the above it can be noted that maths anxiety includes many aspects. In the following section information on the causes of mathematics anxiety will be detailed.

2.1.2 The causes of mathematics anxiety

Mathematics anxiety can be described as a combination of factors as described by Mitchell (1987:15) who states that mathematics anxiety is a combination of physical, cognitive and psychobehavioural components. Physical aspects of maths anxiety are biological, consisting of hormonal, chemical and muscular changes in the body which results in a disability to think (Mitchell 1987:15).

A number of different factors have been described as the causes of maths anxiety. Norwood (1994:248) describes maths anxiety as the results of different factors including the inability to handle frustration, excessive school absences, poor self concept, parental and teacher attitudes towards maths and emphasis on learning maths through drill without understanding. A lack of confidence when working in mathematical situations is described by Stuart (2000:331) as the cause of maths anxiety. Hodges (1983:18) argues that failure

or success in mathematics may be related to individual learning styles and more specifically with the coupling of learning styles and the way in which material is presented. Dossel (1993:6) identified several factors leading to the creation of maths anxiety: These are outlined as follows:

- Personality factors (the belief that success cannot be attributed to effort – feelings associated with lack of control).
- Pressure of perceived authority figures (parents, teachers).
- Time pressure (to answer quickly and verbally).
- Effect of public failure (asking to perform in front of a class).
- Right – wrong dichotomy (the teacher's attention should be directed towards effort rather than achievement).

The beginnings of anxiety can often be traced to negative classroom experiences and the teaching of mathematics (Stodolsky 1985:126; Williams 1988:95). It is considered critical to examine classroom practice and establish whether the roots of maths anxiety may be in instructional methods and in the quality of maths teaching in elementary school (Newstead 1998:55). Greenwood (1984:663) stated that the principal cause of maths anxiety lies in the teaching methodologies used to convey basic mathematical skills. He asserted that the "explain – practise – memorize" teaching paradigm is the real source of the maths anxiety syndrome. He states that teachers create anxiety by placing too much emphasis on memorising formulae, learning mathematics through drill and practice, applying rote-memorised rules and setting out work in the traditional way. Butterworth (1999:349) believes that a lack of understanding is the cause of anxiety and avoidance and that understanding based learning is more effective than drill and practice.

Another source of mathematics anxiety that has been identified is word problems. Tobias (1978:129) believes that word problems are the heart of maths anxiety. Learners need higher levels of reasoning and if not taught strategies to solve these problems, learners may grow up avoiding maths and science (Tobias 1978:129).

The degree of accuracy and ease at which numbers can be manipulated has been identified as a cause of maths anxiety. Mathematics anxiety is the result of nervousness about the required manipulation of numbers in mathematics classes including tests,

homework or in-class instruction (Ashcraft & Faust, 1994:98). Martinez (1987:123) identified a significant component of math anxiety to be the fear of failure. A long term sense of inadequacy by learners was described as the result of the pressures of timed tests, speed drills, and flash cards (Kogelman 1982:32).

Research has shown that a teacher's own mathematics anxiety could be a cause of anxiety for learners. Martinex (1987:117) states that a teacher's own maths anxiety is likely to be transmitted to their students. In a study to determine the underlying anxieties of teacher trainees it was found that many had gaps in their maths knowledge or an awareness of imperfectly learned concepts which in turn, can be transmitted to the learners they teach (Martinex, 1987:120).

Finally, the effect of having to perform and provide explanations in front of teachers or peers has been found to be a source of anxiety. A significant finding by Newstead (1998:66), after a study focusing on maths anxiety between the ages of nine and eleven, was that learners reported a significant amount of anxiety about the social, public aspects of doing maths in the presence of teachers and peers. There were some learners who expressed the fact that this was the only cause of anxiety for them, and that doing sums and working with numbers was not a source of anxiety (Newstead 1998:66). It was found by Kogelman (1982:32) that experiences of learners having been punished or humiliated at the blackboard was very damaging. Newstead (1998:66) concludes from her research that learners learn to do maths before they are able to explain problems and communicate about mathematics. To expect learners to provide explanations to maths questions could cause anxiety at the crucial age between the development of skills for doing maths and the development of skills for explaining maths (Newstead 1998:66).

2.1.3 The consequences of mathematics anxiety

Emotion and anxiety can have a negative effect on the ability of a learner to learn as can be seen from the following research findings. One of the consequences of maths anxiety as stated by Goleman (1996:79) is that learners who are anxious cannot take in information efficiently or deal with it well, resulting in not being able to learn. Goleman (1996:79) describes that the "working memory" becomes swamped when excessive emotion is present and the learner is unable to hold in mind all information relevant to the

task in hand which results in not being able to think straight. Skemp (1986:54) similarly states that anxiety becomes debilitating in terms of performance and higher mental activities and perceptual processes. Strong emotion blocks reasoning and learners under pressure try to remember rather than understand, causing them to be handicapped mathematically (Wells 1994:9).

It has been noted by Ashcraft and Faust (1994:121) that highly mathematics anxious learners tend to avoid the distressing maths stimuli. This has far reaching, national consequences as was highlighted by Hembree (1990:34) whose concern was when otherwise capable learners avoid the study of mathematics, their options regarding careers are reduced, eroding the country's resource base in science and technology. In a study by Chipman, Krantz and Silver (1992:292) it was found that at every level of mathematical skill, maths anxiety had a negative correlation with interest in scientific careers.

As found by research, the speed and accuracy at which learners complete mathematics tasks is dependent on the anxiety that they experience. Ashcraft and Faust (1994:97) found that a group of low anxious learners were consistently more rapid and accurate than a medium anxious group who were consistently the slowest. The most anxious group were the most prone to errors. High maths anxious learners were willing to sacrifice accuracy in order to just finish the task (Ashcraft & Faust 1994:121).

Emotional reactions such as apathy or depression as well as decreasing motivation can be experienced by learners who consistently experience failure, despite trying to succeed (Gentile & Monaco 1988:163). This exposure to uncontrollable failure experiences is referred to by Gentile and Monaco (1988:163) as learned helplessness. Skiba (1990:188) comments that even if a skill is well grounded, the anticipation of possible incompetence may block the ability to carry out the operation.

2.1.4 Treatment of mathematics anxiety

The following paragraphs give an overview of various research findings with respect to the treatment of mathematics anxiety. These include the teacher's attitude and methodology as well as psychological treatments.

Gentile and Monaco (1988:175) state that the teacher is in a position to influence development of learned helplessness by changing beliefs about the causes of success and failure. Learned helplessness can be prevented in the following ways:

- The teacher should provide learners with success experiences.
- Provide learners early with attributions about effort, persistence and strategy.
- Deemphasize attributions that would defy native ability and aptitude.

(Gentile & Monaco 1988:176).

Different teaching methodologies can be used to reduce maths anxiety. Vacc (1993:226) believes that a personal and process-orientated teaching method which emphasises understanding rather than drill and practise reduces anxiety. Problem solving and the discussion of various strategies for solving problems are important for the prevention of maths anxiety (Greenwood 1984:662).

Martinez (1987:121) provides the following guidelines to teachers for creating an anxiety-free maths class:

- Match instruction to cognitive levels – by teaching at the learners level of cognitive development, frustration and anxiety can be prevented.
- Make numbers real by exploring and using examples from everyday living.
- Mastery learning – by reducing the risks and consequences of failing by competing only with themselves, working at the individuals own pace.
- Teaching through play. Maths games and puzzles motivate learning. Early learning experiences that are creative and unpressured reduce early anxiety.

Maree (1992:58) provides the following guidelines for reducing maths anxiety:

- Learning relaxation techniques.
- Re-evaluate test situations by changing attitudes from negative to positive. Poor results do not mean a learner is a failure and will never pass.
- Realise that results have no bearing on the learner as a person.
- Set realistic goals.
- Develop good study methods.

Maths anxiety often begins with the teacher. Maths anxious teachers can result in maths anxious students, and helping teachers confront and control their own fears and feelings of insecurities when faced with numbers is essential to stop the spread of anxiety to learners (Martinez 1987:117).

Another aspect of a teacher's involvement in reducing maths anxiety is the teacher's attitude to errors. Barnes (1984:18) noted that a positive attitude to errors is one of the most important steps in reducing anxiety in the classroom. Learners need to understand that errors are an essential part of the learning process and that mistakes help the learner to discover what it is they do not understand and are essential for progress (Barnes 1984:18). Stressing that no attempted solution is all wrong, and that all solutions involve some correct, logical reasoning, helps learners realize they are not stupid if they make a mistake (Frakenstein 1984:173). Another approach that teachers can use with respect to errors is to remove some of the threat and mystery of evaluation by having learners correct their own work, using an answer key (Martinex 1987:124). The teacher should have learners correct their own errors to show the causes of their mistakes and point out a pattern of errors (Gentile & Monaco 1988:176). Finally, Martinez (1987:121) believes that by letting learners control the evaluation process, they can let them control their own knowledge.

Emotionally, a low self-confidence will negatively affect a learner's performance. Skiba (1990:188) believes that when a learner has a firm belief in his competency he can be protected from the sabotage of uncertainty and concern about failure. This can be accomplished by starting with easy problems and praising each step that is correct (Skiba 1990:188). When learners realise that they can take control of their maths performance, they become encouraged to take control of other aspects of their lives (Kogelman 1981:32). This increases their self-confidence.

Psychological treatments have also been used in the treatment of mathematics anxiety. In the following paragraphs various psychological approaches that have been used by researches are outlined.

Hembree (1990:43) found that psychological treatments such as systematic desensitization and anxiety management training are highly successful in reducing

mathematics anxiety levels. Relaxation training resulted in significantly lower mathematics anxiety and significantly higher mathematics performance (Sharp *et al* 2000:53). Schneider and Nevid (1993:287) found that systematic desensitisation and stress management training with college students lowered maths anxiety but did not change performance on an aptitude test.

Maree (1992:58) suggests consulting a psychologist if anxiety persists and the learner experiences 'striking a blank'. Treatment by psychologists in the form of personal interviews can provide insight into a learners experience regarding past difficulties in mathematics (Long & Ben-Hur 1991:45). By verbalizing fears and frustrations some hostility towards the subject can be overcome and the situation can be reviewed more logically (Skiba 1990:189).

A further psychological model was used by Eisenberg (1992:159) in viewing maths anxiety as a transactional analysis (TA) model. Internal dialogues that develop using the TA model will help to point out critical issues in understanding maths anxiety and show learners how to get past any resentment and limiting beliefs in mathematics (Eisenberg 1992:159).

A psychological tool that is worth mentioning is anchoring. Anchoring is a technique that can be used effectively to reduce an anxiety reaction or a mental block to a task such as maths. An association is made to a positive experience which is then used as an anchor when an anxious reaction becomes disabling, allowing for recall of previously learned information (Thalgott 1986:352).

Another psychological tool that can be used in the treatment of maths anxiety is journal writing. Frakenstein (1984:171) states that keeping a journal can serve as a vent for a learners feelings about mathematics – putting fears down on paper and then re-reading can relieve tension and help put those feelings into perspective. A journal also helps learners to see themselves as competent in maths because they will have a concrete record of their mathematics progress (Frakenstein 1984:171). Journals can also be used for students to write informally, using writing as an extension of their thinking to clarify new concepts and question ideas that remain unclear (Stuart 2000:334). Skiba (1990:189) similarly believes that a journal record of problems explained in a learner's own words

helps overcome anxiety. Dodd (1992:297) notes that the use of peer tutoring in conjunction with writing exercises is an effective way to deal with anxieties. Miller (1991:520) notes that writing in journals offers learners an opportunity to privately seek assistance if something is not understood.

A final psychological approach that can be discussed is one based on behaviour modification. A comprehensive teaching-therapeutic programme where desired behaviour is rewarded (instrumental conditioning) and good performance in maths associated with pleasant experiences (classical conditioning) is outlined by Harcum (1989:40). In a specific case study success in the treatment of maths anxiety was obtained by using the above approach including family therapy and giving the learner a mild tranquilizer to help him relax and reduce negative behaviour and maths anxiety (Harcum 1989:40).

Research has shown that cognitive factors such as those described in the following paragraph should be taken into account in the treatment of maths anxiety. Ma (1999:532) notes that treatments that help students overcome their cognitive difficulties in the learning of mathematics may be associated with an appreciable reduction in maths anxiety. Handler (1990) as described by Ma (1990:532) suggests that a cognitive process should include making knowledge work for the learner, joining skills and content, linking motivation to cognition and using social communities. Hadfield and Maddux (1988:78) similarly believe that cognitive style is associated with mathematics anxiety. Miller and Mitchell (1994: 356) describe a successful treatment of maths anxiety as involving two phases of activities. In one phase the learner receives special tutoring with emphasis on manipulatives whilst attempting to make the content meaningful by relating it to interest and career goals. The second phase is aimed at a different method of evaluation where credit is given for demonstrating understanding through tutoring sessions.

A learner's intrapsychic structure has an effect on his experiencing maths anxiety. Millar and Mitchell (1994:355) point out that a learner's personal belief in being bad at maths needs to be distinguished from having a poor history and not being any good. Skiba (1990:188) suggests dispelling myths such as the belief that a maths IQ exists and that learners who have enjoyed past success in mathematics should be aware that the talent still exists.

Another approach is in using group activities. Group activities have been found to be helpful in reducing anxieties (Dodd 1992:298). Similarly, Vacc (1993:226) noted that encouraging learners to work with peers in groups that are co-operative reduces maths anxiety. Not all researchers have found that learners experience positive outcomes while working in groups and some learners will be reluctant to interact with others in a setting that could be potentially embarrassing. Newstead (1998:66) reported that learners experienced anxiety in the performance of maths in the presence of peers. Greenwood (1984:662) suggests problem solving and the discussion of various strategies for solving these problems is important for the prevention of mathematics anxiety. Wells (1994:10) argues that learners should have the freedom to make their own choices such as being allowed to work by themselves, with a friend or a group of friends. Learners should have a broader and deeper understanding of how professionals feel and behave towards mathematics, including the knowledge that adult mathematicians have a lot of choice in how they work and with whom they work (Wells 1994:10).

As can be seen from the above discussion, the treatments of maths anxiety are many and varied. In the next section the measurement of mathematics anxiety will be discussed.

2.1.5 Measurement of mathematics anxiety

There have been a limited number of instruments developed and used to measure maths anxiety. As described by Suinn, Tayler and Edwards (1989:83) these include the numerical anxiety scale developed by Dreger and Aiken , the Fennema-Sherman mathematics scale and the mathematics anxiety rating scale for adolescents (MARS-A), developed by Richardson and Suinn. Of these the MARS-A is the most popular. It is a ninety eight item scale questionnaire designed specifically for adolescents to estimate their proneness to debilitating degrees of anxiety in numerical situations, including classroom, testing and everyday functions (Hadfield & Maddux 1988:77). Chiu and Henry (1990:121) developed the mathematics anxiety scale for children (MASC) for children from grades four through to eight.

The focus in this research was to identify South African learners in grade eight with mathematics anxiety who could participate in a case study. The study orientation questionnaire in maths (SOM) was designed for South African pupils from grade seven to

grade twelve and was used to identify study orientation including maths anxiety (Maree, Prinsloo & Claassen 1997:3).

From the above topics, it can be seen that many factors contribute to maths anxiety. The consequences of maths anxiety are far reaching, involving not only maths performance and perceptual processes but also avoidance of maths. Treatments of maths anxiety include the teacher's methodology and input as well as psychological treatments. Research studies on mathematics achievement will be outlined in the following section.

2.2 MATHEMATICS ACHIEVEMENT

Mathematics achievement includes discussion of the following: relationships between achievement and anxiety, relationships between achievement and teaching methodology, attitudes to maths achievement and the reasons for poor achievement in mathematics.

2.2.1 Relationship between achievement and anxiety

Several research projects have been undertaken to establish the nature of the relationship between mathematics achievement and mathematics anxiety. In the following paragraphs reference will be made to some of these.

Hembree (1990:33) noted that maths anxiety seriously constrains performance in mathematical tasks and reduction in anxiety is consistently associated with improvement in achievement. As such, it is to be expected that highly maths anxious individuals will be less fluent in computation, less knowledgeable about mathematics, and less likely to have discovered special strategies and relationships within the mathematics domain (Ashcraft & Faust 1994:121). In a meta-analysis, Ma (1999:532) quantified the potential improvement in mathematics achievement when mathematics anxiety is reduced. Ma (1999:533) found that the relationship between maths anxiety and maths achievement is significant from grade 4 and that once maths anxiety takes shape, its relationship with maths achievement is consistent across grade levels. It was also found that the relationship was consistent across gender groups, ethnic groups and instruments used to measure anxiety (Ma 1999:533).

Goleman (1996:84) describes the relationship between anxiety and performance, including mental performance in terms of an upside-down U. At the peak of the inverted U is the optimal relationship between anxiety and performance. Too little anxiety, the first side of the U, brings about apathy or too little motivation to try hard enough to do well, while too much anxiety, the other side of the U, sabotages any attempt to do well.

Number manipulation anxiety and test anxiety showed significant inverse relationships with respect to mathematics achievement. Learners who are anxious about forthcoming tests and number manipulation techniques are likely to perform at a lower level (Wither, 1988:51).

From the above it can be noted that the presence of mathematics anxiety has a negative effect on mathematics achievement.

2.2.2 Relationship between achievement and teaching methods

Previous research with respect to maths achievement and teaching methods is outlined in the following paragraphs.

The teacher's attitude and approach in the classroom has an effect on a learners achievement as can be seen from results of previous research. Dossel (1993:5) has suggested that the atmosphere in the classroom, including perceived warmth, may lower anxiety and improve maths performance. Stuart (2000:334) stated that students like to do what they are good at, and to feel good about maths, teachers need to build up the self-confidence and refine the skills required to be successful at maths.

The Kumon method (see section 2.3.3) is a specific teaching methodology that has been shown by various researchers to have positive effects on maths achievement. Russell (1995:74-76) researched three schools that had followed the Kumon method over a period of at least a year. The results of Russell's (1995:74-76) research are:

- At the Cleora public school in Oklahoma, the Kumon method was introduced in January 1990 for approximately 130 students. A comparison of the Iowa test of basic skills scores from early 1990 to April 1993 shows that the average for the

group, grades 1-8, in total maths including concepts, computation and problem solving rose from the 63rd percentile to the 82nd percentile.

- In Dundee, Illinois, grade 3 students at St.Catherine of Siena school also took the Iowa test of basic skills at the beginning of 1990 and again in grade 5 in 1992. After two years of Kumon study, average scores increased from 39% in computation to scoring 81% and average scores of 56% in total maths to scoring 77%.
- In 1990, the Christ Episcopal school in Texas chose two groups, grade two and grade five for a trial programme in using the Kumon method in its regular maths courses. Results were assessed after one year by comparing their Stanford maths achievement test results. The results are tabulated below:

Stanford achievement test results

2nd grade	**1989**	**1990**
Overall math	53	81
Concepts	58	89
Application	49	76
Computation	49	76
5th grade		
Overall math	76	94
Concepts	76	92
Application	70	85
Computation	71	94

It can be concluded from the above results that after introduction of the Kumon method, the maths achievement increased in all cases.

A similar result was obtained by Barnard (1995:5) in an empirical investigation into the effect of the Kumon method on achievement in mathematics by learners in two private schools in Johannesburg, South Africa. He concluded that learners taught by means of the Kumon method outperformed eighty five percent of the learners taught by means of the traditional method and fared significantly better than learners taught by the means of the problem centred approach (Barnard 1995:5).

Further studies involving the effectiveness of an individualised format of teaching versus the traditional format was conducted by Gudan (1995:81). An outline of research with respect to teaching methodology as described by Gudan (1995:81) follows. The experimental format consisted of a diagnostic test, individualised work plan and learners working at their pace to master topics. The materials were sequenced in a maths workbook with answers provided. The traditional format was lecture and demonstration based. Students that were pre-tested and received individualised instruction benefited the most in terms of post-test scores. Surveys administered to the students indicated that the individualised approach was a positive experience and had a small effect on decreasing maths anxiety.

It can be noted from the above discussion that different teaching methodologies affect maths achievement. In particular, maths skills need to be refined and a learners confidence built up. The Kumon method, and a similar individualised approach by Gudan (1995:81) has a positive relationship with maths achievement.

2.2.3 Attitudes and mathematics achievement

Several researchers have focussed on the effects of the learner's attitude on maths achievement. Hadfield, Martin and Wooden (1992:175) found a strong correlation between the variable of persistence and degree of mathematics anxiety, thus concluding that a student's attitude may be a more important factor than previously thought. It has similarly been noted that more positive attitudes accompany lower levels of anxiety and are conducive to increased gains in the future (Genshaft 1982:34). Wells (1994:9) believes in telling a class beforehand that the subject matter is difficult, giving learners a truthful picture of mathematics as something difficult and challenging, but which they can do successfully, as opposed to leaving learners to draw conclusions from their own failure that maths is difficult.

Misconceptions about the nature of maths have also been investigated. Gourgey (1992:10) states that many learners hold misconceptions about what mathematics is, which results in them performing procedures without understanding, often incorrectly distrusting their own intuitions and feeling powerless when they make mistakes. These misconceptions erode a learners confidence and contribute to their learning difficulties

(Gourgey 1992:10). Sutton (1997:44) states that people misunderstand that in meeting the challenge of the difficulties they experience with maths creates an opportunity to learn life skills.

There is evidence that different cultural groups have different attitudes to maths achievement. Stevenson (1987:28), in a study showing the difference between American and Asian approaches to maths, shows that Americans believe one is either born with a mathematics ability or not. Asians believe mathematics success is a result of hard work, perseverance and hours of study and believe the virtue of effort is the avenue for accomplishment (Stevenson 1987:28). In a study, Wither (1988:51) showed a significant relationship between perseverance and maths achievement.

A learner's personality has been cited by some researchers as having an effect on achievement. Tobias (1978:91) states that the differences in how learners cope with uncertainty, whether they can tolerate a certain amount of floundering, whether they are willing to take risks, what happens to their concentration when an approach fails, and how they feel about failure determine how well they will achieve. Attitude and self-image, particularly during adolescence when the pressures to conform are important, can result in negative attitudes that can inhibit intellect and keep one from learning what is within one's power to understand (Tobias 1978:91). People who trust their intuition, perceiving intuition as flashes of insight into the rational mind, rather than emotional, irrational thoughts are less maths anxious (Tobias 1987:63). Gierl and Bisanz (1995:155) showed that problem solving anxiety related negatively to intrinsic value, confidence and attitude towards success.

Positive experiences and a learner's interest and enjoyment of maths also have an effect on achievement. Wither (1988:51) states that the influence of the enjoyment and value that a learner places on maths will significantly affect achievement. In a study by Le Fevre, Kulak and Heymans (1992:282) it was shown that learners with positive views towards maths rated their skill as high whilst those with negative views indicated that they were anxious about and avoided maths. Stuart (2000:333), in a study, gave students the opportunity to relate their best and worst experiences with mathematics. Positive experiences included good grades, awards, teacher praise and overcoming mathematical difficulty. Worst experiences included failure, criticism and difficulties yet to be overcome.

It can be concluded from the above contributions of various researchers that attitudes, perseverance and personal experiences have an effect on a learner's achievement in mathematics.

2.2.4 Reasons for poor achievement

A limited number of researchers have cited reasons for poor achievement. These will be outlined in the following paragraphs.

Gourgey (1992:10) cites the following as reasons for poor achievement for many learners.

- Maths is emotionally charged, evoking strong feelings of aversion and fear of failure.
- Maths is seen as subject to be performed by applying algorithms dictated by a higher authority, rather than understanding underlying principles that are logical.
- Distrust of own intuitions.
- Feelings of being powerless when mistakes are made and not knowing how to correct them.

Russell (1995:15) believes that learning requires personal effort and learner's need to understand that teachers, parents and peers cannot do the work required of the learner.

In the above sections it can seen that increased anxiety results in decreased achievement. Teaching methods have an effect on maths achievement, and it was noted in particular that the Kumon method resulted in increased achievement. A learner's attitudes and personality also affects achievement. In the next section different teaching methodologies will be discussed in more detail.

2.3 TEACHING METHODOLOGY

The sections that follow will deal specifically with traditional teaching approaches, the outcomes-based teaching approach and the Kumon method. The causes and effects of instructional methods will be discussed as well as learning styles and parental involvement.

2.3.1 Traditional teaching approaches

In a comparison between the traditional "old" and outcomes based education (OBE) "new" approach by the Department of Education (1997:6), the following points define the traditional approach to learning in South Africa:

- Passive learners.
- Exam-driven.
- Rote-learning.
- Syllabus that is content-based and broken down into subjects.
- Textbook/worksheet-bound and teacher centred.
- Syllabus is rigid and non-negotiable.
- Teachers are responsible for learning; motivation is dependent on the personality of the teacher.
- Emphasis is on what the teacher hopes to achieve.
- Content is placed into rigid time-frames.
- Curriculum development is not open to public comment.

2.3.2 Outcomes-based teaching approach

In general, the outcomes based approach (OBE) to learning for South Africa can be summarised as follows:

- Active learners.
- Learners are assessed on an on-going basis.
- Critical thinking, reasoning, reflection and action.
- An integration of knowledge, learning relevant and connected to real-life situations.
- Learner centred, teacher is facilitator, teacher constantly uses groupwork and teamwork to consolidate the new approach.
- Learning programmes seen as guides that allow teachers to be innovative and creative in designing programmes.
- Learners take responsibility for their learning, pupils motivated by constant feedback and affirmation of their worth.
- Emphasis on outcomes – what the learner becomes and understands.

- Flexible timeframes allow learners to work at their own pace.
- Comment and input from the wider community is encouraged.

(National Department of Education, 1997:7)

The curriculum in OBE is defined as 'Everything planned by educators which will help and develop the learner' (National Department of Education 1997:10). The curriculum is influenced by the needs of the community and includes physical resources, work programmes, assessment criteria and extramural programmes that will respond to specific needs of the community and vary from place to place (National Department of Education 1997:11). The curriculum includes eight different learning areas, one of which is numeracy and mathematics which encourages logical thinking, problem solving and analytical skills that will equip learners to cope with a changing technological environment (National Department of Education, 1997:14).

Specific outcomes were developed within OBE to indicate how the critical outcomes will be achieved in each of the eight learning areas. Within the mathematical literacy, mathematics and mathematical sciences learning area, the following specific outcomes are defined as:

- Demonstrate understanding about ways of working with numbers.
- Manipulate number patterns in different ways.
- Demonstrate understanding of the historical development of mathematics in various social and cultural contexts.
- Critically analyse how mathematical relationships are used in social, political and economic relations.
- Measure with competence and confidence in a variety of contexts.
- Use data from various contexts to make informed judgements.
- Describe and represent experiences with shape, space, time and motion, using all available senses.
- Analyse natural forms, cultural products and processes as representations of shape, space and time.
- Use mathematical language to communicate mathematical ideas, concepts, generalisations and thought processes.
- Use various logical processes to formulate, test and justify conjectures.

(Dreyer 2000:11)

Dreyer (2000:23) notes that the learning process within OBE will involve learners being given the opportunity to be creative, critical and to discover things for themselves with the focus being on the acquisition of life skills. Assessment will include self-assessment and peer assessment and will be geared towards helping learners succeed (Dreyer 2000:23).

A number of researches have studied the effects of a similar "new maths" approach in other countries. Lerner (1993:478) comments that the modern maths movement in the United States of America has the goal of leading learners to understand the number system through the process of discovery and exploration. This approach neglected some of the basic psychological aspects of learning and compounded the mathematics problems of learners with learning disabilities (Lerner 1993:478). Merseth (1993:553) in her analysis of the nature of "new math" in the United States curriculum states that the reason behind the failure of new math was that little effort was made to introduce elementary teachers to the materials and teaching approaches. Merseth (1993:553) states further that successful curricular reform requires informed staff development and engagement of teachers.

The effects of a discovery approach to maths have been discussed by the following researchers. Wu (1999:7) points out the negative outcome of having children making up their own algorithms. It is likely that one teacher checking the validity of every individual learner's algorithm in the class will let some incorrect algorithms slip through and these learners will then encounter mathematics with no understanding at all (Wu 1997:7). Wu (1999:6) states that the only negative effect of learning algorithms is that they are not taught properly and that the problem of rote learning lies within inadequate professional development and not within the algorithm. Active learning involving non-routine problems and the need to communicate about these problems leads to intense affective responses, as opposed to being expected to simply practise low-level computational skills (McLeod 1993:761). Lerner (1993:478) refers to a back-to-basics movement which is focussed on a return to intensive teaching of computational facts. Learners with learning disabilities tend to benefit from programmes that are focussed on direct teaching of calculation skills (Lerner 1993:478).

In the above section the OBE teaching approach was discussed. The outcomes for the learning area mathematical literacy, mathematics and mathematical sciences were outlined. Research has been done on the effects of a 'new maths' approach in other countries and these findings has been discussed. In the following section, the Kumon method will be detailed.

2.3.3 Kumon method of instruction

The Kumon method is a simple, methodical approach to learning which provides an effective means to develop the untapped potential of every child (Russell 1995:2). The Kumon philosophy states, 'By discovering the potential of each individual and developing his or her ability to the maximum, we aim to foster sound, capable people and thus contribute to society' (Kumon institute of education 1996:iv). The Kumon institute, established in 1958, has shown learning occurs most efficiently when the level of material to be learned corresponds to the learners level of ability and the rate of progress is controlled by the learner. Because learners set their own pace, there is no pressure to compete and they can enjoy learning. The Kumon philosophy is that there is a natural learning sequence in many subjects, especially maths, and that study should follow this order. The Kumon materials or worksheets are composed of thousands of small steps that guide a learner little by little. A student only advances to more difficult levels once complete mastery of the previous steps has been achieved. This provides a solid foundation without any gaps in learning. The Kumon instructor guides each learner through the materials, working at their own pace and to different levels within the programme. The way to advance to higher levels is to have completely grasped the previous ones and this is determined through monitoring both the speed and accuracy in which the learners work their Kumon worksheets (Russell 1995: 12-15).

The Kumon method promotes learning to an individual's needs and skills. Learners start at a level which is just right for them. Those learners who have strong skills can advance as much as they want to, those with weaker skills can go back to a spot at which they can comfortably work, and once they master this they move on to the next stage (Kumon 1996:15). The way to advance to higher levels is to have completely grasped the previous ones and this is determined through monitoring both the speed and accuracy in which the learners work their Kumon worksheets (Russell 1995:19).

The following are the principles on which the Kumon method is based:

- Repetition: Repetition is important and it is believed that repetition gives learners adequate time to consolidate and master the material (Barnard 1995:1).
- Learning at individual's own pace: Kumon (1996:18) believed in nurturing and developing children's untapped potential to the maximum and that they could achieve this by learning at their own pace. In this way learning is never intimidating and the child acquires knowledge, skill and confidence (Russell 1995:18).
- Easy starting points: Learners whose study skills are insufficient for their present grade level must find the study level at which they are comfortable and have them begin study from that point (Kumon 1996:16).
- Self-learning: Self-learning helps learners develop the ability to solve problems by themselves, enabling children to grow up with a feeling that anything is within their reach if they try (Kumon 1996:18).
- Advancing beyond grade level: Kumon (1996:19) believes that if learners are able to move ahead of their grade level and experience success, their self-confidence and self-composedness will grow.
- Discipline and daily effort: Kumon's primary concern is not with raw intelligence which is innate, but with ability that can be enhanced and developed through effort, which is the goal of the Kumon method (Russell 1995:40).

The Kumon method initially involves a diagnostic or placement test. The results of this test determine the starting point that the learner can easily handle within the Kumon programme. The learner then works daily on a set of worksheets concentrating for ten to thirty minutes a day on solving the worksheets. The work is then scored and learners correct their own mistakes until they get a perfect score of one hundred. The instructor will offer explanations when necessary but the materials are designed so that learners can work independently (Kumon 1991:8).

A description of the contents of the Kumon levels according to the Kumon institute of education (1996:118-141) follows. Completion of these levels would be equivalent to a grade eight level.

Level 2A: Mastering adding up to 10.

Level A: Further mastery of addition and subtraction skills to produce instant answers.

Level B: Skills in vertical addition and subtraction.

Level C: Skills in multiplication and division.

Level D: Developing further skills in multiplication and division and division by two digit numbers. Fractions and reduction of fractions.

Level E: Performing the four operations with fractions.

Level F: Further computational skills with fractions and decimals to consolidate the general arithmetical skills necessary for studying level G which introduces algebra.

It can be seen from the above that the Kumon method has specific principles that underlie the manner in which the worksheets are completed by learners. The philosophy of developing the potential of each individual is inherent in the programme. The causes and effects of various instructional methods as previously researched will be examined in the following section.

2.3.4 Causes and effects of various instructional methods

In a study conducted by Newstead (1998:58), learners' maths anxiety was compared with different teaching approaches, either traditional or alternative. A traditional approach involved learners being taught by pencil-and-paper methods of computation, by teacher demonstration followed by individual practice. Word sums were only given as application after practice and mastering of methods. In the alternative approach learners were required to use and discuss their own strategies for solving word sums, which are used as the principal vehicle for learning. Of primary importance was the solving of non-routine problems and discussing strategies in small groups. A finding of the study by Newstead (1998:68) is that pupils exposed to the alternative approach responded with less overall anxiety and less social anxiety than those exposed to the traditional approach. This shows that learners that are allowed to construct their own strategies for problem solving and can interact with their peers in a supportive way enables them to express ideas without the risk of embarrassment or humiliation.

A different conclusion was obtained in research by Norwood (1994:253) who found that learners with high levels of maths anxiety do not trust their instincts and therefore do not like to work independently or through a discovery-type approach to learning maths.

Learners felt frustration and pressure and were not interested in knowing the "why" in maths; their main concern was with getting their maths "right". Norwood (1994:248) postulates that once success is experienced, learners may be more interested in understanding the skills they have learned and would know the difference between "knowing" and "knowing why". The results of her study show that learners with high mathematics anxiety are more comfortable with a highly structured, algorithmic course than with a less structured, conceptual course in developmental arithmetic (Norwood 1994:248).

In an analysis of the dichotomy between basic skills versus conceptual understanding, Wu (1999:2) concludes that the fluency of executing basic maths skills is essential for further progress and understanding in maths. Furthermore, the automaticity in putting basic skills to use, frees up mental energy to focus on more complicated problems. Wu (1992:2) states that an understanding of mathematics lies within the skills and that skills and understanding are intertwined.

The following models for mathematics teaching are discussed by Gervasoni and Pearn (1996:15) to support learners that have been identified as at risk.

- Recovery education in mathematics – involving the identification, after one year of school, of learners who are unable to benefit from mainstream classroom teaching. These learners are then given intensive individualised teaching to advance them.
- Remedial mathematics education – this would be provided to groups of learners where specific mathematics weaknesses are identified.
- Mathematics intervention model – learners in years one and two are clinically interviewed to identify specific weaknesses in their numerical knowledge and then placed in groups of three or four to receive intensive teaching in a programme relying on verbal interactions between teacher and learner and between learners. A wide range of manipulatives and maths games need to be utilised.
- Mainstream classroom approach – the teacher identifies learners requiring intervention and takes steps within the classroom to assist them.

The above models all have in common the necessity of early identification of learners which are mathematically at risk. Their weaknesses need to be addressed by specific

teaching methods, either within mainstream education or specialised remedial intervention, individually or in groups.

Horowitz (1987:39), in relating to learning disabled maths learners, describes a teaching method that involves patient repetition to solidify a way to deal with a problem, often using concrete materials for explanation. Gourgey (1992:11) describes a model for tutoring maths to learners who have a history of anxiety and poor performance. This includes dialogue, analysis of error, response to affective as well as cognitive needs, re-education of the learning process and use of real-life applications. The teacher should attend to the performance as well as the student's beliefs about maths and problems should be addressed on a one-to-one basis so that individuals can reveal their doubts and fears (Gourgey 1992:11).

In the above section conflicting conclusions from different researches were outlined. The dichotomy of basic skills versus conceptual understanding as a method to reduce anxiety was described. The effect of various other teaching models to address maths problems experienced by learners was outlined. In the following section different learning styles of learners are addressed.

2.3.5 Learning styles

Literature describes various learning styles. Maree (1992:60) states that mathematics essentially requires an active approach, and that paying attention is not enough. Problems are not simply figured out passively, but the learner must involve his whole person into solving maths problems, write, think, do, propose, imagine, fantasize and make sketches (Maree 1992:60). Stuart (2000:334) showed that having learners develop a personal plan of action to address their areas of strength and weakness, gives them some control of their maths education and empowers them as individuals.

Schneider (1988:14) points out that it should be recognised that everyone learns in different ways. Children only reach the age of abstract reasoning between the ages of eleven and twelve and until then should learn by "manipulative or hands on" learning rather than abstract reasoning (Schneider 1988:14).

The presence of individual learning styles is an aspect that should be taken into account if effective methods of teaching are too be presented to individuals. In the final section, the effects of parental involvement will be discussed.

2.3.6 Parental involvement

Another important aspect that needs to be discussed is the effects of parental involvement. Sutton (1997:49-50) gives guidelines on how to improve maths performance and believes that parents should know that it takes time to learn things and that many repetitions through the same material might be needed before it is learnt. Parents should understand that to struggle is okay and when this acceptance comes from parents, learners can relax enough to learn new concepts. If parents believe that struggling implies stupidity or laziness, their children feel the tension which restricts learning. Furthermore parents should resist explaining the struggle as an in-born difficulty in mathematics, genetics or otherwise. They should not affirm "I was never very good at maths, either". Parents need to help their children believe that they can meet the struggle with the belief that they can overcome it.

In a study conducted by Stuart (2000:333) learners had ideas about how they perceived their parents thoughts about maths but these did not necessarily correlate with their own. A learner's likes or dislikes of mathematics depended on their own experiences. It was found however, that learners have more positive experiences with maths if their parents are supportive and helpful in their endeavours.

2.4 CONCLUSION

In this chapter the results of a literature study on mathematics anxiety, mathematics achievement and teaching methodology were detailed. The various definitions and nature of maths anxiety were discussed. This led to an analysis of the causes, consequences and treatments of maths anxiety. The various instruments used for measuring maths anxiety were mentioned and the SOM which is used in this research was introduced.

Mathematics achievement was discussed in relation to anxiety and teaching methods. A result of research done specifically on the Kumon method which is used in this research

was cited. Attitudes to maths achievements as well as the reasons for poor achievement were investigated.

Finally, specific mathematics teaching methodology was discussed. The traditional approach and the OBE approach in the recently changing curriculum of South Africa were outlined. Research conducted in other countries which had previously adopted similar changes in their curriculum was noted. The Kumon method of instruction was detailed. An explanation of the diagnostic test used as well as the relevant Kumon levels for this study were detailed for the purposes of reference and understanding of results obtained in chapters three and four. The causes and effects of various other instructional methods used in previous research were noted. Finally the importance of the effects of individual learning styles and parental involvement was mentioned.

In the next chapter the empirical investigation is detailed. The method of investigation as well as the research design will be explained. The case studies will be described and a qualitative interpretation of each given.

CHAPTER 3

EMPIRICAL INVESTIGATION

3.1 INTRODUCTION

In this chapter different methods of investigation are discussed. The research design used in this research, which includes the case study and literature study, is detailed. The different test media used and a description of the investigation are described. Finally, the findings of the case studies are reported.

3.2 METHOD OF INVESTIGATION

The research design aims to source and analyse previous research in the areas of mathematics anxiety, mathematics achievement and teaching methods. The relationship between these variables is investigated. The aim of the empirical investigation is to investigate the effects of the Kumon programme as a structured intervention programme. This involves the analysis of different case studies with respect to changes in maths anxiety and achievement. The cases are analysed within two groups, the experimental group, having participated in the programme and the control group, having had no intervention.

3.2.1 Qualitative and quantitative research

In this study a qualitative research design is used. The research focuses on the study of different cases. By analysing different cases, it is possible to see common trends and differences. Advantages of a case study design include the ability to gain a perspective of the participants involved in the study within their natural environment. This perspective includes their ideas, feelings, aspects of their personality as well as performances on quantifiable tests. Case studies can form the basis for developing theories and designing educational interventions (Gall, Borg & Gall 1996:585). In the following section the characteristics of qualitative and quantitative research designs is outlined.

3.2.1.1 *Qualitative research*

McMillan and Schumacher (1997:11) outline the following characteristics that define qualitative research:

- Explicit description of data collection and analysis.
- Detailed description of phenomenon.
- Inductive reasoning applied to evidence gained from sources.
- Synthesised interpretations.
- Extensions of understandings by others.

3.2.1.2 *Quantitative research*

As described by McMillan and Schumacher (1997:11) quantitative research involves the following:

- Explicit description of data collection and analysis procedures.
- Scientific measurement and statistics used.
- Deductive reasoning applied to numerical data.
- Statements of statistical relevance and probability.
- Results replicated by others.

3.2.2 Research design

Different aspects of the research design are detailed in the following paragraphs.

3.2.2.1 *Case study*

In this research a case study research design is used. The case study is an appropriate research method when the uniqueness of the individual needs to be taken into account (Neale & Liebert 1986:25). The case study is anchored in real-life situations which results in a holistic account of the phenomenon, providing insights that can help structure further research (Merriam 1988:32). Case studies vary in their nature; some are intensive descriptions of a program, event or process and some go beyond descriptive and are interpretive in nature, the data being analysed and interpreted. Case studies can be evaluative in that they assess the merits of a particular practice or program. Most case studies are a combination of description and interpretation, or description and evaluation (Merriam 1988:35). A case study, whose results negate an assumed universal law or

relationship, is evidence enough to review the law or relationship and the underlying assumptions (Neale & Liebert 1986:28).

A cross-case analysis is used in this research. Each case is first treated as a comprehensive case itself and then an interpretation based on evidence from these cases is presented (Merriam 1988:154).

Criterion sampling involves the selection of cases that satisfy a specific criterion. This strategy is particularly useful in studying educational programmes (Gall, Borg & Gall 1996:234). In this research, learners presenting with high maths anxiety will be identified for the case studies.

A pretest-posttest control-group design is used. Two groups participate in the research. The experimental group receives a specific treatment whilst the control group receives no treatment. In this way internal validity is increased. The design involves administration of a pretest which measures the dependent variable, implementation of the experimental treatment (independent variable) and the administration of a posttest that measures the dependent variable again (Gall, Borg and Gall 1996:491-494). In this research, the pretest-posttest design is used twice, firstly for the dependent variable of mathematics anxiety and secondly for the dependent variable of mathematics achievement. The independent variable in both cases is the participation in the Kumon mathematics programme. Results are analysed in terms of the effects of the Kumon methodology on mathematics anxiety and mathematics achievement.

In this case study, triangulation, which involves multiple methods, is used to collect data for analysis. The method of triangulation combines methods such as interviews, observations and physical evidence to study the same unit. In this way, quantitative data from other instruments can be used to support findings from qualitative data (Merriam 1988:68-69). Multimethods within a case study design are particularly useful and appropriate when a programme or innovation is evaluated or studied (McMillan and Schumacher 1997:396). The research design of this case study is complex in nature and supports the purpose of the study where quantitative methods are used to undertake a qualitative evaluation.

3.2.2.2 *Literature study*

A literature study, focusing on previous research with respect to mathematics anxiety, mathematics achievement and teaching methodology was conducted. The findings of previous research are analysed and summarised. This allows for the results of this case study to be compared to previous research.

3.2.3 Test media used

The test media that were used in the case studies are discussed. These include the study orientation questionnaire in maths (SOM), Kumon diagnostic mathematics tests, analysis of school marks and interviews. The test media are used twice and on two groups, the experimental and control groups. The media are firstly used before the beginning of the Kumon programme and secondly after working on the programme for a period of five months. This enables the researcher to analyse and evaluate the results obtained.

3.2.3.1 *SOM*

In this case study, the study orientation questionnaire in maths (SOM) is used. The questionnaire is used to identify study orientation in six fields, one of which is mathematics anxiety. The description and rationale of the fourteen questions which comprise the field of mathematics anxiety is described by Maree, Prinsloo and Claassen (1997:7) as follows: Panic, anxiety and concern are manifested in the form of aimless, repetitive behaviours such as biting of nails and excessive sweating. When a learner is emotionally disturbed, his motivation in mathematics is negatively affected. Furthermore a learner's cognitive functioning and risk taking attitude is delayed when emotional lability is present in the mathematics class.

A high percentile ranking for mathematics anxiety is an indication to the relative absence of mathematics anxiety (Maree, Prinsloo & Claassen 1997:15). Percentile rankings of thirty or below were considered as presenting with high mathematics anxiety.

3.2.3.2 *Kumon diagnostic test*

A diagnostic test is a form of an achievement test that is used to identify a learners strengths and weaknesses in a particular subject. They usually focus on the low end of

the achievement spectrum and provide information of the achievement of skills that the subject involves (Gall, Borg & Gall 1996:266).

The Kumon P4 mathematics diagnostic test was used to ascertain level of mathematics achievement. The standard time allowed for completion is fifteen minutes and the total number of questions is sixty. Questions include horizontal and vertical addition and subtraction, multiplication of single digit and double digit numbers and division by both single digit and double digit numbers, including remainders. The results of the test ascertain the starting level on the Kumon programme.

3.2.3.3 *Analysis of school marks*

The school marks were taken from the teacher's record book. For the purposes of this research the marks at the end of the first term and the end of the second term were used for comparative purposes. The first term results included an average of all the class tests and assignments whilst the second term results included an average of the class tests as well as the June exam. Kumon was introduced to the experimental group of grade eight learners at the beginning of February and continued until the end of July. Analysing the school marks during this period allowed for more detailed study of the cases.

3.2.3.4 *Interviews*

There are different types of interviews ranging from highly structured, questionnaire driven interviews at one pole to open-ended, conversational formats on the other (Merriam 1988:73). In highly structured interviews, questions and the order of the questions are determined ahead of time. Semi-structured interviews are guided by a list of questions or issues to be explored but the exact wording and order is not pre-determined. Unstructured interviews involve no pre-determined criteria and are essentially exploratory (Merriam 1988:74).

A pre-test unstructured interview (telephonic) with the parents of the identified learners was conducted. The aim was primarily to explain the programme, get permission for participation in the programme and get some past history of the learner. A structured post-test interview was conducted with the experimental group (appendix A) and the control group (appendix B).

The rationale behind the questions asked in appendix A is as follows:

1. To determine whether Kumon was done on a daily basis, underlying self-discipline and self-motivation.
2. Investigation of self-motivation and personality.
3. Investigation of personality and daily study habits. Underlying self-discipline and self-motivation.
4. Investigation of underlying feelings of boredom and perceived unnecessarily being held back from a faster rate of progression.
5. How the learner perceived the outcomes of participation in the programme.
6. Because the Kumon worksheets that the learners were completing were below their class level, it was necessary to ascertain how they felt about the easy starting levels.
7. How the learner perceives the methodology of the structured worksheets.
8. How the learner perceives the methodology of self-learning.
9. To determine the underlying feelings towards maths.
10. To determine if there is perceived anxiety towards maths and maths tests.
11. How the learner perceives any changes to how he feels about maths because of participation in the programme.
12. What aspects the learner identifies as having changed because of participation in the programme.
13. To determine the motivation and commitment of the learner to continue to higher levels of study.
14. To determine what the perceived differences would be if the learner had attended a Kumon centre twice a week, rather than receiving the worksheets without any other interaction with a supervisor or other Kumon students.
15. To ascertain the level of interest and belief in ability to pursue a career involving the sciences and mathematics.
16. How the learner perceives the traits of confidence, speed, accuracy, test results, self-esteem, belief in ability, daily study habits and mental alertness both before participation in the programme and after. This information can be analysed and used for comparisons.

The rationale for the questions asked in appendix B is as follows:

1. To determine the underlying feelings towards maths.

2. To determine whether there is any perceived anxiety towards maths and maths tests.
3. To determine if the learner has been exposed to any other programme or assistance which could have affected the post-test results obtained.
4. To investigate aspects of the learner's personality.
5. To determine levels of self-motivation and willingness to address anxiety and achievement.
6. To ascertain the level of interest and belief in ability to pursue a career involving the sciences and mathematics.
7. How the learner perceives the traits of confidence, speed, accuracy, test results, self-esteem, belief in ability, daily study habits and mental alertness both before participation in the programme and after. This information can be analysed and used for comparisons.

3.2.4 Description of investigation

At the beginning of February 2002, sixty eight grade eight learners, all from the same school and living in the same socio-economic area participated in answering the SOM questionnaire to identify the presence of mathematics anxiety. They also completed the Kumon P4 diagnostic test to ascertain level of mathematics achievement. Of these learners thirteen were identified as having high mathematics anxiety. From these learners, five were randomly chosen to participate in the Kumon programme and five were chosen to act as a control group. None of the learners were known to the researcher, thereby excluding any bias.

The parents of the identified learners were contacted telephonically when the programme was explained and permission granted for their participation. The scholastic history of the learners and an analysis of their school marks were noted only after the post-tests, further ensuring no bias with choice of learners to participate in the programme.

The learners on the Kumon programme started working at the beginning of March and continued for a period of five months, until the end of July 2002. The learners exchanged work on a weekly basis, handing in completed work and receiving new work for the week. The learners had to time their work daily. The work was marked by the researcher when it

was handed in and any necessary corrections done. There was no other interaction and learners completed their worksheets entirely as self-study. During this period, there was a short Easter break and a three week July holiday. At the beginning of August 2002, post-tests were done with the learners on the Kumon programme as well as the control group. A post-test interview was conducted both with the experimental group and the control group (see appendix A and B respectively).

Results of two of the learners have not been included for the following reasons:

- HA, a learner from the control group could not understand and follow the post test interview. His home language is Xhosa and his verbal abilities in English very limited. The researcher felt that this would have affected his understanding and answering of the anxiety questionnaire, making these results invalid.
- DM, a learner in the Kumon group started off the programme well and then stopped doing the work. She moved house and her mother became very ill, being hospitalised for a long period followed by another serious illness in the family. She was often absent from school and could not cope emotionally and discontinued the programme.

The class teacher knew the ten learners who were identified, but was unaware of the learners who were on the programme and those who were in the control group. This helped to ensure that all learners were treated the same in the classroom situation. It also allowed for an unbiased, unstructured post test interview with the teacher regarding changes she observed amongst the ten learners at the beginning of the third term. The researcher used the teacher's record book for an analysis of marks during the first and second terms. The research results include a 1st term average composed of small class tests, and the 2nd term average which includes the June exam result.

3.3 LEARNERS ON THE KUMON PROGRAMME (EXPERIMENTAL GROUP)

In this section the case studies of the learners of the experimental group are discussed. An analysis of each case study in terms of mathematics anxiety, mathematics achievement and perceptions of study methodology is presented.

The specific study methodology as described in chapter three is the Kumon method. The important aspects to note with regards the philosophy of the method are the following:

- Individualised learning: Learners work at their own pace and at their own level of ability.
- Structured learning materials: The worksheets are designed to lead a learner through finely graded steps from an easy starting point to advanced levels. The worksheets are presented in specific levels, with twenty books, each composed of ten pages, totalling two hundred worksheets in each level. An outline of the contents of the levels completed by the learners is now given for clarity of understanding and reference. A level of D21, for example, would describe the twenty first page of two hundred worksheets in level D.

  Level 2A: Adding up to +10; Basic subtraction

  Level A: Mental addition and subtraction to produce "instant answers"

  Level B: Skills in vertical addition and subtraction

  Level C: Fundamental skills in multiplication and division

  Level D: Further development of multiplication and division skills including division by two and more digits. Reduction of fractions.
- Learning through mastery: Learners are required to complete worksheets within a standard required time and a specific degree of accuracy before moving through the programme. The learner is therefore required to do a lot of repetition to ensure mastery of maths skills. Learners are responsible for correcting their own mistakes to a level where one hundred percent accuracy is achieved.
- Self-learning: Learners are required to work on their own, with the premise that the ability to master basic skills is a pre-requisite to understanding mathematical concepts. This concept involves self-discipline and fosters self-motivation and strong study habits.
- Develop the potential of every learner: By allowing the learner to experience successes and mastery of difficult concepts, their confidence and self-esteem are increased.

3.3.1 Case study ND

Chronological age (C.A.) at the start of the programme:13 years 7 months

Scholastic history: ND attended one year at pre-school before going to the junior primary for 3 years. This was followed by a senior primary for 4 years. Both schools are in the same geographic area. He has not repeated any grade. His final grade 7 report rated his maths skills as 4 (on a scale 1-5, with 5 being excellent). His work habits, attitude and self-discipline were rated as satisfactory. His school attendance is good.

In a parent telephonic interview, ND's mother stated that ND always had a flair for numbers. He has never experienced any problems related to maths and she was surprised that he presented with maths anxiety. He never put off doing his maths homework, completing it before any other homework. She was happy that he participates in the programme.

Results

Test	Pre-test result	Post-test result
Anxiety rating	15	85
Kumon P4 diagnostic test	Time: 15 minutes Accuracy: 53/60	Time: 13 minutes Accuracy: 57/60

ND started Kumon on level A and completed up to level D21. He repeated some books on level B and level C. ND did his work conscientiously. It was always timed and with minimal errors.

In a post-test interview compiled for the experimental group the following points were noted in response to questions asked (see appendix A). The responses that follow compare with the questions asked in appendix A.

1. He did his work daily, at approximately the same time in the afternoon.
2. The reason he did it was that he wanted to better his marks. His mother never had to remind him; he also felt it was his obligation to do it. He never has a problem with doing homework, even his schoolwork.
3. He felt no different about doing his homework in the holidays. It was, to him, just the same as any other day, and there was little else that he did in the holidays.
4. Repetition did not affect him, most of the time he was unaware of repeating.

5. He felt it definitely helped him a lot. "This term I got over 90%, previously I got between 60% and 70%. I don't get so stuck anymore, finishing off problems completely before going on to the next one".
6. He felt it was better to start from easier work to harder. "I found that harder things became easier to work hard because started with easier stuff. It is not just lumped together, a whole bunch of difficult work".
7. He liked the way the work was graded from easy to hard and that there was lots of practise.
8. He liked the fact that he could be independent with his work, not relying on others or external motivation.
9. He likes everything about maths and dislikes nothing.
10. He does not worry about maths or maths tests.
11. He feels much more confident after doing Kumon.
12. What changed the most for him was, "Confidence then marks, maths is much easier to do now".
13. Given the choice, he would continue with the programme.
14. He felt that by attending an after school centre would have made no difference in how he did the programme or his results. "It's just doing the books that counts".
15. He sees himself following a career in architecture, and needing maths and science.
16. The following traits he rated in terms of bad, average, good.

Trait	Before	After
Confidence (maths)	average	good
Speed (maths)	good	good
Accuracy (maths)	bad	average
Test results (school)	average	good
Self-esteem	good	good
Belief in ability (maths)	good	good
Daily study habits	good	good
Mental alertness	average	good

His class teacher commented that she saw a big difference in ND's confidence. She described him always sitting quietly at the back in a corner and never participating in class

or asking questions. He is now forthcoming, often coming to the front desk to ask questions. His first term average was 83% and his second term average was 91%.

Qualitative interpretation of the case study: ND

Maths anxiety	Maths achievement	Teaching method
• Decreased by a scale of 70 points on the SOM. • Does not worry about maths or tests	• Accuracy increased by 7% on the post test. • Speed increased by 2 minutes on a 15 minute test. • School marks went from 83% to 91%	• Better to start from easy and increase to harder work. • Repetition was not a problem. • He would continue the programme • "Doing the books that counts" – more than attending a centre

ND is a conscientious worker, doing work daily and in a routine manner. He showed self-motivation, and a level of commitment. He rates his belief and self-esteem, both before and after participation in the Kumon programme, to be good. His Kumon progress was from level 2A to level D21. He felt what changed the most for him was firstly his confidence then his marks. His teacher noted a significant increase in his confidence.

He believes the following traits have improved:

- Confidence (maths)
- Accuracy (maths)
- Test results (school)
- Mental alertness

Conclusion: Maths anxiety decreased and maths achievement increased after participation in the Kumon programme.

3.3.2 Case study CB

Chronological age (C.A.) at start of the programme: 13 years 1 month
Scholastic history: CB attended pre-school and then two primary schools, changing from one to the other after his 2nd grade. Both schools are in the same geographic area. He has not repeated any grade. He has a history of bad behaviour from the time he started school. He was assessed by a clinical psychologist in 1995 and diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). His average IQ was recorded as 107. He was placed on Ritalin at the beginning of his grade 2 year and is still on the medication daily. Reports from teachers say that without Ritalin he becomes very disruptive. His grade 7 school report rates his maths as excellent with his attitude to work satisfactory and his behaviour as needing attention.

In a telephonic interview with CB's mother, she felt that CB did not experience any negativity towards maths. She felt that he presented with no learning disabilities, none had been brought to her attention by any school. She informed me that he was on Ritalin and was keen that he participates in the programme.

Results

Test	Pre-test result	Post-test result
Anxiety rating	30	50
Kumon P4 diagnostic test	Time: 15 minutes Accuracy: 45/60	Time: 15 minutes Accuracy: 48/60

CB started the Kumon programme on level A and completed up to level C71. CB started off the programme very well. When he got to level B and the worksheets that included vertical subtraction problems, he started to miss out pages and the odd problem on a page. When asked about his reasons for doing this, he said "The minuses are a bit difficult – the rest is easy". He did not hand in work for 2 consecutive weeks, and then caught it all up and handed it in. He did not always time his work which resulted in repetition of some worksheets, but his accuracy was generally good.

In a post-test interview compiled for the experimental group the following points were noted in response to questions asked (see appendix A). The responses that follow compare with the questions asked in appendix A.

1. He did his work daily, before doing any other homework.
2. The reason he did his Kumon daily was because he knew he had to hand it in, and once done it was out of the way. He did it because he was asked to do it. It became a routine and then he never had to be reminded.
3. He felt very bad about doing Kumon in the holidays. "I didn't like it at all. In the July holidays we went away for 2 weeks and I didn't take it with. I feel that holidays are for enjoyment".
4. Repetition did not worry him. "I feel I know things better because of it".
5. He felt Kumon did help him. "You get used to it especially because of the repetition of the same type of thing. Things become more automatic, especially the tables".
6. He felt the learning materials were relevant. "Some stuff was difficult and I had to think about it". He felt it was a good thing to start easy to warm up and then become harder. "If I didn't have easy first then it would have taken so much longer because my brain would have to be thinking too much".
7. CB found it easy to work through the worksheets, especially because they "started from easy stuff".
8. He felt it was OK to do it on his own, but did not like doing work in the holidays.
9. He likes maths when he can do it well and fast. He dislikes long and difficult work.
10. He does not worry about maths or tests, " not anymore at least". "I used to feel that I had to pass and didn't know whether it would be easy or difficult".
11. He feels more positive about maths now, " because I know I can do it".
12. What changed the most for him was that he got faster.
13. If given the choice, he would continue with Kumon, but only if he spent no more than 20 minutes a day on it.
14. He felt that attending a centre would not be more beneficial. "It would take up more time, to walk there and walk home. Just doing it is important".
15. He sees himself as probably doing a career in computers. "Maths is everywhere".
16. The following traits he rated in terms of bad, average and good.

Trait	Before	After
Confidence (maths)	average	good
Speed (maths)	bad	good
Accuracy (maths)	average	good
Test results (school)	average	good
Self-esteem	average	good
Belief in ability (maths)	bad	good
Daily study habits	bad	good
Mental alertness	average	good

CB's teacher noted that he was more confident in the classroom. His first term average was 78% and his second term average was 60%.

Qualitative interpretation of the case study: CB

Maths anxiety	Maths achievement	Teaching method
• Decreased by a scale of 20 points on the SOM. • Doesn't worry about maths or tests anymore.	• Accuracy increased by 5% on the post test. • Speed remained at 15 minutes on the post test. • School marks went from 78% to 60%	• Better to start from easy and increase to harder work as his brain didn't have too much to think about. • Repetition was a good thing. It made things automatic, especially tables. • "Doing the books that counts" – more than attending a centre • He would choose to continue, but only if it didn't take too much of his time. • Just doing the work

		was important and not necessarily attending a centre

CB reports that he did his work regularly and that it became a routine. He did not have a high level of commitment as he felt it wasn't right to do work in the holidays, and did not complete work assigned for the holidays. He also missed out some pages and did not always time his work. His work was irregularly handed in. His scholastic record reveals a history of disruptive behaviour and a diagnosis of ADHD. He takes Ritalin daily.

His Kumon progress was from level A to level C71. He believes the greatest area of difference for him was that his speed improved. His teacher noticed an increase in his confidence.

He believes the following traits have improved:

- Confidence (maths)
- Speed (maths)
- Accuracy (maths)
- Test results (school)
- Self-esteem
- Belief in ability (maths)
- Daily study habits
- Mental alertness

Conclusion: Maths anxiety decreased and maths achievement increased by a small amount on the Kumon test but decreased at school. His perception of his test results having increased from average to good does not coincide with the fact that his school average decreased.

3.3.3 Case study SM

Chronological age (C.A.) at start of the programme: 13 years 6 months

Scholastic history: SM attended preschool followed by one primary school from grade one through to grade seven. In grade one he was assessed and attended speech lesson for language and auditory perceptual problems. He was identified as having poor concentration and put on a trial period of Ritalin in grade two. There was no apparent difference between the Ritalin and placebo and Ritalin was discontinued. His grade seven report rates his maths performance as satisfactory.

In a telephonic interview with SM's mother it was noted that SM seems to battle with reading but enjoys maths. His mother was very willing that he participate in the programme.

Results

Test	Pre-test result	Post-test result
Anxiety rating	25	40
Kumon P4 diagnostic test	Time: 15 minutes Accuracy:40/60	Time: 15 minutes Accuracy: 43/60

SM started the Kumon programme on level 2A and completed up to level C31. SM applied himself well and responsibly throughout the programme. He worked thoroughly, scoring mostly 100% for his worksheets. When the workload at school became a lot for him with projects and tests due at the end of term, he would come and negotiate a work strategy for the completion of his Kumon worksheets. This meant, at times, halving the number of worksheets to be completed within certain weeks.

In a post-test interview complied for the experimental group the following points were noted in response to questions asked (see appendix A). The responses that follow compare with the questions asked in appendix A.

1. He did his work about every 2nd day, and then would catch up by doing double in one sitting.
2. He did his work because he thought it would help him with his maths and he wanted to do it. His mom constantly asked him whether his Kumon had been done. "She basically forced me to do it for my own good".

3. He felt it was OK to do Kumon in the holidays, although it was done irregularly. He would do it if he had nothing else to do as he and then "caught up" on days missed.
4. Repetition he did not worry about, "I just did it".
5. He felt it did help him a lot. "I used to be slow and now am faster. Sometimes in tests when under pressure for time I mess up. This is because I become worried that I won't finish and then lose marks. But by rushing I mess up and lose even more marks. Kumon helped me because I am now faster".
6. "It was good to do easy levels, but my friends would tease me about the easy work when they saw me doing it at home. This made me feel stupid amongst my friends, but inside I didn't really feel stupid. For me it was better to start from easy and step by step rather than being lumped with grade eight stuff at the beginning". He used to compare his worksheets with those of the other learners in the programme and realised they were doing harder levels than him. "This made me feel I was the worst of the group".
7. He liked the way the worksheets went from easy to harder. "It made it easier to manage the harder stuff later".
8. SM felt it was OK to do Kumon on his own, but his mom was behind him, constantly reminding him to his work. If this was not the case he would not have had the motivation to do his work. He did not manage the self-discipline to do his work daily.
9. He likes maths; it is one of his best subjects because he likes to figure things out. He hates maths when no explanations are give and "you are just expected to do it". He asks for help from his father.
10. He does get worried during the time that tests are being handed out. This is because he worries whether he will finish in time when he sees the length of the test paper. He does not worry the days prior to test, only when he actually sees them handing out the papers.
11. Nothing has changed about how he feels about maths because of doing the Kumon.
12. What changed for him because of participation in the programme was the realisation to "just do it and it will get over with. I don't put off doing things so much anymore".
13. Given the choice he would continue with the programme because "it will help me, it has benefited me".

14. He felt that it would have better for him to attend a centre because his mother would have forced him more to do it then. "More effort would have been used to get me there and she would have made sure I did it everyday".
15. He sees himself as being an electrician. His father always tells him he needs maths and science.
16. The following traits he rated in terms of bad, average or good.

Trait	Before	After
Confidence (maths)	average	good
Speed (maths)	bad	average
Accuracy (maths)	average	average
Test results (school)	average	good
Self-esteem	average	average
Belief in ability (maths)	average	good
Daily study habits	good	good
Mental alertness	average	average

His teacher noted that SM was more confident in the classroom. His average marks in term one was 63% and those of his second term, 85%.

Qualitative interpretation of the case study: SM

Maths anxiety	Maths achievement	Teaching method
• Decreased by a scale of 15 points on the SOM. • Worries when tests are being handed out for fear of not finishing in time. • Rushes to finish then messes up even more.	• Accuracy increased by 5% on the post test. • Speed remained at 15 minutes on the post test. • School marks went from 63% to 85%	• Good to start from easy and increase to harder. • Repetition was not a problem for him. • He would choose to continue because he felt it benefited him. • He felt it would be better for him to be at

		a centre because there would be more effort to get the work and therefore more effort in doing it.

SM judged himself on how was doing in relation to others on the programme. His comments from his friends about the easy work made him feel stupid. He was not regular with how he did his Kumon, in the holidays. He would only do it if there was nothing else to do. He was not self-motivated and his mother would often prompt him to do it. Despite this, he felt it had helped his speed a lot.

SM's Kumon progress was from level 2A to level C31. What changed for him was not too put things off, but to get on and do what had to be done. His work ethic improved. His teacher noticed an improvement in his confidence.

He believes the following traits have improved:

- Confidence (maths)
- Speed (maths)
- Test results (school)
- Belief in ability (maths)

Conclusion: Maths anxiety decreased and maths achievement increased after participation of the programme.

3.3.4 Case study RJ

Chronological age (C.A.) at start of programme: 14 years and 3 months
Scholastic history: He attended pre-school, where he was held back a year before starting grade one as he was not school ready. He attended a junior primary for three years, continuing in the feeder primary school from grade four to grade seven. His grade seven report assessed his maths computational skills, class work and grasping of new concepts to be areas of concern. His problem solving was described as an area of great concern.

His overall assessment was that the outcomes for grade seven had not been mastered to the standard required to pass, but was promoted to grade eight. He would need the support of educators and family to succeed.

His mother, in a telephonic interview noted that RJ never really grasped the fundamentals of mathematics resulting in his general achievement not being of a high standard. He has always presented as being very hyperactive with short attention levels. His mother describes him as tending to become very agitated and not completing what he has set out to do. She also reported that he has asthma and eczema. He uses an asthavent pump daily. There are times that his chest gets so tight that he requires hospital treatment. She welcomed his participation in the programme.

Results

Test	Pre-test result	Post-test result
Anxiety rating	15	3
Kumon P4 diagnostic test	Time: 15 minutes Accuracy: 40/60	Time: 7 minutes Accuracy: 36/60

RJ started Kumon on level 2A and completed up to level C151. He completed levels 2A and A with ease. From level B he started to leave out the odd page. He was always very quick with his times and at the lower levels, accuracy was not affected. From level C he started needing more repetition because of errors. He would often forget his homework, and then hand in double the following week.

In a post-test interview complied for the experimental group the following points were noted in response to questions asked (see appendix A). The responses that follow compare with the questions asked in appendix A.

1. He did his work daily at a regular time, before doing any other homework.
2. The reason for him doing the worksheets was that he wanted to get better marks. He never had to be reminded to do his Kumon. He generally always did his homework diligently. He did his Kumon because, "It was the right thing to do".

3. He felt it was OK to do Kumon in the holidays. He did it before going out anywhere. "It didn't take lots of time – so it was OK".
4. He did not worry about the repetition, he hardly realised he was even doing it.
5. It did help him. "I can now read through the sum and do it correctly. Before I was more impulsive, now I am more confident and aware of operations and what to do".
6. He felt it was the same type of stuff he did at school. It was a good thing that it went from easier to hard because, "It teaches you that if you can do easier work, then you can do the harder stuff. If you revise easy stuff, then you are able to do the harder stuff in maths tests. Now it feels easier".
7. RJ enjoyed the way the worksheets were structured. "More practise on the easier stuff made the harder stuff easier."
8. He liked doing the Kumon on his own; he did not need any external motivation to do his work because he never found any of it difficult.
9. He likes the challenge of solving maths problems. He dislikes it when he gets difficult sums and then he doesn't know what to do. "I don't do it then and then I get into trouble".
10. He doesn't worry about his maths as he feels he can get help from his father.
11. He feels more confident about doing sums. When sums get hard he tends now to persevere to work them out.
12. What changed the most for him was that he is passing some tests now. "In grade seven I was never passing. I can also help others in class to sort their sums out".
13. Given the choice he would stay on the programme for " however long it takes". He is confident that it would help him.
14. He felt that if he could attend a centre he would. He felt that at some stage the work would become harder and he would get stuck with the worksheets and then there would be somebody to help him.
15. He sees himself as being a doctor and would need maths and science.
16. The following traits he rated in terms of bad, average or good.

Trait	Before	After
Confidence (maths)	average	good
Speed (maths)	average	good
Accuracy (maths)	bad	good

Test results (school)	average	good
Self-esteem	average	good
Belief in ability (maths)	average	good
Daily study habits	average	good
Mental alertness	average	good

His teacher reported that RJ appeared quite nervous and was inconsistent in finishing his work. His maths skills were described as an area of great concern at the end of his grade seven year. His first term average was 45%, but due to many absences in the term, is perhaps not a realistic mark. His second term average was 41%.

Qualitative interpretation of the case study: RJ

Maths anxiety	Maths achievement	Teaching method
• Increased by a scale of 12 points on the SOM. • He perceives himself not to worry about maths as his father can help him	• Accuracy decreased by 6% on the post test. • Speed decreased by 8 minutes. • School marks have decreased. His 1st term average mark is perhaps not realistic due to absenteeism. His grade 7 report described his maths as an area of great concern, with his outcomes not meeting the required standard to pass.	• Good to go from easier to hard, revising easier work made it easier to do harder stuff. • Repetition was not a problem • He would choose to continue because he is confident it helped him. • He felt it would be better for him to be at a centre because the work would become more difficult and then someone would have to be there to help you.

RJ has medical problems related to his asthma and eczema. I believe this is a source of anxiety for him as he often is hospitalised due to asthma. He is described as being agitated, impulsive and not completing tasks. He has low levels of concentration. His teacher describes him as being nervous and she did not see any change in him during the course of the programme.

RJ's Kumon progress was from level 2A to level C151. The greatest difference for him was that he is passing some tests now. He never passed in grade seven and now he helps others in his class.

He believes the following traits have improved:

- Confidence (maths)
- Speed (maths)
- Accuracy (maths)
- Test results (school)
- Self-esteem
- Belief in ability (maths)
- Daily study habits
- Mental alertness

Conclusion: Maths anxiety increased, his speed was almost halved in the post test and this led to a loss of accuracy in the post test. His school marks have decreased. Due to many absences in the first term, this result could be unrealistic.

A cross case analysis and final summary of the above results of the experimental group will be done in chapter four.

3.4 LEARNERS NOT ON THE KUMON PROGRAMME (CONTROL GROUP)

In this section the case studies of the learners of the control group are discussed. An analysis of each case study in terms of mathematics anxiety and mathematics achievement is presented.

3.4.1 Case study MF

Chronological age at the start of the programme: 13 years 2 months.
Scholastic history: MF's maths number manipulation, accuracy and confidence assessment at the end of his grade 7 year was described as only able to manage at a basic level and with support. Problem solving skills were described as managing but not consistently.

Results

Test	Pre-test result	Post-test result
Anxiety rating	15	20
Kumon P4 diagnostic test	Time: 15 minutes Accuracy: 28/60	Time: 15 minutes Accuracy: 27/60

In a post-test interview complied for the control group the following points were noted in response to questions asked (see appendix B). The responses that follow compare with the questions asked in appendix B.

1. MF doesn't like maths at all. "It is difficult and I have never liked it".
2. MF does feel worried about maths tests because "If I fail maths then I will fail the year. I start to worry when the papers are being handed out".
3. MF has not had any extra lessons since the beginning of the year.
4. MF does feel that she would benefit from extra help in maths
5. She does not see herself as following a career in maths or science.
6. The following traits she rated as bad average or good.

Trait	Beginning of year	Beginning of 3rd term
Confidence (maths)	bad	average
Speed (maths)	average	average
Accuracy (maths)	average	average

Test results (school)	average	average
Self-esteem	good	good
Belief in ability (maths)	bad	bad
Daily study habits	good	average
Mental alertness	good	good

Her teacher reports no noticeable change in her from the beginning of the year. She is very weak at maths, but always does her work. Her first term average was 20% and the second term average 9%.

Qualitative interpretation of the case study: MF

Maths anxiety	Maths achievement
• Decreased by a scale of 5 points on the SOM • Worries that she will fail because of failing maths	• Accuracy decreased by 2% on the post test • School marks decreased from 20% to 9%

MF has a negative attitude towards maths, disliking it and finding it difficult. She believes she can get better if she gets extra lessons in some form. Her teacher did not report any change in her confidence from the beginning of the year.

MF rated the following traits to have improved since the beginning of the year:

- Confidence (maths)

MF rated the following traits to have declined since the beginning of the year:

- Daily study habits

MF is not realistic about herself. She describes her maths confidence as good and her belief in her ability to do maths as bad. She rates her accuracy, speed and test results at school to be average which is not the reality.

Conclusion: Maths anxiety decreased slightly and maths achievement decreased with no intervention.

3.4.2 Case study HS

Chronological age at the start of the programme: 13 years 9 months.
Scholastic history: HS 's grade seven report described her maths attitude, problem solving skill, use of formula's understanding of graphs and communication of maths ideas as satisfactory. She was described as being polite and well-disciplined with a positive attitude. She was a prefect in her grade seven year. In her grade two year she was assessed by the school health services and described as having possible depression. She had to repeat grade two because of poor performance. She did have an occupational therapy assessment and her fine motor co-ordination was found to be weak but not enough to affect her functionally. She did not attend any therapy. In grade five she was conditionally transferred due to maths results which were very poor.

Results

Test	Pre-test result	Post-test result
Anxiety rating	30	35
Kumon P4 diagnostic test	Time: 15 minutes Accuracy: 42/60	Time: 15 minutes Accuracy: 42/60

In a post-test interview complied for the control group the following points were noted in response to questions asked (see appendix B). The responses that follow compare with the questions asked in appendix B.

1. HS likes geometry because she can understand it better. She does not like it "When I don't understand the work, which happens often. I also don't like the calculations because I struggle, it takes too long".
2. "I always worry that maths tests will be difficult and that I will fail".
3. She has not had any extra help with maths this year.
4. She does not feel anything can be done for her to solve her maths problems or decrease the anxiety she feels. She does not worry for any other subjects, only

maths since grade eight. When asked whether she thought extra lessons would help she replied, "Maybe I would understand more, but the problem is with me and not with how it is taught".

5. She will not follow a career in maths or science.
6. The following traits she rated as bad, average or good.

Trait	Beginning of year	Beginning of 3rd term
Confidence (maths)	good	bad
Speed (maths)	average	bad
Accuracy (maths)	average	bad
Test results (school)	average	bad
Self-esteem	average	average
Belief in ability (maths)	bad	bad
Daily study habits	bad	bad
Mental alertness	bad	bad

Her teacher did not notice any change in her confidence since the beginning of the year. She is often absent from school. Her fist term average was 41% and her second term average was 54%.

Qualitative interpretation of the case study: HS

Maths anxiety	Maths achievement
• Decreased by a scale of 5 points on the SOM • Worries that maths tests will be difficult and that she will fail	• Accuracy stayed the same in the post test. • School marks increased from 41% to 54%

HS dislikes maths when she does not understand it. She believes that her problems in maths are inherent in her. She has a history of bad maths understanding and in grade 2 was diagnosed with possible depression. She has had no additional help since the

beginning of the year. Her teacher did not see any change in her since the beginning of the year. HS noted no traits to have improved since the beginning of the year.

HS noted the following traits to have decreased since the beginning of the year:

- Confidence in maths
- Speed in maths
- Accuracy in maths
- School test results

In general she rated herself bad in every trait except self-esteem which she rated as average. These ratings do not correlate with her school test results, but her results from the P4 Kumon test shows a low level of computational ability.

Conclusion: Maths anxiety decreased slightly and maths achievement at school increased with no intervention.

3.4.3 Case study OM

Chronological age at the start of the programme: 14 years 3 months.
Scholastic history: His attitude to maths and ability with graphs was described at the end of his grade seven year as being able with some support. He was experiencing problems with problem solving, handling and interpreting data and the use of formulae.

Results

Test	Pre-test result	Post-test result
Anxiety rating	20	25
Kumon P4 diagnostic test	Time: 15 minutes Accuracy: 10/60	Time: 15 minutes Accuracy: 8/60

In a post-test interview complied for the control group the following points were noted in response to questions asked (see appendix B). The responses that follow compare with the questions asked in appendix B.

1. What he likes about maths is "If you can do it, it feels good". He dislikes working out sums and that he generally can't do it.
2. He does not particularly feel anxious or worried about maths. "If I pass I pass, if a fail I fail, that's just the way it is".
3. He has not had any extra help or lessons since the beginning of the year.
4. He feels that if he gets some sums right then his worry about maths will decrease. He feels he could get help from his friends and his teacher.
5. He would like to take maths because " there are more opportunities then".
6. The following traits he rated as bad, average or good.

Trait	Beginning of year	Beginning of 3rd term
Confidence (maths)	average	good
Speed (maths)	bad	average
Accuracy (maths)	average	good
Test results (school)	average	good
Self-esteem	average	good
Belief in ability (maths)	average	good
Daily study habits	bad	good
Mental alertness	average	good

His teacher has not noticed any significant changes in him. His average for the first term was 28% and his average for the second term was 13%.

Qualitative interpretation of the case study: OM

Maths anxiety	Maths achievement
• Decreased by a scale of 5 points on the SOM • Does not worry about passing or failing.	• Accuracy decreased by 3 % in the post test. • School marks decreased from 28% to 13%

OM enjoys the feeling of maths when he can achieve. He feels that if he can achieve, his anxiety will decrease. He feels he could get better if helped by peers or his teacher. He has not had any intervention since the beginning of the year. His teacher did not notice any difference in his confidence since the beginning of the year.

OM noted the following traits to have increased since the beginning of the year:

- Confidence (maths)
- Speed (maths)
- Accuracy (maths)
- School test results
- Self-esteem
- Belief in ability (maths)
- Daily study habits
- Mental alertness

OM is not realistic about himself. He rates his accuracy and tests results as good but the reality of his school mark is 13%.

Conclusion: Maths anxiety decreased slightly and maths achievement decreased with no intervention.

3.4.4 Case study WM

Chronological age at the start of the programme: 13 years 5 months
Scholastic history: WM has asthma, but not severely. His maths was rated generally as a "4" on a scale of 1-5, with 5 being the highest. His school attendance was described as generally good.

Results

Test	Pre-test result	Post-test result
Anxiety rating	5	40
Kumon P4 diagnostic test	Time: 15 minutes	Time: 15 minutes

	Accuracy: 44/60	Accuracy: 33/60

In a post-test interview complied for the control group the following points were noted in response to questions asked. (See appendix B). The responses that follow compare with the questions asked in appendix B.

1. Maths is WM's best subject. He likes the difficult stuff because it is challenging. "I do well at maths". There is nothing he dislikes about maths.
2. He does not get nervous for maths tests, but does for EMS because it is difficult.
3. He has only had extra maths lessons in grade 3, but no intervention since the beginning of his grade eight year.
4. He feels that if he attends extra maths lessons he would improve in all areas.
5. He would like to follow a career in accounting.
6. The following traits he rated as bad, average or good.

Trait	Beginning of year	Beginning of 3rd term
Confidence (maths)	average	good
Speed (maths)	bad	good
Accuracy (maths)	bad	good
Test results (school)	average	good
Self-esteem	average	good
Belief in ability (maths)	good	good
Daily study habits	average	average
Mental alertness	average	average

His teacher did not notice any changes in him since the beginning of the year. His average for the first term was 73% and his second term average was 59%.

Qualitative interpretation of the case study: WM

Maths anxiety	Maths achievement
• Decreased by a scale of 35 points on	• Accuracy decreased by 18 % in the

the SOM • Does not get nervous for maths tests	post test. • School marks decreased from 73% to 59%

WM believes that he does well in maths and dislikes nothing about maths. His teacher did not notice any difference in his confidence during the year. He has had no intervention in maths and believes that extra lessons would help him improve in all areas.

WM noted the following traits to have increased since the beginning of the year:

- Confidence (maths)
- Speed (maths)
- Accuracy (maths)
- School test results
- Self-esteem

Note that WM perceives his accuracy and test results to have improved, but the reality is a decrease in achievement.

Conclusion: Maths anxiety decreased and maths achievement decreased with no intervention.

A cross case analysis and final summary of the above results of the control group is done in chapter four.

3.5 CONCLUSION

In this chapter, the differences between qualitative and quantitative research design are outlined. The research design involves a case study using multiple methods to collect data on mathematics anxiety, mathematics achievement and the Kumon programme as a structured method of intervention. Quantitative data is used from a pre-test / post-test control group design. Qualitative data from a literature study, unstructured telephonic interviews with parents of the experimental group, unstructured interview with the teacher

of all the learners, analysis of school marks and structured post-test interviews with both the experimental group and the control group were conducted and results noted.

Criterion sampling ensured that learners with high mathematics anxiety were identified for the case studies. The different test media used were identified and a description and rationale for each was given. A description of how the research was conducted as well as the results of both the experimental group and the control group was noted.

A cross case analysis and final summaries are conducted in the next chapter. This enables the researcher to make conclusions and recommendations for future research.

CHAPTER 4

FINDINGS AND RECOMMENDATIONS

4.1 INTRODUCTION

In this chapter a summary of previous research findings and recommendations with respect to mathematics anxiety, mathematics achievement and teaching methods is discussed. A summary and cross case analysis of the case studies of the empirical investigation conducted in this research is detailed. The limitations of this research as well as recommendations for further research are noted.

4.2 SUMMARY OF LITERATURE STUDY

In this section a summary of the literature study with respect to mathematics anxiety, mathematics achievement and teaching methodology is done.

4.2.1 Mathematics anxiety

Mathematics anxiety encompasses feelings of tension, dread and helplessness. This anxiety is often accompanied by mental disorganisation and a panic to perform in the presence of teachers and peers (Ashcraft & Faust 1994:98; Newstead 1998:66). A learner who experiences mathematics anxiety is often caught up in a cycle which involves negative self-talk, an inability to think clearly and avoidance of mathematics (Spielberger 1972:482; Williams 1988:96).

The causes of mathematics anxiety include the following:

- Inability to handle frustration, excessive school absences, poor self concept, parent and teacher attitudes (Norwood 1994:248).
- Individual learning styles and the way the material is presented (Hodges 1983:18).
- Negative classroom experiences (Stodolsky 1985:126; Williams 1988:95).
- Fear of failure and personality factors (Hodges 1983:18; Dossel 1993:6).
- Teaching methodology:

- drill without understanding (Butterworth 1999:349; Norwood 1994:248; Greenwood 1984:663).
- word problems (Tobias 1978:129).
- time pressure (Kogelman 1981:32; Dossel 1993:6).

- Teachers own mathematics anxiety and gaps in mathematical knowledge (Wood 1988:10; Martinex 1987:117).
- Social and public aspect of having to explain problems and communicate about mathematics (Newstead 1998:66).

The consequences of mathematics anxiety include a decrease in the ability to perform higher mental activities and perceptual processes (Goleman 1996:79; Skemp 1986:54). This threatens both achievement and participation in mathematics (Ashcraft & Faust 1994 121). This has national consequences for future participation in scientific related careers (Hembree 1990:34; Chipman, Krantz & Silver 1992:292).

The treatment of mathematics anxiety includes many aspects.

- Provide learners with successful experiences (Gentile & Monaco 1988:175).
- Let leamers correct their own errors and be part of their own evaluation process. A positive attitude to errors is important (Gentile & Monaco 1988:176; Martinez 1987:121; Barnes 1984:18).
- Match instruction to cognitive levels (Martinez 1987:121).
- Mastery learning to reduce risks of experiencing failure (Martinez 1987:121).
- Let learners work at their own pace (Martinez 1987:121).
- Start with easier problems and praise each step to accomplish more (Skiba 1990:188).
- Psychological treatments like systematic desensitization, anxiety management training, relaxation training, personal interviews, transactional analysis and anchoring. (Hembree 1990:43; Sharp *et al* 2000:53; Schneider & Nevid 1993:287; Maree 1992:58; Long & Ben-Hur 1991:45; Eisenberg 1992:159; Thalgott 186:352).
- Develop good study methods (Maree 1992:58).
- Keeping a journal of feelings, fears and mathematics progress (Frakenstein 1984:171; Stuart 2000:334; Skiba 1990:189; Miller 1991:520).
- Peer tutoring and writing exercises (Dodd 1992:297).

- Dispelling the myth of the existence of a maths IQ (Skiba 1990:188).
- The discussion of various strategies for problem solving (Greenwood 1984:662).
- Personal and process-orientated teaching method (Vacc 1003:226).

Mathematics anxiety can be measured by the following scales:

- Mathematics anxiety rating scale for adolescents (Hadfield & Maddux 1988:77).
- Mathematics anxiety scale for children (Chiu & Henry 1990:121).
- Study orientation questionnaire in maths (Maree 1997:3).

Newstead (1998:55) states the importance of investigating instructional methods and the quality of maths teaching to be the roots of maths anxiety. Kostka (1986:533) similarly stated the need to develop and determine which programmes would be appropriate to develop maths skills for learners with various amounts of mathematics anxiety.

4.2.2 Mathematics achievement

A consistent relationship between maths anxiety and achievement has been found from previous research. The presence of mathematics anxiety is related to poor mathematics achievement (Hembree 1990:33; Ma 1999:532). The teacher's role in maths achievement has been also been noted. A warm atmosphere in the classroom and the ability of the teacher to build self-confidence increases achievement in maths (Dossel 1993:5; Stuart 2000:334). Research conducted with respect to the Kumon method show that the Kumon method of instruction has positive effects on maths achievement (Russell 1995:74-76; Barnard 1995:5). In a separate study of individualised instruction, it was shown that individualised instruction outperformed traditional teaching methods (Gudan 1995:81).

It was noted that attitudes and a learner's personality played a role in achievement. The role of attitudes to mathematics achievement was described (Sutton 1997:44; Hadfield, Martin & Wood 1992:175; Gourgey 1992:10; Genshaft 1982:34). The willingness to persevere, results in a higher level of achievement (Wither 1988:51).

4.2.3 Teaching methods

A traditional teaching approach described by the Department of Education (1997:6) includes passive learners that are exam driven and focussed on rote learning. Teachers are responsible for teaching a content based rigid syllabus within time frames. The outcomes based approach to learning in South Africa is described by the Department of Education (1997:7) as including active learners that are assessed on an on-going basis. Learners are responsible for their learning with the emphasis being on what the learner becomes and understands. The teacher is seen as the facilitator and needs to be innovative and creative in working with the learning programmes which are seen as guides. Teamwork is encouraged. The curriculum is influenced by the needs of the community and is divided into eight different learning areas with the focus being on the acquisition of life skills.

It has been found by Lerner (1993:478) that the new approach compounded mathematical problems of learners with learning disabilities. Wu (1999:6) believes that the understanding of mathematics lies within the skills and that the automaticity of basic skills frees up mental energy to focus on more complicated problems.

The Kumon method of instruction is a structured method that aims to develop the potential of the learner. Learners need to be given materials that match their individual ability and the individual must determine the rate of progress. Speed and accuracy are monitored continuously and the learner is required to repeat worksheets until a level of mastery is achieved (Russell 1995:2-15). The principles behind the Kumon method are that self-learning develops the ability to solve problems and that ability is enhanced through effort. By experiencing success, self-confidence and self-composedness of the individual grows (Kumon 1996:18; Russell 1995:40).

Researchers have found differing results with respect to teaching methodology. Newstead (1998:68) found that learners who were exposed to an alternative approach (using own strategies for solving word sums) responded with less anxiety to those exposed to a traditional pencil-paper method of computation taught by teacher demonstration followed by individual practice. Norwood (1994:253) found that learners with anxiety do not trust their instincts and do not like to work through the discovery–type approach, feeling frustrated and not interested in the "why" in maths, but rather in getting their maths "right".

4.3 CONCLUSIONS AND SUMMARY OF EMPIRICAL INVESTIGATION

A summary of the qualitative interpretations of the case studies in chapter three is presented. A cross case analysis of both the experimental and control group is detailed. The findings and conclusions which follow cannot be generalised as a limited number of learners were involved in the empirical investigation. Tendencies can merely be indicated.

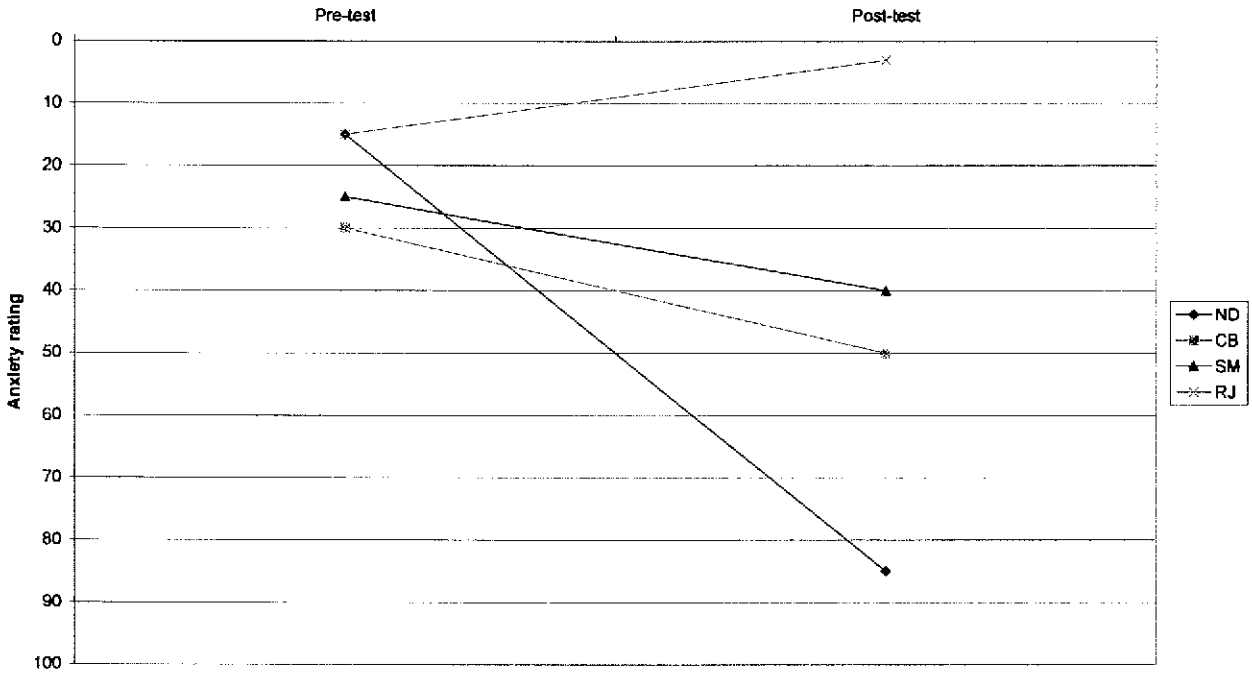
4.3.1 Analysis of learners on the Kumon programme (experimental group)

A cross case analysis is done with respect to anxiety rating and achievement. The results used are those of the pre- and post-test scores of the SOM and Kumon P4 diagnostic test respectively. Conclusions made with respect to school marks are based on the marks obtained by the learners during the first and second terms. Interpretative evaluations are made according to responses and information gained from the interviews which included telephonic interviews with the parents, informal interaction with the teacher and post-test interviews with the learners in both the experimental and control groups.

4.3.1.1 *Conclusions with relation to anxiety rating*

Table 4.1 shows the changes in anxiety rating for learners on the Kumon programme. The table is to be interpreted as follows: The anxiety rating is represented on the vertical axis whilst the horizontal axis shows the time of the test, either before the intervention programme (pre-test) or after the programme (post-test). A low rating on the SOM questionnaire implies high anxiety (Maree, Prinsloo & Claassen 1997:15). The anxiety scale on the graph has been reversed to provide greater clarity: Thus a positive slope indicates an increase in anxiety whilst a negative slope indicates a decrease in anxiety.

Table 4.1: Learners on Kumon programme - Changes in anxiety rating



Three out of the four learners showed a decrease in their anxiety. CB and SM showed a similar degree of change whereas ND showed a marked decrease in anxiety. RJ showed an increase in anxiety rating.

- Each learner presented with a different personality profile. ND, who is conscientious, with a high level of self-motivation and commitment showed the greatest decrease in anxiety. CB, who is diagnosed and on Ritalin for ADHD, and has a record of disruptive behaviour was more irregular with his work and challenged the routine of daily work including holiday work. His anxiety showed a decrease. SM presented as being self-conscious and judging himself against the performance of others as well as the remarks of his peers. He was not self-motivated, having to be prompted by his mother to do the work. His anxiety also showed a decrease. RJ who presented with severe asthma is agitated, nervous and impulsive showed an increase in maths anxiety. This implies that medical conditions and personal trauma can affect anxiety and personality.
- All of the learners rated that their confidence had improved.
- The class teacher noted a significant improvement in the confidence of all learners except RJ.
- All of the learners rated their belief in their ability to do maths as "good".

- SM rated his self esteem to be "average", whilst the others rated self esteem to be "good".
- None of the learners noted a decline in self-esteem or belief in their maths ability.

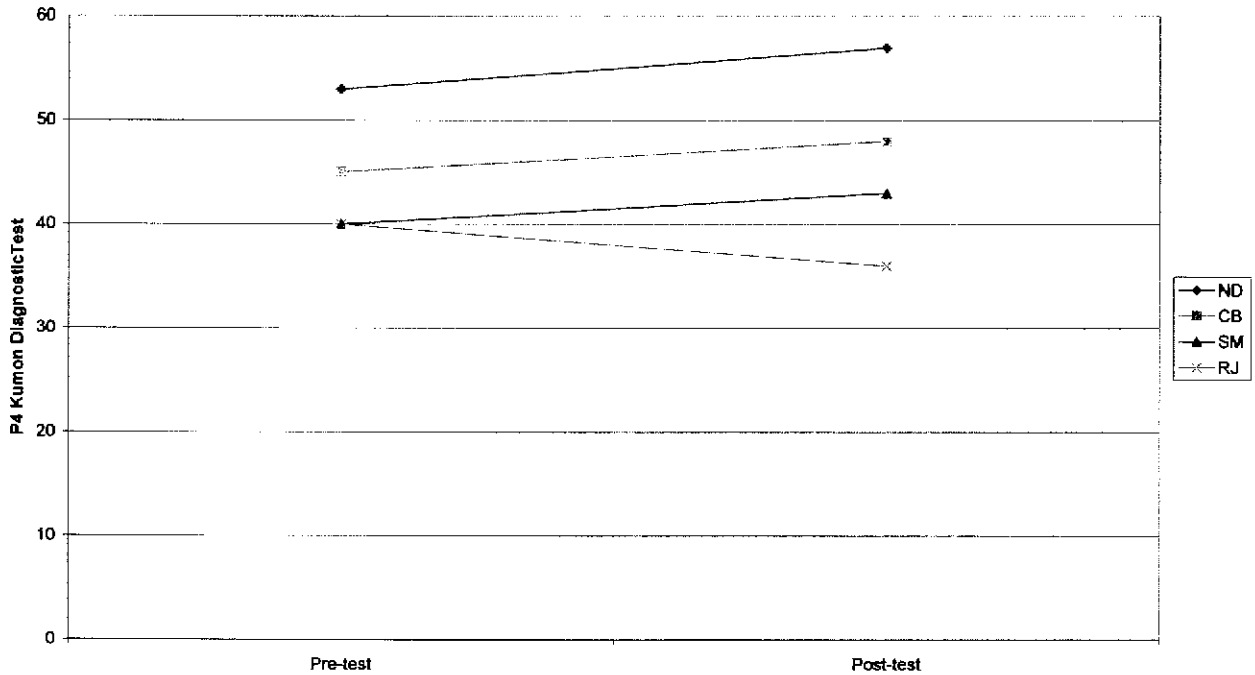
Final conclusions:

The learner's personality affected both how they approached the Kumon programme and how they perceived anxiety. Learners started the Kumon programme on very easy starting points and consequently did not reach levels which were on curriculum level within the five months they participated in the programme. Despite this, all learners who participated in the Kumon programme rated their confidence to have improved. The teacher also noted significant positive changes in the confidence of all learners, except for RJ, whose anxiety had increased. From this, a positive relationship between confidence and anxiety can be deduced. Participation in the Kumon programme resulted in learners perceiving their ability to do maths as being "good". It can be implied that easy starting levels and the experience of success is important to developing confidence and positive beliefs in one's ability which positively influences anxiety.

4.3.1.2 *Conclusions with relation to mathematics achievement*

Table 4.2 shows the changes in achievement of learners on the Kumon programme. The table is to be interpreted as follows: On the vertical axis is the achievement result. On the horizontal axis are the times of the test, being the pre-test (before the intervention programme) and the post-test (after the intervention programme). If the slope of the straight line graph is positive, it indicates an increase in achievement. A negative slope of the line graph indicates a decrease in achievement.

Table 4.2: Learners on Kumon programme - Changes in achievement



- ND, CB and SM showed an increase in their achievement on the P4 post-test. RJ showed a decrease in achievement.
- ND and RJ showed an increase in their speed, but only RJ lost accuracy with this increased speed.
- Accuracy, as indicated in the post-test interview, was perceived by all learners to have improved, except for SM who rated accuracy to have remained the same.
- Speed, as indicated in the post-test interview, was perceived to have improved by all learners except for ND who rated it to have stayed the same.
- Mental alertness, as indicated by the post-test interview, was perceived SM to have remained the same, all other learners rated an increase in mental alertness.
- All the errors made in the post tests were consistent with the Kumon levels completed by the learners.

Final conclusions

Mathematics achievement increased by a similar margin in three of the cases. The learner, RJ, who showed a decrease in achievement also, had shown an increase in anxiety. The learners ND, CB and SM whose anxiety decreased, also showed an increase

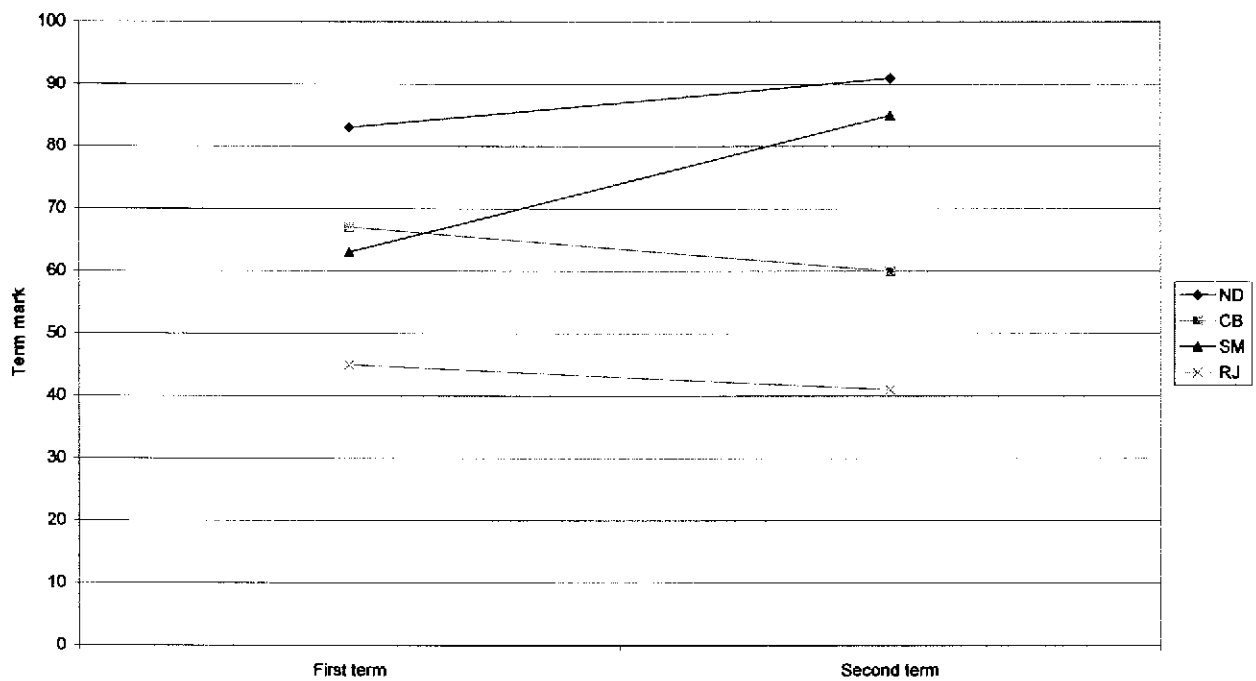
in achievement. From this it can be implicated that a positive correlation exits between anxiety and achievement. It is also of note that the RJ, whose anxiety had increased also showed the greatest increase in speed, at the expense of accuracy.

It is important to note that the errors that were made in the post test achievement test were consistent with Kumon levels completed. This is an indication that the Kumon levels that learners were placed on were appropriate and that completed levels were mastered.

4.3.1.3 *Conclusions with relation to school marks*

Table 4.3 shows the changes in school marks of learners who participated in the Kumon programme. On the vertical axis is the mark of the learner. On the horizontal axis is the time period, being the end of the first term and the end of the second term. A positive slope of the straight line graph indicates an increase in marks, whilst a negative slope of the graph, indicates a decrease in school marks.

Table 4.3: Learners on Kumon programme - Changes in school marks



- School marks increased for ND and CB.
- Test results at school, as indicated in the post test interview, were rated by all learners as having improved.

- None of the learners were working on Kumon levels that were appropriate for grade eight level maths.

Final conclusions

School marks were compared after the first term and after the second term. The first term's marks were composed of small class tests, whilst the second term consisted of small tests and the mid-year exam. It would, perhaps, be more meaningful to have been able to analyse results after the mid-year exam and the end of year exam. It is of note that none of the learners on the Kumon programme reached Kumon levels that were grade eight appropriate. SM and ND showed an increase in achievement in the Kumon post-tests and also an increase in their school marks. RJ, who showed increased anxiety and decreased achievement in the Kumon post-test, also showed a decrease in school marks. RJ was regularly absent from school in the first term because of his medical condition. This had an effect on his first term mark as his average was taken over fewer marks and therefore might not be a true reflection of his abilities.

4.3.2 Analysis of learners not on the Kumon programme (control group)

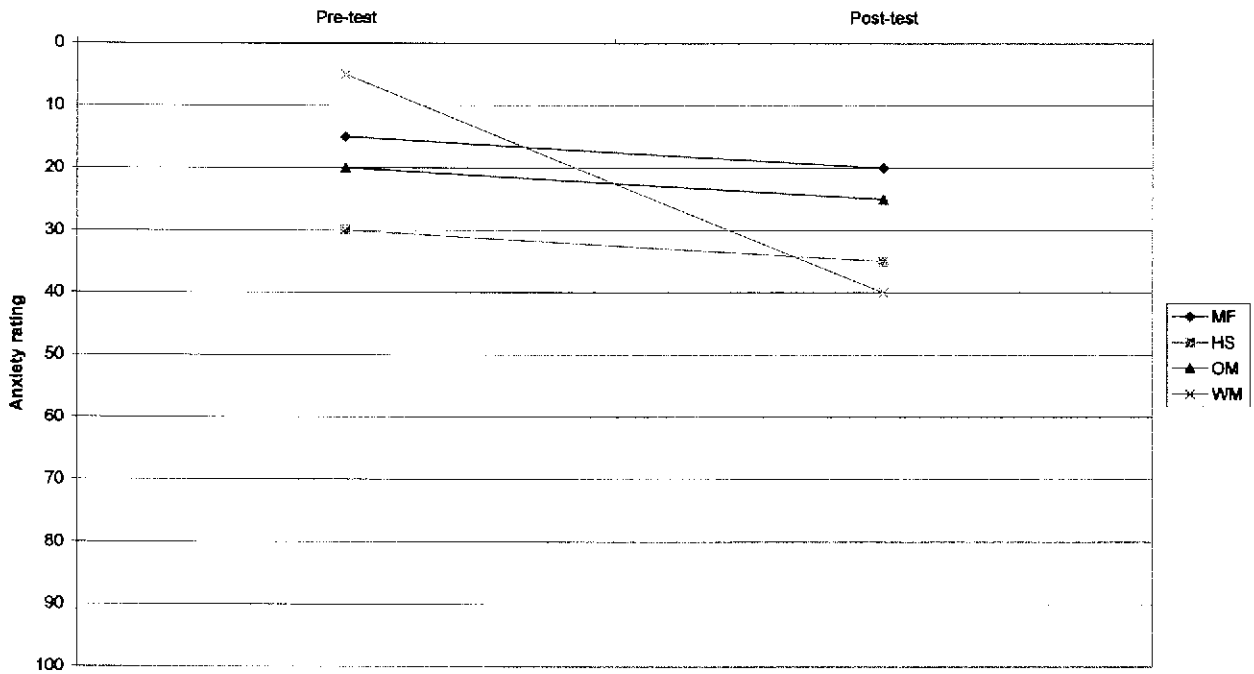
A cross case analysis is done with learners who did not receive any intervention. During the time the research was conducted, none of these learners received any other help or assistance of any kind. The analysis is done with respect to anxiety rating and achievement. The results of the pre-test and post-test scores of the SOM and Kumon P4 diagnostic test are used respectively. Conclusions made with respect to school marks are based on the marks obtained by the learners during the first and second terms. Interpretative evaluations are made according to responses and information gained from post-test interviews with the learners in both the experimental and control groups.

4.3.2.1 *Conclusions with relation to mathematics anxiety*

Table 4.4 shows the changes in anxiety rating for learners in the control group. The table is to be interpreted as follows: The vertical axis represents the anxiety rating whilst the horizontal axis shows the time of the test, either before the intervention programme (pre-test) or after the programme (post-test). It is noted that a low rating on the SOM questionnaire implies high anxiety (Maree, Prinsloo & Claassen 1997:15). The anxiety

scale on the graph has been reversed to provide greater clarity and a positive slope indicates an increase in anxiety whilst a negative slope indicates a decrease in anxiety.

Table 4.4: Learners in control group - Changes in anxiety rating



- Anxiety decreased for all subjects.
- Anxiety in all cases remains below a score of 40 (high anxiety).
- As indicated by the post-test interview, the teacher did not notice any difference in confidence.
- MF, OM and WM, as indicated by the post-test interview rated their confidence as having improved. HS rated his confidence to have decreased.
- MF and HS, in the post-test interview, rated belief in their ability to be "bad".
- As indicated in the post-test interviews, MF and HS rated self-esteem to have remained the same, whilst OM and WM rated their self-esteem to have increased.

Final conclusion

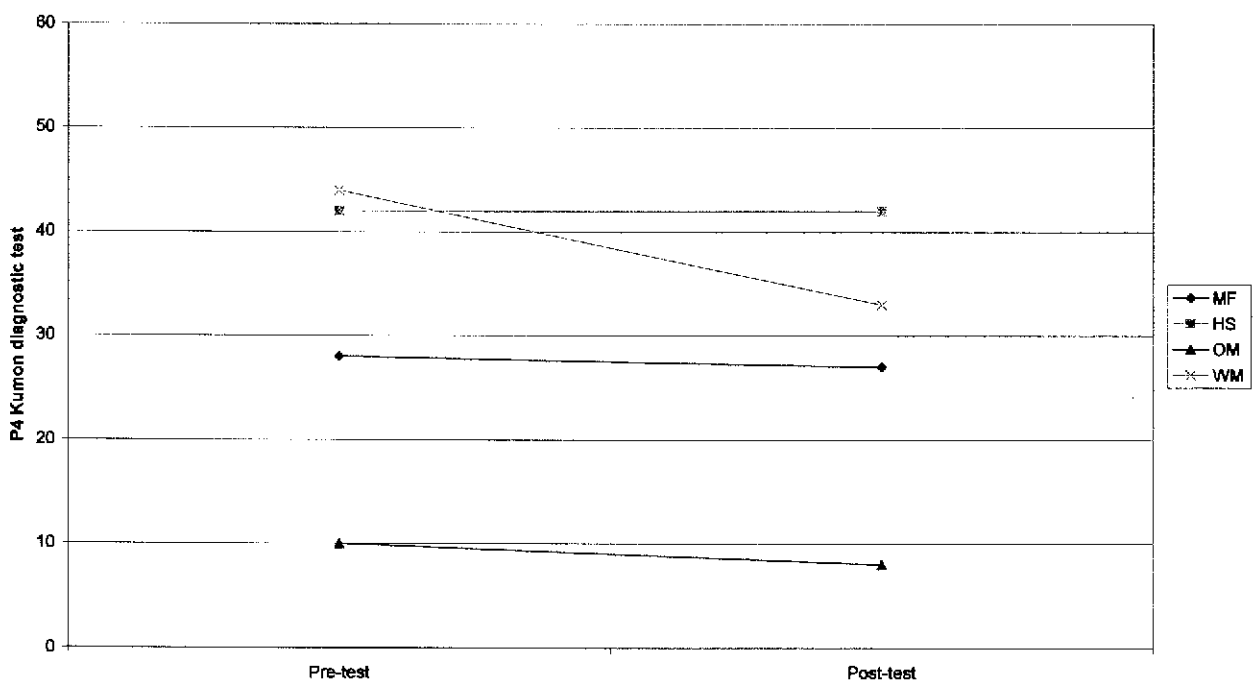
All learners in the control group showed decreased levels of anxiety after the five month period. It is of note that, although decreased, these anxiety ratings were still high. The teacher had not noticed any difference in any of these learners' levels of confidence, whilst

all but one of the learners themselves rated themselves as having increased confidence. The fact that half the learners rated their ability "bad", but with improved confidence and the same or increased self-esteem is indicative that their personal confidence and self-esteem is not necessarily connected anxiety levels.

4.3.2.2 *Conclusions with relation to mathematics achievement*

Table 4.5 shows the changes in achievement of learners in the control group. The table is interpreted as follows: On the vertical axis, the P4 diagnostic test results are read. On the horizontal axis the time period of the pre- and post-tests are given. If the slope of the straight line is flat, then no change of achievement is noted. If the slope of the graph is negative, the achievement has decreased.

Table 4.5: Learners in control group - Changes in achievement



- Achievement has decreased in three of the learners and stayed the same for HS.
- Speed and accuracy, as indicated by the post-test interview, was perceived to have stayed the same for MF. HS perceived his speed and accuracy to have decreased. OM and WM rated their speed and accuracy to have increased.
- Mental alertness, as indicated by the post-test interview, was perceived to have stayed the same for all learners, except for OM who rated his mental alertness to have increased.

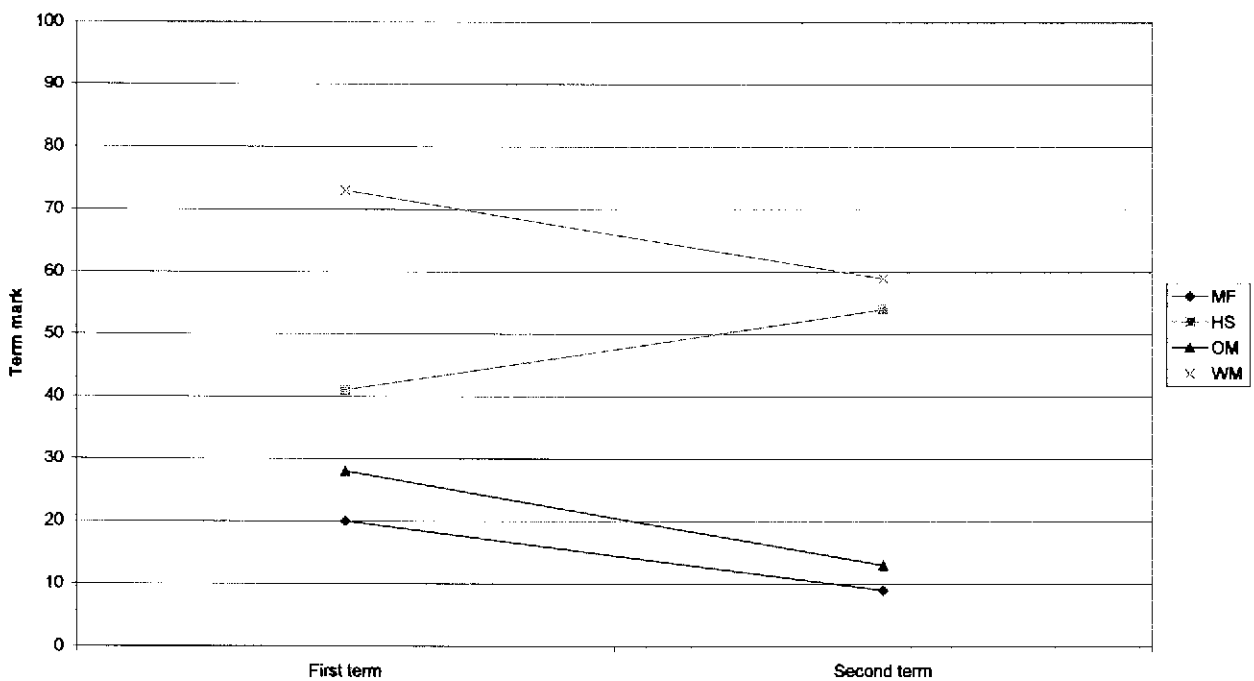
Final conclusions

None of the learners in the control group achieved better in their post Kumon diagnostic test. This implies that the learners had not increased their ability over the five months of class instruction in grade eight. If one considers the nature of the basic operations tested in the P4 Kumon test, it is implied that these basic skills are not improved on unless there is some intervention to do so. It would appear that the ability to perform basic mathematical skills will not happen naturally, or with teaching at higher levels. The teaching of algebra does not necessarily ensure an ability to perform basic calculations.

4.3.2.3 *Conclusions with relation to school marks*

Table 4.6 shows the changes in school marks of learners in the control group. On the vertical axis is the school mark and on the horizontal axis is the time period, being the pre- and post-test. A negative slope of the straight line graph indicates a decrease in school marks, whilst a positive slope indicates an increase in school marks.

Table 4.6: Learners in control group - Changes in school marks



- Results have decreased for WM, OM and MF. HS showed an increase in marks.
- Based on the post-test interview, MF perceived her results to have stayed the same. HS rated his results to have decreased. OM and WM rated their school

results to have increased. This seems to be an indication of denial of the reality of low achievement.

Final conclusions

All learners who showed a decrease in their achievement on the P4 Kumon post-test showed a decrease in their school marks. This is indicative of a lack of basic calculation skills impacting negatively on the ability to do higher levels of maths. HS, who showed an increase in her school marks, remained consistent with her achievement in basic skills as tested on the Kumon test.

4.3.3 Findings

In the following paragraphs, overall findings between the experimental group and control group relating to maths anxiety and achievement are noted. Perceptions of learners are noted and conclusions drawn.

4.3.3.1 *Findings relating to anxiety:*

- Three out of the four learners participating in the Kumon programme showed a decrease in anxiety. All learners in the control group showed a decrease in anxiety. Comparatively, there was a greater decrease in anxiety amongst the group participating in the intervention programme. Learners in the control group had post-test anxiety ratings of forty or less. The learners, whose anxiety decreased in the experimental group, had post-test ratings of above forty. The pre-test anxiety ratings for both groups were approximately the same. From this is can be implicated that the learners on the Kumon programme benefited in terms of significantly reduced anxiety.
- It is possible that generalised anxiety (due to starting high school and the introduction of a new environment) could have been present at the beginning of the grade eight year when the pre-test was done. This could have decreased after five months which could have influenced the results.
- All learners who participated in Kumon who showed decreased anxiety, showed increased achievement on the P4 Kumon test. Those learners in the

control group either remained the same, or decreased their scores on the P4 post-test achievement test.

- All learners in the Kumon group rated themselves as having increased confidence. This was also noted by the teacher in three of the four cases. Three of the learners in the control group rated their confidence to have increased, two as "good" and one as "average". Only one learner rated her confidence as "bad". The teacher noted all the learners in the control group as not showing any changes.
- Three of the learners participating in the Kumon programme rated an increased belief in their ability to maths. Two of the control group rated their belief in their ability as "bad", and two as "good". It would appear that a learner's perception of their ability has no relationship to their anxiety.
- All learners rated their self-esteem as the same or better whether they participated in the programme or not. From these findings it can be implied that self-esteem is not related to anxiety.

4.3.3.2 *Findings relating to mathematics achievement:*

- The learners who participated in the Kumon programme rated their own achievement as improved in terms of maths speed, accuracy and school test marks. Learners from the control group rated their speed, accuracy and school test results to have decreased remained the same or improved.
- School term results improved for three out of four learners in the Kumon group. All learners in the control group showed a decrease in their school term results. It can be implicated that the Kumon programme had a positive effect on the achievement of learners. These findings correlate with previous research from the literature study.
- All mistakes made by the Kumon group in the post-test P4 Kumon test related directly the level of mastery reached in the Kumon levels.

4.3.3.3 *Perceptions of learners resulting from the Kumon methodology:*

- The learners who participated in Kumon all had confidence in the method as expressed by their desire to continue if given the choice.

- All learners expressed the fact that they enjoyed working from easier levels to harder levels.
- Being able to correctly work maths sums is important for the learner and increases confidence and their ability.
- Repetition is perceived as helpful and increasing the ability to perform speedily and accurately.
- Daily work establishes a routine and increased work ethic.
- Extrinsic or intrinsic motivation is dependant on individual personality.
- Personal trauma and medical conditions can affect the outcome of an individualised programme.

4.4 REVIEW OF HYPOTHESIS

The aim of this research was to investigate, through empirical case studies, the effects of the Kumon programme, as a structured teaching method, on a learner's anxiety and achievement. The results of this investigation are analysed in tables 4.1 to 4.6. The general aim of the literature study, to investigate previous research in the areas of mathematics anxiety, mathematics achievement and teaching methodology, has been detailed in chapter two and summarised in chapter four.

The results support the hypothesis that a structured teaching method results in a decrease in mathematics anxiety and an increase in mathematics achievement. Results also show that achievement increased with three learners on the Kumon achievement test, and decreased with the control group. This suggests that with the intervention of the Kumon method, learner's anxiety decreased and achievement increased.

4.5 LIMITATIONS OF THIS RESEARCH

The following limitations with regard to the literature study and empirical investigation were noted for this research:

- The literature study in chapter two was of limited scope, which resulted in some theories and research findings not mentioned.

- Only a few participants were involved in the research. Findings can be described, but not generalised.
- The time period that learners in this study were exposed to the Kumon programme was too short. Because of low starting point levels, a period of at least a year would ensure learners complete Kumon levels that are grade appropriate.
- No consideration was given to gender in the choice of learners participating in the programme or in the control group.
- Not sufficient consideration was given to initial levels of achievement in the choice of learners participating in the intervention programme or in the control group.
- School marks were limited to class tests, with one exam result. More significant analysis would have been done if the period under review fell between and included the June and November exams.

4.6 SUGGESTIONS FOR FURTHER INVESTIGATION

Aspects which can be investigated further include the following:

- The relationship between personality traits and levels of maths anxiety.
- The relationship between personality traits and levels of maths achievement.
- Differences in anxiety and achievement amongst various socio-economic groups.
- The presence of denial as a defence mechanism to facing the reality of poor maths achievement.
- Quantitative investigation into mathematics anxiety and the level of basic mathematical skills of South African learners at the end of the various phases within the OBE curriculum (grades three, grade six, grade nine).

The main focus of future research should be a quantitative study that is statistically significant on the development of mathematical skills and competency within the changing curriculum of South Africa, as well as any resulting mathematics anxiety. Future studies should investigate the impact of the changing curriculum on tertiary studies and involvement in the fields of science and technology. This is of national importance.

4.7 CONCLUSION

In this research it was found that learners on the Kumon programme who showed decreased anxiety showed an increase in achievement on the Kumon post-test. All but one of these learners also showed an increase in their school marks. The learner who showed an increase in anxiety, showed a decrease in achievement in both the Kumon post-test and his school marks. It was found that a learner's personality and personal life situations have an effect on anxiety and achievement. Learners on the Kumon programme experienced the methodology positively. They all found benefit in starting at easy starting points and doing repetition of the materials increased their ability and speed. They perceived themselves to have increased confidence and this was noted by their teacher, with the exception of the learner whose anxiety had increased. These learners all perceived themselves as following a career that involved maths.

The learners in the control group all showed a decrease in anxiety with no intervention. The decrease was not significant and all still presented with relatively high anxiety. They all showed a decrease in their achievement on the Kumon post-test, except for one, whose scores remained the same. These learners all perceived that they could do better if they had extra help in some form, although none had made any effort to better their situation. The teacher did not find any changes in the confidence of these learners and the learners perceived their abilities unrealistically. Half of these learners did not want to follow a career which involved maths.

If the tendencies that have been described are valid, the result for the future of South Africa is significant. Our nation requires graduates in mathematics and science to support and develop our industries. If a teaching methodology that is structured, and based on mastery of basic skills through repetition reduces anxiety and increases achievement, should this type of teaching method not be used to serve the long term interests of learners and South Africa as a nation?

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APPENDIX A

Post test interview: Experimental group

NAME:

1. How often did you do your Kumon?
2. What made you do the worksheets?
3. How did you feel about doing it in holidays?
4. How did you feel about repetition?
5. Do you think it helped? If so in what aspect?
6. Do you think the worksheets you did were relevant? What do you think of the easy starting levels?
7. What do you think about the way the maths materials are presented?
8. How did you feel about doing Kumon entirely on your own – self study?
9. What do you like and dislike most about maths generally?
10. Do you feel worried about maths and maths tests?
11. Has how you feel about maths changed because of Kumon?
12. What do you think changed the most because of participating in programme?
13. If you could stay on the programme for longer to reach higher levels would you?
14 If you could have attended a Kumon centre (at another venue) twice a week with other learners, rather than have received the worksheets at school, would you have found it more beneficial?
15. Do you see yourself following a career involving maths or science?
16. How do you rate yourself before the programme and after participation in the programme. Please rate yourself as bad, average or good.

Trait	Before	After
Confidence (maths)		
Speed (maths)		
Accuracy (maths)		
Test results (school)		
Self-esteem		
Belief in ability (maths)		
Daily study habits		
Mental alertness		

APPENDIX B

Post test interview: Control group.

NAME:

1. What do you like and dislike most about maths generally?
2. Do you feel worried about maths and maths tests?
3. Have you had any assistance or help in maths since the beginning of the year?
4. Do you feel anything can be done to improve your marks or your anxiety?
5. If you could attend extra lessons would you?
6. Do you see yourself following a career involving maths or science?
7. How do you rate yourself at the beginning of the first term and the beginning of the third term? Please rate yourself as bad, average or good.

Trait	Beginning of year	Beginning of 3rd term
Confidence (maths)		
Speed (maths)		
Accuracy (maths)		
Test results (school)		
Self-esteem		
Belief in ability (maths)		
Daily study habits		
Mental alertness		