EFFECTS OF NUMERICAL-COGNITION AND EMOTIONAL-FREEDOM TECHNIQUES ON MATHEMATICS ANXIETY AND ACHIEVEMENT AMONG NON-SCIENCE SECONDARY SCHOOL STUDENTS WITH PSEUDO-DYSCALCULIA IN IBADAN

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ABSTRACT

Anxiety and low achievement in Mathematics are critical challenges facing secondary school students in Nigeria, especially non-science. One of the factors responsible for poor performance in Mathematics is phobia. Many children and young adults develop a fear for Mathematics while they are in school, often as a result of inappropriate methods of teaching or lack of interest on the part of the students. Despite previous studies on Mathematics anxiety (such as systematic desensitization; Verbalizing Fears and Frustrations Techniques; etc.), the problem of Mathematics anxiety and low achievement still persist. Mathematics anxiety and low achievement are both emotional and cognitive problems hence; there is need for Numerical Cognition (NCT) and Emotional Freedom Techniques (EFT). This study, therefore, investigated the effects of NCT and EFT on Mathematics anxiety and achievement among selected secondary schools.

The pretest-posttest, control group, quasi-experimental design was adopted. Simple random sampling technique was used to select 120 participants for the study. The participants were randomly assigned to NCT, EFT and control groups. The training was conducted for ten weeks. Mathematics Achievement test (r = 0.90), Mathematics Anxiety scale (α = 0.89), Mathematics Efficacy scale (α = 0.86) and Pseudo-dyscalculia scale (α = 0.93) were used for data collection. Fourteen hypotheses were tested at 0.05 level of significance and data were analysed using Analysis of Covariance.

There were significant main effects of treatments on Mathematics anxiety ($F_{(2,109)} = 173.020$, $ŋ^2 = 0.760$) and achievement $F_{(2,109)} = 42.161$, $ŋ^2 = 0.432$). The treatments accounted for 83.0% variance in the reduction of Mathematics anxiety of the participants while EFT was more effective ($x = 33.8$) than NCT ($x = 45.4$) in reducing students' Mathematics anxiety. Also, the treatment accounted for 78.6% variance in Mathematics achievement of the participants while EFT was also more effective ($x = 71.7$) than NCT ($x = 59.3$) in enhancing students' Mathematics achievement. There were significant main effects of Mathematics efficacy ($F_{(1,109)} = 34.973$, $ŋ^2 = 0.243$) on Mathematics anxiety. There were significant interactive effects of treatments and Mathematics efficacy ($F_{(2,109)} = 26.394$, $ŋ = 0.195$) on Mathematics anxiety. Also, there were significant main effects of Mathematics efficacy ($F_{(1,109)} = 21.00$, $ŋ^2 = 0.162$) on Mathematics achievement. There were significant interactive effects of treatments and Mathematics efficacy ($F_{(2,109)} = 6.116$, $ŋ^2 = 0.053$) on Mathematics achievement of the students. There were 3-way interaction effects of treatments, mathematics efficacy and gender on Mathematics anxiety ($F_{(2,109)} = 7.327$, $ŋ^2 = 0.063$). By implication, these two techniques are important in helping students to have positive thought about Mathematics and learn how to adjust their negative thought and believe in their ability to excel in the subject.

Numerical-cognition and emotional-freedom techniques were effective in reducing anxiety and enhancing achievement in Mathematics in both male and female. Based on these findings, it is recommended that these techniques could resolve phobia in Mathematics and improve the students' performance in the subject.

Key words: Numerical cognition, Emotional-freedom, Mathematics anxiety, Mathematics achievement, Pseudo- dyscalculia
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DEDICATION

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Taiwo A.K.

CERTIFICATION

I certify that this work was carried out by Adebukola Kabir TAIWO (Matric: 87991) in the Department of Guidance and Counselling, Faculty of Education, University of Ibadan.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The place of Mathematics in the life of any nation is one which is inextricably linked with the place of development in that nation (Okereke, 2002). Indeed no nation that wants to develop scientifically and technologically neglects the Mathematical component of her school curriculum. The increasing attention given to Mathematics stem from the fact that without Mathematics there is no science, without science there is no modern technology, and without modern technology, there is no modern society. This therefore suggests that there could be no real technological development without a corresponding development in Mathematics both as conceived and as practiced (Salau, 2002 in Anaduaka, 2008).

According to Soyemi (2001 in Anaduaka, 2008), Mathematics simply put, is the science of structure, order, numbers, space and quantity. It is a relationship which revolves around the elementary practice of counting, measuring and describing of shapes and objects. To him, it is a way of life and an all embracing body of knowledge that opens up the mind to logical reasoning, analytical thinking and the ability to make abstract objects look real or concrete. From social or economic perspective, he saw Mathematics as a key element and activity in day to day living that every human being practices in one form or the other. The table below represents the trend of performance of students in Mathematics in the last five years in six states. The result showed that performance of students in Mathematics is getting worse and worse.

Table 1.1
Performance in Mathematics at WASSCE from 2001 – 2005 from six states in Nigeria

States	**2001 %**	**2002 %**	**2003 %**	**2004 %**	**2005 %**
Lagos	25.5	25.6	30.0	30.2	34.2
Oyo	15.5	14.8	15.6	22.0	22.6
Bauchi	24.5	25.0	46.7	37.0	33.9
Akwa-Ibom	19.1	24.2	14.1	30.4	26.1
Kano	20.7	16.5	18.8	14.9	17.0
Nassarawa	4.5	4.9	5.1	5.8	4.7
Total					

Source: West African Examination Council.

Despite the relative importance of Mathematics, it is very disappointing to note that students' achievement in the subject has remained consistently poor. Statistics abound to show that mass failure in Mathematics especially in the Senior Secondary Certificate Examination (SSCE) is real and that the trend of students' performance has been on the decline (Agwagah, 2001; Arnazigo, 2000; Betiku, 2002; Salau 2002; WAEC, 1990, 2000, 2004, 2006, NECO, 2010).

A lot of researches have as a matter of fact been carried out to ascertain the root causes of this and to proffer solutions. Consequently, research efforts geared towards finding reasons and possible solutions for the problems have not yielded much positive effect, as the result analysis for the 2006, 2009 SSCE and NECO 2010 revealed that only fifteen percent of the candidates qualified for university admission with credits in five subjects which includes English and Mathematics (WAEC, 2006, 2009; NECO 2010). The poor states in which science and Mathematics are taught in some Nigerian schools have been revealed by many research findings (Betiku, 2002; Oyedele, Eule & Langkuk, 2002). Harbor-Peters (2001) identified several factors as responsible for the poor achievement of students in Mathematics. According to her, some of these factors emanate from sources which are psychological, physiological and environmental.

Byrd in Aprebo (2002) asserted that poor achievement in Mathematics emanated from anxiety and fear. Mathematics phobia, he said, has been an academic disease whose symptoms are always expressed on the faces of the learners in the Mathematics classroom. According to Harbor-Peters (2001), it is unfortunate that students who regard Mathematics as hard are compelled to study one form of Mathematics or the other. This is because Mathematics pervades all forms of learning (Harbor-Peters, 2001).

Mathematics anxiety is one of the most serious limitations to education. Many children and young adults develop a fear for Mathematics while they are in school. Mathematics anxiety and low self-efficacy affect many individuals through feelings of tension, apprehension, or fear that interfere with the manipulation of numbers and the solving of Mathematics problems in a wide variety of ordinary life and academic situations (Ashcraft, 2002). Mathematics is considered as one of the toughest subjects by majority of students. There are very few students in the classroom who really love to learn and explore Mathematical concepts. Mathematics problems among students especially in Nigeria are very real. It has been noted that anxiety in Mathematics can cause one to forget and lose one's self-confidence. Students may acquire it in the classroom from lack of understanding and self-doubt, which often results in avoidance strategies that further exacerbate the problem (Ashcraft, 2002). Mathematics anxiety can be viewed as a perpetual cycle of knowledge gaps and lack of confidence. It begins when teachers fail to engage their students in meaningful and memorable lessons (Jackson & Leffingwell, 1999). Students subsequently lay an incomplete foundation for Mathematics knowledge, which becomes increasingly unstable as new ideas build upon faulty concepts. The eventual collapse of this fragile structure leads to avoidance and anxiety related to Mathematics (Turner et al., 2002). In some, this disabling condition could be caused by teachers assigned to teach Mathematics. When some of these students re-enter the elementary education system as teachers, they restart the treacherous cycle that robbed them of an invaluable knowledge of Mathematics and the balanced education they deserved.

Bamidele (2005) stated that in Nigerian schools, students' general impression is that Mathematics is a dreadful subject. But ironically, this subject is the basis for scientific and technological advancement of any country. Mathematics anxiety is an intense emotional feeling of anxiety that people have about their ability to understand and do Mathematics. People who suffer from Mathematics anxiety feel that they are incapable of doing activities and participating effectively in classes that involve Mathematics. Some Mathematics anxious people even have a fear of Mathematics called *pseudo-dyscalculia*, which is described as false belief in Mathematics disability caused by lack of, inconsistent, poor, or inappropriate systematic Mathematics instruction; inattention, fear, anxiety, or emotion.

Many students often choose their courses in the universities on the basis of how little Mathematics is required for the degree. Some students may even experience worse problems when they find out that their alternative degree they put in for have some courses that require Mathematics orientation like Statistics. By this, some students find it very difficult to cope with Statistics, some try to readjust, while others resign to fate. Mathematics anxiety is an emotional, rather than intellectual problem because the problem emanates from inconsistent emotion and therefore interferes with a person's ability to learn Mathematics which later results in an intellectual problem.

Mathematics anxiety can be a disabling condition, causing humiliation, resentment, and even panic. Students who experience Mathematics problems have their mind go completely blank and feel they cannot do it. Most of the time they cannot even remember how to solve the simplest calculations. Some students often believe that there is always one right answer to Mathematics, and if you cannot find it, you have failed. Mathematics examinations often terrify students. At the time of examination, some students experience sweaty palm, breathe too fast, and often they cannot make their eyes focused on the paper. It is even worse if they look around, because they would see everybody else working, and believe that they are the only one who cannot do it. Mathematics anxiety can be extreme; often caused by having a negative attitude due to a previous bad experience. A student who has experienced frequent failure in Mathematics is unlikely to be motivated to improve his or her performance. It is probable that he or she attributes the failure to bad luck, or difficulty of the subject. The student is likely to believe that increased effort and persistence will not make any difference in the outcome, that he or she has no control over success or failure in Mathematics; and to develop a stance of helplessness and passivity (Corral, 1997).

Anxiety reactions to Mathematics situations may contribute to failure in Mathematics. In fact, a person who has high Mathematics anxiety may actually be unable to perform well in test, and may be unable to learn in a Mathematics classroom. Mathematics anxiety also directly contributes to avoiding Mathematics. It is commonly accepted that Mathematics is difficult, obscure, and of interest only to certain people, i.e., the geniuses. The consequence in many English-speaking countries, and especially in Nigeria, is that the study of Mathematics carries with it a stigma, and people who are talented at Mathematics or profess enjoyment of it are often treated as though they are not quite normal. Mathematics anxiety has been related to teachers and the classroom setting. Mathematics anxious teachers can result in Mathematics anxious students (Bamidele, 2005). Mathematics 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).

Self-efficacy is the judgments individuals make about their potential to learn successfully and the belief in their own capabilities. The choices people make; the efforts they put forth, and how long they persist are influenced by self-efficacy (Bandura, 1997; Schunk, 1996). According to Bandura, every individual possesses a belief system that exerts control over his/her thoughts, emotions and actions. Among the various mechanisms of human agency, none is more central or pervasive than self-efficacy beliefs (Bandura & Locke, 2003; Pajares, 2000).

Expectations about doing well in Mathematics (confidence) relates closely to one's beliefs about personal capabilities for successfully performing domain-specific tasks (self-efficacy). Students with higher levels of self-efficacy set higher goals, apply more effort, persist longer in the face of difficulty and are more likely to use self-regulated learning strategies (Wolters & Rosenthal, 2000). Students make judgments about their Mathematics capabilities based on accumulating knowledge and experience. They tend to see themselves as either mathematically inclined or disinclined. These perceptions of Mathematics efficacy are shaped by an unlimited array of personal, environmental, and behavioural factors. In the academic milieu, learners make judgments about their capabilities based on comparisons of performance with peers (Brown & Inouye, 1978; Schunk, 1987; Schunk & Hanson, 1985; Schunk, Hanson, & Cox, 1987), successful and unsuccessful outcomes on standardized and authentic measures, and feedback from others such as teachers (Bouffard-Bouchard, 1989; Schunk & Rice, 1987), parents, and peers. These sources of information about their capabilities accumulate within individuals to form perceptions of Mathematics competencies. But these judgments are fluid in that they are altered along the way according to new experiences and knowledge. Students whose perceptions of their capabilities are high often go on to challenge themselves, persevere in the face of difficulties, and expend greater effort resulting in more successful experiences. Self-doubters on the other hand often resign early in the face of difficulty (Bandura, 1986; Brown & Inouye, 1978). If students are able to perform a task successfully, then their self-efficacy can be raised. In contrast, if students are not able to perform a task, then they may believe that they do not have the skills to do the task which, in turn, lowers their self-efficacy. Personal goal-setting is influenced by their self-appraisal of capabilities. The stronger the perceived self-efficacy, the higher the goals or challenges people set for themselves and the firmer is their commitment to them (Bandura, 1991).

Competent functioning in Mathematics requires self-beliefs of efficacy to perform effectively (Bandura, 1986). People tend to avoid tasks and situations they believe exceed their capabilities, but they undertake and perform assuredly activities they judge themselves capable of handling (Bandura, 1997). Pajares and Miller (1994) asserted that efficacy in problem-solving had a causal effect on students' performance. Research findings support the view that high achieving Mathematics students have higher and more accurate efficacy beliefs (Pajares & Kranzler, 1995; Bandura, 1997; Pajares & Miller, 1994). Efficacy beliefs towards a certain task are accurate when they correspond to what the person can actually accomplish.

The term cognition refers to a faculty for the processing of information, applying knowledge, and changing preferences. It is also termed as the mental functions, mental processes (thoughts) and states of intelligent entities. It focuses on the specific mental processes such as comprehension, inference, decision-making, planning and learning (Lycan, 1999).

Numerical Cognition is a subdiscipline of cognitive science that studies the cognitive, developmental and neural bases of numbers and Mathematics. It deals with how students acquire an understanding of numbers, and how much is inborn. It also has to do with how humans associate linguistic symbols with numerical quantities. This brings knowledge of how these capacities underlie our ability to perform complex calculations. In each case, it throws light into the neural bases of these abilities, both in humans and non-humans, the metaphorical capacities and processes that allow us to extend our numerical understanding into complex domains such as the concept of infinity; the infinitesimal or the concept of the limit in the calculus.

Numerical Cognition perspective emphasizes that participants can become stuck by focusing on their past and current "bad" behavior and failures versus focusing on future solutions. This therapy will try to increase student performance by removing obstacles to student learning. Students accomplish more when they concentrate on their successes and strengths rather than their failures and deficits. There are so many advantages for students who know how to constructively solve problems. Students should be looked at as being good and capable of rational thought but without any influence from teachers or significant adults a student will likely focus more on their own negative side.

Once the therapist or researcher begins to shift to the positives of the good things that are going on in a student's life, the students usually will switch to that, open up and talk about it too. Students do have the capacity to act on common sense if given the opportunity to identify common sense problem-solving strategies. Solution-focused problem solving in numerical cognition is based on the theory that small changes in behavior lead to bigger changes in behavior. The therapy would emphasize a role shift for students. Small shifts in role by a student will cause shifts in other places. In this regards, teachers will also be focused to develop an alliance with the student and work together to determine the problem and the cause. Identify the student's strength, and then they can build strengths and foundations which will lead to positive changes. When the plan does not seem to be working and the student seems to be repeating the same pattern or does not have the ability to control compulsive behaviors then the educator has to watch for a pattern and reinforce with positive.

This therapy pursues the positive and students are more likely to find a solution to a problem when they concentrate on their successes rather than their failures. Students must realize that they play a huge part in the success of their problem solving process and that change will occur. Once the changes begin to happen then the student will realize that their lives can be very different. Then it is time to have the students set goals and then monitor their progress. The therapist will then try to use comprehension strategies to translate the linguistic and numerical information in the problem and come up with a solution. For example, the therapist may read the problem more than once and may reread parts of the problem as they progress and think through the problem.

Emotional Freedom Techniques (EFT) is a meridian based intervention, a psychotherapeutic tool that is claimed to be able to relieve many psychological conditions, including anxiety, low achievement and other psychopathology like depression, post traumatic stress disorders, stress, addictions and phobias (Feinstein, 2005). The basic EFT technique involves holding a disturbing memory or emotion in mental focus and simultaneously using the fingers to tap on a series of twelve specific points on the body (Rowe, 2004). The theory behind EFT is that negative emotions are caused by disturbances in the body's energy field (Swingle, 2000). Human thoughts are constantly creating patterns of electrical energy that cause the release of neurotransmitters, hormones and other chemicals in the body that people feel as emotions. Student who have Mathematics disabilities have negative emotions which are unhelpful thoughts and beliefs, and are significant factors in the development of depression, anxiety, anger, low self-esteem, self-defeating behaviours, difficulty with coping, negative emotion and lack of Mathematics efficacy. When there is a disruption in the body's electrical flow, such as the fight or flight response, humans feel it. If the disruption continues, it can lead to emotional distress and eventually physical problems. When the disruption is removed, the distress stops.

Emotional Freedom Techniques (EFT) work for the immediate and permanent elimination of various phobias. Many EFT practitioners have cured all sorts of anxiety and phobias of people who have battled with it for years or all their lives (Perkins & Rouanzoin, 2002). Clinical examination of EFT has proved to solve problems on limiting beliefs about performance, anxieties in general. The client is then asked to think of his/her problem while a desensitization procedure is followed, involving tapping on the body (the client tapping on his or her own body). The tapping appears to disrupt the previous patterning of cognitive-emotional response, inducing a dissipation of distress; the tapping is accompanied by a statement of self-acceptance in relation to the target problem (which reduces a common tendency to resist the desensitisation). Tapping may, at certain points in the process, be accompanied by eye movements, humming and counting, and the tapping is continued until subjective distress is eliminated.

EFT is usually self administered and always easy to learn and can be used to treat any emotional problem ranging from mild to severe, and from short term to chronic. It also helps alleviate chronic physical pain (Callahan, 2001). EFT stimulates certain pressure points in the body. This has the effect of redirecting the body's basic energies. To use EFT tapping therapy, begin by thinking of the feeling you want to treat. Perhaps one feels generally stressed, upset, anxious (for example Mathematics) or something at the back of the mind that one feels negatively about or situation is bothering one, simply focus on the problem (Andrade & Feinstein, 2003)

The practitioner closely monitors the client's progress from moment to moment, by careful observation and by asking the client to provide ratings of the Subjective Units of Disturbance (SUDs). This feedback is used to guide the process (Ruden, 2005). The method may be used by skilled psychological therapists who are able to track the client's progress through the layers of anxieties, dysfunctional cognitions, and traumatic memories. It may also be readily employed by the client as a simple stress-relief and affect-regulation tool. The method does not require the client to relive emotional trauma – nor does it require him or her to talk in detail about the experience (Wells, Polglase, Andrews, Carrington & Baker, 2003).

EFT may readily be combined with other psychological methods, including other cognitive-behavioural strategies. In clinical practice the actual tapping procedure is likely to be embedded within much more activity of a conventional verbal cognitive or psychoanalytic (or other) nature. Through the ordinary discourse of psychotherapy, the practitioner will identify the affective, cognitive, and psychodynamic areas to target with EFT (Wells, 2000).

The EFT in solving Mathematics anxiety and phobias involve redirecting the old thought patterns or response mechanisms of anxious or phobic people to the subject or teacher they have a phobia or anxiety about and basically creating a new set of more useful patterns or mechanisms of behaviour to replace the old phobic response. There has to be acceptance that despite the phobic condition, the person is loved or he or she loves himself or herself. Eventually, the fear or fright will be replaced by curiosity and there will be lesser resistance and anxiety (Swingle, 2000).

Reduction of Mathematics anxiety and enhancing Mathematics achievement through Numerical-Cognition and Emotional Freedom Techniques appear to be scarce. This study would therefore expand the frontiers of knowledge on Numerical Cognition and Emotional Freedom Techniques in reducing Mathematics anxiety and enhancing Mathematics achievement among non-science students with fear of Mathematics. Participants in this study would be trained with Numerical Cognition Strategy and Emotional Freedom Techniques to reduce anxiety in Mathematics and enhance Mathematics achievement. It is believed that when students are trained to reduce their anxiety in the Mathematics, their achievement will be more enhanced, thereby helping students to acknowledge the fact that their problems in the subject have to do with their cognition and negative emotion and therefore will be prepared to restructure it and build confidence in them.

1.2 Statement of the problem

Anxiety and low achievement in Mathematics pose some serious limitations on non-science students in Nigeria. This is because, more than any subjects offered at the secondary school level, Mathematics seems to be the most dreaded especially for non-science students. It can be thought of as either an aversion or a fear of working with numbers or equations. Many children and young adults develop a fear for Mathematics while they are in school. This often is a result of inappropriate methods of teaching or lack of interest on the part of the students. This usually makes the students to avoid all Mathematics related subjects such as Statistics at higher levels. This could result in many problems such as avoidance, negative emotions, anxiety and low achievement on the subject. A lot of students in Nigeria have been deprived of certain professional and personal opportunities when they become graduates simply because they fear or perform poorly in Mathematics. These negative experiences could remain throughout their adult lives. The fear of, or low achievement in Mathematics is often associated with pain and frustration. For example, some people get frustrated when they hear that the type of career they intend to do or are doing requires some Mathematics applications like banking, accounting, auditing and so on. Some people even find it difficult to play some games that require Mathematical concepts because of their low state of mind in the subject. This leads to questions like: what actually causes anxiety in Mathematics and low achievement in the subject? How do we solve the problem? What techniques are most appropriate in treating the problem? What suggestions do we offer?

Various Psychological Treatments have been used in the treatment of Mathematics anxiety in the past. Such treatments include systematic desensitization (Hembree, 1990); Relaxation Training and Stress Management (Schneider & Nevid, 1993) others include Personal Interviews Technique; Verbalizing Fears and Frustrations Techniques; Transactional Analysis Model; Anchoring Technique; Journal Writing Technique; Peer Tutoring; Comprehensive Teaching-Therapeutic Programme. However, the above studies and other studies have not been able to deal extensively with Numerical Cognition and Emotional Freedom Techniques on how they can be used to solve Mathematical problems

Although Numerical Cognition Technique has been used by researchers to treat Mathematics Anxiety in the past, yet most of these studies only see Mathematics problems among students as intellectual rather than emotional problems. Therefore, the intellectual problem in Mathematics is a result of negative emotion towards the subject, probably from the teachers that take the subject or lack of motivation by the significant others. In this case, the present study has combined Emotional Freedom Technique together with Numerical Cognition in order to also deal with emotional problems or phobias that students have for Mathematics.

1.3 Purpose of the Study

The general purpose of this study is to reduce anxiety in Mathematics and enhance Mathematics achievement among non-science students with *pseudo-dyscalculia* through Numerical Cognition and Emotional Freedom Techniques. It is believed that these two techniques would serve as an impetus to higher educational attainment in Nigeria. The specific objectives are to:

i. assess main effect of numerical cognition and emotional freedom techniques in reducing anxiety and enhancing achievement in Mathematics among the students.
ii. explore the main and interactive effect of gender and Mathematics efficacy (moderating variables) on Mathematics anxiety of the participants.
iii. find out the main and interactive effect of gender and Mathematics efficacy (moderating variables) on Mathematics achievement of the participants.

1.4 Significance of the Study

The study served as contributions to knowledge in the field of Tests and Measurement, Educational Psychology and other related specializations. The outcome of this study shed light on the efficacy of the two techniques in reducing Mathematics anxiety and enhancing Mathematics achieverment. In the area of Clinical Psychology, the efficacy of Emotional Freedom Technique was revealed in dealing with all emotional related problems. In the areas of Educational Psychology, the study would alleviate the fear students have for Mathematics and improve their academic life. The study would serve as an eye-opener to researchers who would like to carry out researches on the techniques to treat various psychological issues. The present study would also serve as credible reference tool to psychometricians, clinical psychologists, educational psychologists, teachers, school counselors and other related experts in managing psychopathologies and other students' academic problems especially those who have phobia for a particular subject.

Students of Mathematics through the findings of this study would begin to have a better understanding of themselves and their capabilities and see that they can all learn Mathematics through whatever their strength intelligence or learning styles. This would help to build their self confidence and get them always prepared for meaningful learning in the subject. The results of this study would make clear to teachers the fact that a situation where students are left as passive listeners in the classroom tend to kill their interest and enthusiasm and so hinder learning. Professional bodies, school administrators and other interest groups in the educational sector would through the findings of the study, be able to organize more worthwhile seminars and workshops for students, teachers and school administrators that would yield greater result in alleviating anxiety of Mathematics. This study would serve as an empirical basis for future research reference and citations as there are paucity of research evidence on the use of Numerical Cognition and Emotional Freedom Techniques in reducing anxiety in Mathematics and enhancing Mathematics achievement.

1.5 Scope of the study

The study investigated the effects of numerical-cognition and emotional freedom techniques on Mathematics anxiety and achievement among non-science secondary school students with pseudo-dyscalculia in Ibadan. The scope of the study was non-science (students who are offering arts subjects) secondary school students in three selected secondary schools in Ibadan metropolis. SSI students were observed because they are just transiting from junior secondary schools.

1.6 Operational Definition of Terms

The following terms are defined as they will be used in the study:

Numerical Cognition Technique: Numerical Cognition, is described, within the context of this study, as a technique that is used to treat various Mathematics problems arising from cognitive, developmental and neural bases of numbers and Mathematics that are present within individuals.

Emotional Freedom Technique: Emotional Freedom Technique, within the context of this study, is a Emotional-freedom-based intervention that involves tapping some parts of the body in order to energize emotions to be able to correct emotional problems in Mathematics.

Mathematics Anxiety: Mathematics anxiety can be viewed in this study as fear that students have for Mathematics that further leads to lack of self confidence, poor problem solving and avoidance of the subject.

Mathematics Efficacy: This can be described as a variables used to moderate the relationship between the techniques (Numerical Cognition and Emotional Freedom) and criterion variables (Mathematics anxiety and achievement). It is described as students' confidence and positive sense of judgment in their abilities to solve mathematical problems.

Mathematics Achievement: This can be described, within the context of this study, as developed and validated Mathematics achievement test or stimulus presented to the student in order to test their performance in the subject.

Non-Science students: This can be defined as secondary school students who offer arts/humanities subjects.

Pseudo-dyscalculia – This is described as false belief in Mathematics disability by students, caused by lack of, inconsistent, poor, or inappropriate systematic Mathematics instruction; inattention, fear, anxiety, or emotion.

CHAPTER TWO

LITERATURE REVIEW

Introduction

Designing and identifying sensible intervention strategies and practical ways to alter self-efficacy beliefs and anxiety when they are inaccurate and debilitating to students has been suggested as an important and viable avenue of future research (Bandura, 1997). In this research work, various theories and literature will be reviewed on numerical cognition and emotional freedom. Empirical review or related studies will be sought to see how these two techniques influence Mathematics anxiety and Mathematics achievement of students. The subsections of this chapter is further highlighted below:

Theoretical Background

- Concept of Mathematics Anxiety
- Concept of Mathematics Achievement
- Concept of Mathematics efficacy
- Concept of pseudo-dyscalculia
- Classification of dyscalculia
- Concept of Numerical Cognition
- Concept of Emotional Freedom

Theoretical framework

- Information processing theory
- Constructivism theory
- Social cognitive theory

Empirical Findings

- Numerical cognition and Mathematics Anxiety
- Numerical cognition and Mathematics Achievement
- Emotional freedom techniques and Mathematics Anxiety
- Emotional freedom techniques and Mathematics Achievement
- Mathematics efficacy and Mathematics Anxiety

- Mathematics efficacy and Mathematics Achievement
- Gender and Mathematics Anxiety
- Gender and Mathematics Achievement

2.1 THEORETICAL BACKGROUND

2.1.1 Concept of Mathematics Anxiety

According to Fiore (1999), Tobias and Weissbrod (1980) Mathematics anxiety is defined as the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a Mathematics problem. It is both an emotional and cognitive dread of Mathematics. While some measure of anxiety can be motivating or even exciting, too much anxiety can cause "downshifting" in which the brain's normal processing mechanisms begin to change by narrowing perceptions, inhibiting short term memory and behaving in more primal reactions (McKee, 2002). Pries & Biggs (2001) describe a cycle of Mathematics avoidance: In phase one, the person experiences negative reactions to Mathematics situations. These may result from past negative experiences with Mathematics, and lead to a second phase in which a person avoids Mathematics situations. This avoidance leads to phase three, poor Mathematics preparation, which brings them to phase four, poor Mathematics performance. This generates more negative experiences with Mathematics and brings us back to phase one. This cycle can repeat so often that the Mathematics anxious person becomes convinced they cannot do Mathematics and the cycle is rarely broken. Arem (2003) equates a lot of Mathematics anxiety with Mathematics test anxiety, which she asserted is three-fold: Poor test preparation, poor test-taking strategies and psychological pressures.

Research confirms that pressure of timed tests and risk of public embarrassment have long been recognized as sources of unproductive tension among many students. Three practices that are a regular part of the traditional Mathematics classroom and cause great anxiety in many students are imposed authority, public exposure and time deadlines. Although these are a regular part of the traditional Mathematics classroom cause great deal of anxiety. Mathematics anxiety has been defined as feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of

Mathematical problems in a wide variety of ordinary life and academic situations. Mathematics anxiety can cause one to forget and lose one's self-confidence (Tobias, 1993).

Studies have shown that students learn best when they are active rather than passive learners (Spikell, 1993). Everyone is capable of learning, but may learn in different ways. Students' prior negative experiences in Mathematics class and at home when learning math are often transferred and cause a lack of understanding of Mathematics. According to Sheila Tobias, millions of adults are blocked from professional and personal opportunities because they fear or perform poorly in mathematics for many, these negative experiences remain throughout their adult lives. This may more particularly true of the study of Mathematics because "Mathematics offers what is perhaps the clearest and most concentrated example" of intelligent learning, "which is to say the formation of conceptual structures communicated and manipulated by means of symbols" (Skemp, 1971, p.16).

Anxiety reactions to Mathematical situations may contribute to failure in Mathematics (Tobias & Weissbrod, 1980). In fact, a person who has high math anxiety may actually be unable to perform well on test, and may be unable to learn in a Mathematics classroom. Mathematics anxiety also directly contributes to avoiding Mathematics (Tobias & Weissbrod, 1980, p.63). The ways in which avoidance contributes to failure and anxiety are perhaps a little less clear. Avoidance of Mathematics engenders failure because a person who has successfully avoided Mathematical situations for some time may lack the skills and knowledge needed when he or she is presented with a situation requiring its use. This is situation in which the individual is very likely to fail. Similarly, the person who has avoided Mathematics and is suddenly confronted with a circumstance requiring it is likely to be painfully aware of his or her lack of preparation and become anxious about it as a result. Thus the avoidance of Mathematics can lead to failure and/or anxiety with staggering effect. Of course, if one could only continue to avoid Mathematics situations, neither failure nor anxiety would result.

The phenomenon of Mathematics anxiety itself is of interest to the education community only because individuals find themselves placed in situation requiring that they either use or learn Mathematics, or both. Without conditions necessitating the use of Mathematics, Mathematics anxiety, however high the individual's level would not be of any consequence. An underlying assumption of this model is that Mathematics anxiety is of interest only to those people who have been influenced by it in the past, in career choices, for example, those who are influenced by it presently, as in a Mathematics class, or those who will in influenced by it in the future, as in a required Mathematics class or job skill. As long as a person has no need for Mathematics, Mathematics anxiety is unimportant.

Avoidance can occur for many reasons. Sometimes it is a simple as students being extremely gifted in non-Mathematical areas and choosing to spend their time and energy on the subject in which they are gifted. Individuals may also decide that the study or use of Mathematics is not appropriate for them. This may be the result of sex-role stereotyping or other beliefs held by their socio-economic group.

Tobias asserted that "most people leave school as failures at Mathematics" (1978, p.26). Hilton (1980, p. 176) lists the causes of failure to be "bad teaching, bad texts, and bad educational instruments (p. 177)." He went on to include rote calculations, memory dependence, authoritarianism, spurious applications and unmotivated problems as additional factors which inhibit success in many students. Kogelman and Warren (1979) hypothesized that perceived rigidity of rules and an inordinate emphasis on right answers may drive some students, who are intellectually capable of learning Mathematics from success to failure. In addition, the cumulative nature of Mathematics may be a source of failure for students who must be absent from school for any length of time. Regardless of how or why individuals fail in Mathematics, they often experience what Tobias (1978) calls "sudden death (p.27)." Whether it was timed tests on multiplication facts, the introduction of operations fractions, multi-stage word problems, or solving equations that caused the difficulties, for many "failure was sudden and very frightening" (Tobias, 1978, p. 44). Presumably, students do not really just suddenly reach a concept or procedure that they cannot learn. In Lazarus' (1974) analysis of Mathematics anxiety, he hypothesized a "latency stage" – a period in which the student has been relying on a memorize-what-to-do strategy in learning Mathematics.

The transition from Confidence to Anxiety has been hypothesized to be the result of unpleasant experiences associated with learning or doing Mathematics (Byrd, 1982; Kogelman & Warren, 1979; Tobias, 1978). Many people recall their first negative experiences with Mathematics with surprising vividness and clarity. They may remember how the teacher looked or dressed and what type of Mathematics task was involved. Students recollect Mathematics being taught in an atmosphere of tension created by an emphasis on swift computations and correct answers (Tobias, 1978). Sometimes these negative experiences are not school related, but are associated with a parent or sibling who acts as tutor (Kogelman & Warren, 1979). In addition to these stresses, tests on mathematics serve as high stress producers. Kogelman & Warren (1979) found that Mathematics "has long been associated with the pressures of performing and being evaluated" (p.58), and far too frequently, the associations are not pleasant ones.

A student who has experienced frequent failure in Mathematics is unlikely to be motivated to improve his or her performance. It is probable that he or she attributes the failure to bad luck, or difficulty of the subject. The student is likely to believe that increased effort and persistence will not make any difference in the outcome, that he or she has no control over success or failure in Mathematics; and to develop a stance of helplessness and passivity (Corral, 1997).

According to Dodd (1999), the lack of confidence is probably the Mathematics-anxious learner's greatest obstacle. In addition, the loneliness of thinking you're the only one with Mathematics anxiety can be debilitating. She asserted that Mathematics anxiety isn't an inherited tendency, it's created. She asserted, "It can be created when teachers place too much emphasis on memorizing formulas and applying rules" and that "It can result when teachers fail to realize the critical connection between students' academic performance and their feelings about themselves and the subject being studied" (page 296).

Mathematics anxiety can be described as a combination of factors as described by Mitchell (1987) who states that mathematics anxiety is a combination of physical, cognitive and psychobehavioural components. Physical aspects of Mathematics anxiety are biological, consisting of hormonal, chemical and muscular changes in the body which results in a disability to think (Mitchell 1987). A number of different factors have been described as the causes of maths anxiety. Norwood (1994) describes Mathematics anxiety as the results of different factors including the inability to handle frustration, excessive school absences, poor self concept, parental and teacher attitudes towards Mathematics and emphasis on learning Mathematics through drill without understanding. A lack of confidence when working in mathematical situations is described by Stuart (2000) as the cause of Mathematics anxiety. Hodges (1983) 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) identified several factors leading to the creation of Mathematics 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; Williams 1988). It is considered critical to examine classroom practice and establish whether the roots of Mathematics anxiety may be in instructional methods and in the quality of Mathematics teaching in elementary school (Newstead 1998).

Greenwood (1984:663) stated that the principal cause of Mathematics 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 Mathematics 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) 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) believes that word problems are the heart of Mathematics anxiety. Learners need higher levels of reasoning and if not taught strategies to solve these problems, learners may grow up avoiding Mathematics and science (Tobias 1978).

The degree of accuracy and ease at which numbers can be manipulated has been identified as a cause of Mathematics 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). Martinex (1987) 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 1983).

Research has shown that a teacher's own mathematics anxiety could be a cause of anxiety for learners. Martinex (1987) states that a teacher's own Mathematics 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 Mathematics knowledge or an awareness of imperfectly learned concepts which in turn, can be transmitted to the learners they teach (Martinex, 1987). The effect of having to perform and provide explanations in front of teachers or peers has been found to be a source of anxiety. It was found by Kogelman (1982) that experiences of learners having been punished or humiliated at the blackboard was very damaging. Newstead (1998) concludes from her research that learners learn to do Mathematics before they are able to explain problems and communicate about mathematics. To expect learners to provide explanations to Mathematics questions could cause anxiety at the crucial age between the development of skills for doing Mathematics and the development of skills for explaining Mathematics (Newstead 1998).

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

Mathematics anxiety as stated by Goleman (1996) 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) 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) 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 hand icapped mathematically (Wells 1994).

It has been noted by Ashcraft and Faust (1994) that highly Mathematics anxious learners tend to avoid the distressing Mathematics stimuli. This has far reaching, national consequences as was highlighted by Hembree (1990) 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.

Krantz and Silver (1992) asserted that at every level of mathematical skill, Mathematics 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. 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). This exposure to uncontrollable failure experiences is referred to by Gentile and Monaco (1988) as learned helplessness. Skiba (1990) comments that even if a skill is well grounded, the anticipation of possible incompetence may block the ability to carry out the operation.

2.1.2 Concept of Mathematics Achievement

Student achievement in schools has always been a concern for parents, students and educators. There have been several theories on what help students achieve in a Mathematics class. A number of variables have been identified to be responsible for poor achievement of students especially in mathematics. According to Betiku (2002), these variables are government related, curriculum related, examination body related, teacher related, students related, home related and textbook related. Some specific variables have also been identified by Amazigo (2000), such as poor primary school background in Mathematics, perception that Mathematics is difficult, large classes, psychological fear of the subject, lack of incentives for the teachers, students not interested in the subject, etc. Similarly Salau (2002) listed problems that seem to beset mathematics education in Nigeria, and which have resulted to consistent poor achievement of students in SSCE as;

1. Acute shortage of qualified professional mathematics teachers.
2. Undue emphasis on syllabus coverage at the expense of meaningful learning.
3. Exhibition of poor knowledge of mathematics content by many teachers.
4. Over- crowded mathematics classroom.
5. Students' negative attitude towards mathematics.
6. Adherence to odd teaching in-spite of exposure to more viable alternatives, to mention but a few.

It is possible that these factors act singly or in combination for some students in affecting their achievement in mathematics. However, Salau (2002) believes that through instructional strategies geared towards demystifying the subject in the Nigerian classroom, the poor state of mathematics education in the country can be redressed. There is increasing concern about the number of learners who drop Mathematics in the latter years of high school. Barnes (1984) 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). In a further report by Unesco, Unicef and the South African Department of Education, (Sunday Times, 16 July 2000) 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). Wu (1999) 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).

Mathematics, by its nature involves both cognition and affective effects. Sutton (1997) argues that the glory of mathematics lies in the fact that Mathematics 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, mathematics achievement and instructional techniques for the reduction and prevention of anxiety (Hadfield 1988).

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 2000). More recent statistics with respect to pass rates for mathematics have not been officially published. Coetzer (2001) notes that progressive schools in the United States of America that followed a curriculum similar to curriculum 2005 showed similar results, especially as reg

Hembree (1990) noted that Mathematics 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 Mathematics 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). In a meta-analysis, Ma (1999) quantified the potential improvement in mathematics achievement when mathematics anxiety is reduced. Ma (1999) found that the relationship between mathematics anxiety and mathematics achievement is significant from grade 4 and that once mathematics anxiety takes shape, its relationship with mathematics 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).

Goleman (1996) 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). From these it can be noted that the presence of mathematics anxiety has a negative effect on mathematics achievement. The teacher's attitude and approach in the classroom has an effect on a learner's achievement. Dossel (1993) has suggested that the atmosphere in the classroom, including perceived warmth, may lower anxiety and improve mathematics performance. Stuart (2000) stated that students like to do what they are good at, and to feel good about mathematics, teachers need to build up the self-confidence and refine the skills required to be successful at mathematics.

It has been noted that more positive attitudes accompany lower levels of anxiety and are conducive to increased gains in the future (Genshaft 1982). Wells (1994) 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 mathematics is difficult. Misconceptions about the nature of mathematics have also been investigated. Gourgey (1992) 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). Sutton (1997) states that people misunderstand that in meeting the challenge of the difficulties they experience with mathematics creates an opportunity to learn life skills.

There is evidence that different cultural groups have different attitudes to mathematics achievement. Stevenson (1987), in a study showing the difference between American and Asian approaches to mathematics, 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). A learner's personality has been cited by some researchers as having an effect on achievement. Tobias (1978) 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 mathematics anxious (Tobias 1987).

2.1.3 Concept of Mathematics Efficacy

Research on Mathematics teaching has recently focused on affective variables, which were found to play an essential role in influencing behaviour and learning (Bandura, 1997). The affective domain is a complex structural system consisting of four main components: emotions, attitudes, beliefs and values (Goldin, 2002). Beliefs can be defined as one's knowledge, theories and conceptions and include whatever one considers as true knowledge, although he or she cannot provide convincing evidence to support it (Pehkonen, 2001). Self-beliefs can be described as one's beliefs regarding personal characteristics and abilities and include dimensions such as self-concept, self-efficacy and self-esteem. Self-efficacy can be defined as one's belief that he/she is able to organize and apply plans in order to achieve a certain task (Bandura, 1997).

According to Bandura (1997) every individual possess a belief system that exerts control over his/her thoughts, emotions and actions. Among the various mechanisms of human agency, none is more central or pervasive than self-efficacy beliefs (Bandura & Locke, 2003; Pajares, 2000). Self-efficacy is a task-specific construct and there is a correspondence between self-efficacy beliefs and the criteria task being assessed. In contrast, self-concept is the sense of ability with respect to more global goals (Pajares, 2000; Bandura, 1986), while self-esteem is a measure of one's feeling of pride about a certain trait, in comparison with others (Klassen, 2004). The task-specificity of efficacy beliefs implies that related studies are more illuminating when they refer to certain tasks, such as problem posing; the predictive power of self-efficacy is in this case maximized (Pajares & Schunk, 2002). On the other hand, the level of specificity could not be unlimited; as Lent and Hackett (1987) have rightly observed, specificity and precision are often purchased at the expense of practical relevance and validity.

Research on self-efficacy has recently been accumulated providing among other things notable theoretical advances that reinforce the role attributed to this construct in Bandura's (1997) social cognitive theory. Several works (Pajares & Schunk, 2002; Pajares, 2000; Bandura, 1997) have indicated a strong correlation between Mathematics self-efficacy and Mathematics achievement (Klassen, 2004). It was further found that Mathematics self-efficacy is a good predictor of Mathematics performance irrespective of the indicators of performance (Bandura, 1986) and regardless of any other variables (Bandura & Locke, 2003). It was found that Mathematics self-efficacy is a better predictor of Mathematics performance than Mathematics anxiety, conceptions for the usefulness of Mathematics, prior involvement in Mathematics, Mathematics self-concept and previous Mathematics performance (Klassen, 2004; Pajares & Miller, 1994). It is noteworthy that self-efficacy beliefs were even found to be a stronger predictor of performance than general mental ability (Pajares & Kranzler, 1995).

Self-efficacy beliefs have already been studied in relation to a lot of aspects of Mathematics learning, such as arithmetical operations, problem-solving and problem-posing. Pajares and Miller (1994) asserted that efficacy in problem solving had a causal effect on students' performance. Research findings support the view that high achievements in Mathematics students have higher and more accurate efficacy beliefs (Pajares & Kranzler, 1995). Efficacy beliefs towards a certain task are accurate when they correspond to what the person can actually accomplish.

Perceptions of self-efficacy come from personal accomplishments, vicarious learning experiences, verbal persuasions, and physiological states (Bandura, 1986; Ingvarson, Meiers, & Beavis 2005; Tanner & Jones, 2003). A self-efficacy impact on a learner's potential to succeed (Bandura, 1977). Self-efficacy is a valuable tool for Mathematics educators. It is important for educators to know how students feel, think, and act, about, within, and toward Mathematics (Yates, 2002). The influence of attitudes, values and personality characteristics on achievement outcomes and later participation in the learning of Mathematics are important considerations for Mathematics educators (Yates, 2002).

One way to gain insight into how learners feel, think, and act, about and toward Mathematics is to examine their psychological domains of functioning: the affective, the cognitive, and the conative (Huitt, 1996; Tallon, 1997). It is important to examine each domain as a student may feel efficacious within the affective domain but less confident within the cognitive domain. Affect is a student's internal belief system (Fennema, 1989). The affective domain includes students' beliefs about themselves and their capacity to learn Mathematics; their self esteem and their perceived status as learners; their beliefs about the nature of Mathematics understanding; and their potential to succeed in the subject (Tanner & Jones, 2003). The cognitive domain considers students' awareness of their own Mathematics knowledge: their strengths and weaknesses; their abstraction and reification of processes; and their development of links between aspects of the subject (Tanner & Jones, 2000). Cognition refers to the process of coming to know and understand; the process of storing, processing, and retrieving information. The cognitive factor describes thinking processes and the use of knowledge, such as, associating, reasoning, or evaluating.

Conation refers to the act of striving, of focusing attention and energy, and purposeful actions. Conation is about staying power, and survival. The conative domain includes students' intentions and dispositions to learn, their approach to monitoring their own learning and to self-assessment. Conation includes students' dispositions to strive to learn and the strategies they employ in support of their learning. It includes their inclination to plan, monitor, and evaluate their work and their predilection to mindfulness and reflection Tanner & Jones, 2000).

Self-efficacy is a domain-specific construct in academics. Many, including Bandura, argue that it is also task-specific, and attempts to measure self-efficacy at the domain level often result in ambiguous or unclear results (Bandura, 1986; Pajares & Miller, 1994c, 1995). Many of the studies that show self-efficacy to account for lesser variance than other personal determinants often stray from Bandura's prescriptions for a microanalytic strategy. Often these studies assess self-efficacy globally with just a few scale items; that is, they ask participants to report on their confidence or efficacy with regard to a specific academic domain, and not a specific performance task. At this level of self-reporting, it is expected that self-efficacy cannot reliably be separated from other personal determinants such as self-concept, anxiety, self-confidence, and background. It thus raises the question of whether one is actually measuring self-efficacy, or more generally measuring attitudes and other common mechanisms toward a given academic domain. Of course, the latter are important in some areas of educational research, but do not always give sufficient evaluative information for performance on specific, criteria tasks. One possible lens from which to view self-efficacy within the context of instructional technology is to consider one's judgments of personal capabilities to authentically accomplish a specific performance objective. Self-efficacy and performance are inextricably related, and in the domain of Mathematics both are often correlated with gender.

In academic domains, the research on self-efficacy is less extensive. However, it is seen as being applied to such diverse academic domains as Mathematics, computer literacy, writing, in service teacher training, choice of academic majors, and so on. Many of these studies are correlational and describe how self-efficacy relates to academic outcomes. Schunk (1997) is one of the more prolific researchers applying self-efficacy as an academic construct. He and his colleagues often used a research paradigm that goes beyond correlational analysis to include instructional interventions designed to raise learners' percepts of efficacy and corresponding performance on criteria tasks. Schunk's (1997) treatments to influence self-efficacy include variations on modeling, attributions of success or failure, and goal-setting.

Pajares (2000) and colleagues (Pajares & Kranzler, 1995; Pajares & Miller, 1994a; Pajares & Miller, 1994b; Pajares & Miller, 1994c) often used advanced statistical procedures to account for the explanatory and predictive variance of self-efficacy in relation to other personal determinants, such as anxiety, academic background, self-confidence, and so on (Pajares & Kranzler, 1995; Pajares & Miller, 1994a; Pajares & Miller, 1994b; Pajares & Miller, 1994c; Pajares & Miller, 1995). Consistently, Pajares and colleagues find that self-efficacy maintains high explanatory and predictive power for Mathematics performance.

2.1.4 Concept of Pseudo-dyscalculia

Dyscalculia is described as disabilities experienced from mathematical activities, which may be as a result of developmental processes of the child, cognitive disabilities, environmental factors, etc. A majority of dyscalculia cases, experienced by individuals with average or superior intelligence, are exclusively caused by failure to acquire Mathematics fundamentals in school. Worldwide, Mathematics has the highest failure rates, and lowest average grade achievements. Almost all students, regardless of school type or grade, cannot perform in Mathematics on par with their intellectual abilities. This is not surprising because sequential Mathematics instruction requires a perfect command of acquired fundamentals. (CTLM 1986) The slightest misunderstanding makes a shaky mathematical foundation.

Cohn (1968) explains that having a disability in Mathematics is socially acceptable. He asserts that math ability is more regarded as a specialized function, rather than a general indication of intelligence. As long as one can read and write, the stigma and ramifications of math failure can be diminished and sufficiently hidden. Sharma, concurs, explaining that in the West, it is common to find people with high IQ's who shamelessly accept incompetency in math. At the same time, they find similar incompetence in spelling, reading, or writing, totally unacceptable. Prevailing social attitudes excuse math failure. Parents routinely communicate to their children that they are "no good at math." (Sharma 1989).

Shelia Tobias, in 1978, realized that because only 8% of girls took 4 years of math in high school, 92% of young women were immediately eliminated from careers and study in science, chemistry, physics, statistics, and economics. Half of university majors were closed to them. Tobias states that women avoid math, not because of inability, but because women are "socialized" away from studying math. She advocates "math therapy" for both sexes to overcome "math anxiety." (Tobias 1978, 12-13). Sharma asserts that gender differences in math skills are due more to social forces than to gender-specific brain construction and function. He believes that gender differences can be eliminated by equalizing the activities and experiences of both boys and girls at every level of development. The social forces that direct a child's experiences and choice of activities lead to the differences in the neurological sophistication of boys and girls. (Sharma 1989). For example, most studies show that girls do better than boys in math until the age of 12. Then boys dominate the subject. This difference can be explained by analyzing the gender-specific development of math prerequisite, spatial orientation skills. The main reason for this is the methodology of teaching in pre-school and elementary grades, where focus is on fine-motor skill development. (Sharma 1989).

As with all abilities, math aptitude can be inherited or an inborn disposition. Studies of identical twins reveal close math scores (Barakat 1951). Research into exceptionally gifted individuals shows high levels of math knowledge in early childhood, unexplained by external influences. Family histories of mathematically "gifted" and "retarded" individuals, revealed common aptitudes in other family members. (CTLM 1986). Even the most "mathematically gifted" individual can be hindered by inadequate Mathematics education. Likewise, a "mathematically retarded" individual will not attain competency in math despite intensive systematic training. (CTLM 1986)

2.1.5 Classification of Dyscalculia

Quantitative dyscalculia is a deficit in the skills of counting and calculating. Qualitative dyscalculia is the result of difficulties in comprehension of instructions or the failure to master the skills required for an operation. When a student has not mastered the memorization of number facts, he cannot benefit from this stored "verbalizable information about numbers" that is used with prior associations to solve problems involving addition, subtraction, multiplication, division, and square roots. Intermediate dyscalculia involves the inability to operate with symbols, or numbers. (CTLM 1989). Pseudo-Dyscalculia can be described as Mathematics inability caused by lack of, inconsistent, poor, or inappropriate systematic Mathematics instruction: inattention, fear, anxiety, illness, absence, or emotion. Psychology is concerned with the disorders and disturbances of math abilities. Neurology and psychiatry deal with the disturbed functions resulting from brain damage. (CTLM 1986) Each profession uses specific terminology to describe math disabilities. The result is the categorical fragmentation of classes and types of dyscalculia, as seen in the table below:

Table 2.1: Classification of Dyscalculia by Centre for Teaching/Learning of Mathematics (CTLM, 1986)

	Class	Name	Definition	Examples
1	Class A	Developmental Dyscalculia	Dysfunction in math, in individuals with normal mental functioning, resulting from brain anomalies inherited or occurring during prenatal development. Discrepancy 1-2 standard deviations below the mean, between mental age and math age. Clear retardation in math	Numerical difficulties with: counting, recognizing numbers, manipulating math symbols mentally and/or in writing, sequential memory for numbers and operations, mixing up numbers in reading, writing, recalling, and auditory processing, memory. Much more

			development.	effort is required.
2	Class B	Post-Lesion Dyscalculia	Math disability that is the result of brain damage/ head injury, cerebral dysfunction, or Minimal Brain Damage.	
3	Class C	Pseudo-Dyscalculia.	Environmentally Caused Dyscalculia. Math inability caused by: lack of, inconsistent, poor, or inappropriate systematic math instruction; inattention, fear, anxiety, illness, absence, or emotion.	
4	Class A-Type 1	Dyscalculia Subtypes occurring with Normal Mental Ability		
5	Class A- Type 2	Secondary Dyscalculia	Dyscalculia coexisting with oligophrenia, mental retardation, or dementia.	
6	Class A-1-a	Dyscalculia	Total inability to	

		MODERATELY SEVERE:	abstract, or consider concepts, numbers, attributes, or qualities apart from specific, tangible examples.	
7	Class A-1-b	Acalculia	Complete inability of math functioning.	
8	Class A-1-c	Oligocalculia	A relative decrease of all facets of math ability.	
9	Class A-2-a	Secondary Dyscalculia	Dementia with dyscalculia.	
10	Class A-2-b	Secondary Acalculia	Mental retardation with dyscalculia.	
11	Class A-2-c	Secondary Oligocalculia	Oligophrenia with dyscalculia.	
12	Class A-2-d	Secondary Paracalculia	A neurotic aversion to numbers.	
13	Class C	Environmentally Caused Dyscalculia	Math inability caused by: lack of, inconsistent, poor, or inappropriate systematic math instruction; inattention, fear, anxiety, illness,	

			absence, or emotion.	
14	Class C-Type 1	Pseudo-acalculia		
15	Class C- Type 2	Pseudo-dyscalculia		
16	Class C- Type 3	Pseudo-oligocalculia		
17	Class D	Para-calculia	MOST SEVERE: Dyscalculia with Learned Math Avoidance.	
18	Class D-1	Motor Verbal Paracalculia		
19	Class A-1-a-D	Dyscalculia + Learned Math Avoidance		
20	Class A-1-b-D	Acalculia + Learned Math Avoidance		
21	Class A-1-c-D	Oligocalculia + Learned Math Avoidance		
22	Class C-1-a-D	Pseudo-acalculia + Learned Math Avoidance		

23	Class C-1-b-D	Pseudo-dyscalculia + Learned Math Avoidance		
24	Class C-1-c-D	Pseudo-oligocalculia + Learned Math Avoidance		
25	Class A-1-a-I	Verbal Dyscalculia	Dysnomia for quantitative terms, elements and relations. Capable of performing operations involved. Counting disorders.	Cannot verbally name amounts of things, numbers, terms, symbols, and operations. Cannot associate numerals to amounts of things. Cannot verbally continue counting patterns. May be able to read and write dictated numbers. Capable of performing operations involved
26	Class A-1-a-I-a	Motor Verbal Dyscalculia	Cannot read or write dictated numbers.	May incorrectly write numbers as they are literally pronounced:

				"Five hundred and 4" as 5004, etc.
27	Class B-1	Sensory -Verbal Dyscalculia	Brain-damaged. Cannot display a requested number of items physically or pictorially. Cannot read or write numbers, or count items.	
28	Class A-1-a-II	Practognostic Dyscalculia	Impaired ability to manipulate real or pictured items for mathematical purposes. Apraxic (Processing errors that result in inability to perform purposeful motor actions, especially sequences.)-Perceptual Dysfunction.	Cannot manipulate, add, compare, or estimate quantity or magnitude of physical or pictured items. May be able to read, write, and imitate written numbers and operations. Cannot compare, comprehend, or describe part-whole relationships, spatial details, shapes and sizes.
29	Class A-1-a-II-a	Finger Apraxia or Gnosia	Inability to recognize objects by touching with the fingers.	Cannot use fingers to assist with math processing, cannot carry numbers or follow computational

				sequences. Cannot count by heart.
30	Class A-1-a-II-b	Apraxic Dyscalculia	Inability to purposeful motor acts, especially a sequence of movements. Caused by processing errors.	Cannot count by heart. Cannot use fingers to assist with math processing, cannot carry numbers or follow computational sequences.
31	Class A-1-a-II-c	Numerical Dyslexia or Literal Dyslexia	Performs below intellectual, developmental, and academic level. Difficulty with, or inability to read serial numbers, digits, place value, operational signs, math symbols, fractions, squares, roots, decimals, and the language of math. Can be caused by apatic agnosia, or directional confusion. Usually occurs with other types.	May transpose (mix up) [21 as 12], interchange similar digits[6 and 9], inappropriately insert, or omit digits, words, & signs. May read without acknowledging place value: 5007 as "five hundred seven," or 576 and "five seven six."
32	Class A-1-a-III	Lexical Dyscalculia or Numerical	Difficulty with, or inability to read serial numbers, digits, place	May transpose (mix up) [21 as 12], interchange similar

		Dyslexia	value, operational signs, math symbols, fractions, squares, roots, decimals, and the language of math. Can be caused by apatic agnosia, or directional confusion. Usually occurs with other types.	digits[6 and 9], inappropriately insert, or omit digits, words, & signs. May read without acknowledging place value: 5007 as "five hundred seven," or 576 and "five seven six."
33	Class A-1-a-III-a	Numerical Dysgraphia	Inability to write numbers because of inefficient motor skills or insufficient coordination of visual perception skills and fine motor skills.	
34	Class A-1-a-III-b	Numerical Dyscalculia or		
35	Class A-1-a-III-(a+b)-c	Numerical Dysmbolia		
36	Class A-1-a-IV	Graphical Dyscalculia or Numerical	Disability in writing math symbols. Usually occurs with literal dysgraphia and literal dyslexia.	May be unable to form/write individual digits, or copy them. Cannot encode (write) numbers correctly: [5731 as "5000700301" or omits zeros: 5073 as

		Dysgraphia		"573"] Writing #s in mixed up order, or opposite direction. May be able to write words for numbers.
37	Class A-1-a-IV-a	Numerical Dysgraphia	Inability to write numbers because of inefficient motor skills or insufficient coordination of visual perception skills and fine motor skills.	
38	Class A-1-a-IV-b	Numerical Dyscalculia		
39	Class A-1-a-IV-(a+b)-c	Numerical Dysmbolia	Lexical dyscalculia occurring with graphical dyscalculia. OR Numerical Dyslexia occurring with numerical Dysgraphia.	
40	Class A-1-a-V	Ideognostic Dyscalculia or Asemantic Aphasia or Dysymbolia TESTS: [a}100-7-7-7-7-7-7-	Poor mental comprehension of quantitative concepts. A dysfunction of the cognitive function of forming or assigning numbers & symbols	May be unable to calculate the easiest sums mentally, or at an age/ academically appropriate level. May be able to read and write numbers but is

		7.....mentally first/writing 2nd; {b} Series Completion.	"notions" or meaning. Inability to do mental math. Aphasia is the inability to express meaningful verbal identifications (of math symbols).	oblivious to their meaning. Unable to distinguish colors of objects, or objects from a competing background. Cannot identify a specified number of items.
41	Class A-1-a-V-a	Dysymbolia		
42	Class A-1-a-V-b	Acalculia	MOST SEVERE: Extreme difficulty in grasping principles and logic of math concepts and reasoning, Gnostic disturbance is noted when can do test mentally but not in writing.	Is unable to continue the sequence of numbers in the most basic of given series.
43	Class A-1-a-VI	Operational Dyscalculia (Anarithmetie) Tests: Note performance strategy. Have subject verbalize thinking, if possible.	Inability to learn and apply the rules for addition, subtraction, multiplication and division resulting in a disability to successfully perform math operations.	Frequent errors include: mixing up operations like +/-, -/□ , x/□ , x/+; mistaken or oversimplification of complex operations; insisting on written computation over mental calculation,

				uses fingers to assist mental or written computation.
44	Class A-1-a-VI-a	Sensory-verbal (Cannot count out)		
45	Class A-1-a-VI-b	Motor-Verbal (Cannot name)		
46	Class A-1-a-VI-c	Sequential Dyscalculia	Poor memory for: counting sequences, operational sequences, math facts, time, direction, schedules.	
47	Hypocalculia	Hypo- denotes a lack or deficiency in.		
48	Oligocalculia	Oligo- new, recent	A serious retardation in developmental math abilities caused by mental retardation.	Treatment: Appropriately motivate student to learn math, then fill in the knowledge and skill gaps with remedial techniques.
49	Calculasthenia (LESS SERIOUS)		A socially caused deficit in the level of math acquisition, skills,	

			and knowledge.	
50	Acalculia	A- without, not		
51	Paracalculia	Para- functionally disordered or diseased condition, or similar to, but not identical to a true condition or form.		
52	Learning Disability	Term from education and educational psychology.		Focus on Learning Problems in Mathematics.
53	Terms containing "calculia"	Are from the fields of neurology and neuro-psychology.	.	

(CTLM 1986)

2.2 THEORETICAL FRAMEWORK

2.2.1 Information Processing Theory

Information-processing theories of anxiety (Anderson, 1983; Newell and Simon 1972), analyze cognitive performances into complexes of rules, but performances critically depend on interactions among those rules. Each rule can be thought of as a component of the total skill, but the rules are not defined independently of one another. The relevance of this theory to the present study has been explained in four claims and has been further elaborated. The most significant point of this theory is that Mathematics disability is situational and one can improve upon it if proper restructuring is carried out. Again, the theory postulated that knowledge transfer or application of knowledge is very important.

The whole purpose of modeling information processing theories of cognition on Mathematics anxiety is that people who are mathematical disinclined goes through negative information processing in their brain, and this in turn feed back negative thoughts within the particular individuals. Unlike earlier behaviourist theories, information-processing theories do not posit a simple one-to-one mapping between individual rules or knowledge components and individual bits of behaviour. They deny this precisely because continual interaction can be observed among components of knowledge and behaviour. Information-processing psychology has advanced rapidly by developing methods both for identifying the components and for studying them in their interactions with their entire contexts. This is the meaning of the "unified theories of cognition" (Newell, 1991) which has guided so much of the recent research and theory-building.

The information-processing approach tries both to deepen our understanding of the components and to understand the relations among them and with their environments. Examples of these methods of componential analysis are the use of think-aloud protocols as data (Ericsson and Simon, 1993) and the use of models that simulate the interactions of perceptual, memory, learning and thinking processes over a wide range of cognitive tasks (Anderson, 1993; Feigenbaum and Simon, 1984; Newell, 1991). Assessing learning and improving learning methods require careful task analysis at the level of component skills, intimately combined with study of the interaction of these skills in the context of broader tasks and environments.

It is a well-documented fact of human cognition that large tasks decompose into nearly independent subtasks (Simon, 1981, Card, Moran & Newell, 1983), so that only the context of the appropriate subtask is needed to study its components. For instance, there is no need to teach or assess the ability to perform multi-column addition in the context of calculating income taxes. The process of adding tax deduction items is the same as the process of taking sums in other tasks. And whether one does the sum by hand or by calculator is unlikely to affect the rest of the tax calculation procedures. Thus, the larger procedure is independent of the summing procedure, just as the summing procedure is independent of the larger procedure.

In general, situated learning focuses on some well-documented phenomena in cognitive psychology and ignores many others. While cognition is partly context-dependent, it is also partly context-independent; while there are dramatic failures of transfer, there are also dramatic successes; while concrete instruction helps, abstract instruction also helps; while some performances benefit from training in a social context, others do not. The development from behaviourism to cognitivism was an awakening to the complexity of human cognition. The analysis offered by situated learning seems a regressive move. What is needed to improve learning and teaching is to continue to deepen our research into the circumstances that determine when narrower or broader contexts are required and when attention to narrower or broader skills are optimal for effective and efficient learning.

That action situationally grounded is surely the central claim of situated cognition. It means that the potentialities for action cannot be fully described independently of the specific situation. But the claim is sometimes exaggerated to assert that all knowledge is specific to the situation in which the task is performed, and that more general knowledge cannot and will not transfer to real-world situations. Supposed examples of this are Lave's (1988) description of Orange County homemakers who did very well at making supermarket best-buy calculations but who did much worse on arithmetically equivalent school-like paper-and-pencil Mathematics problems. Another frequently cited example is Carraher, Carraher and Schliemann's (1985) account of Brazilian street children who could perform Mathematics when making sales in the street but were unable to answer similar problems presented in a school context. An example in the Nigerian setting is that, some secondary school students who are not mathematically inclined at school may be good when making calculation at sales. This then means that, student can as well perform better in Mathematics at school because their problem of Mathematics is situational.

Even if these claims are valid and generalisable beyond the specific anecdotes that have been cited, they demonstrate at most that particular skills practiced in real-life situations do not generalize to school situations. They assuredly do not demonstrate that arithmetic procedures taught in the classroom cannot be applied to enable a shopper to make price comparisons or a street vendor to make change. What such observations call for is closer analyses of the task demands and the use of such analyses to devise teachable procedures that will achieve a balance between the advantages of generality and the advantages of incorporating enough situational context to make transfer likely. What they also call for is research on the feasibility of increasing the application and transfer of knowledge by including ability to transfer as a specific goal in instruction – a skill that is given little attention in most current instruction.

At one level there is nothing new in this claim about the contextualization of learning in Mathematics. There have been numerous demonstrations in experimental psychology that learning in Mathematics can be contextualized (Godden & Baddeley, 1975; Smith, Glenberg, & Bjork, 1978). For instance, Godden and Baddeley (1975) found that divers had difficulty remembering under water what they learned on land or vice versa. However, it is not the case that learning is totally tied to a specific context. In fact, there are many demonstrations of learning that transfer across contexts and of failures to find any context specificity in the learning (Fernandez & Glenberg, 1985; Saufley, Olaka, & Baversco, 1985).

How tightly learning will be bound to context depends on the kind of knowledge being acquired. Sometimes knowledge is necessarily bound to a specific context by the nature of instruction. In other cases, how contextualized the learning is depends on the way the material is studied. If the learner associates the knowledge with material from a specific context, it becomes easier to retrieve the knowledge in that same context (Eich, 1985), but perhaps harder in other contexts. One general result is that knowledge is more contexts bound when it is just taught in a single context (Bjork & Richardson-Klavhen, 1989).

Clearly, some skills, like reading, transfer from one context to another. For instance, the very fact that we can engage in a discussion of the context-dependence of knowledge is itself evidence for the context independence of reading and writing competence. Many of the demonstrations of contextual-binding from the situated camp involve Mathematics, but clearly, Mathematics competence is not always contextually bound either. Although the issue has seldom been addressed directly, the psychological research literature is full of cases where Mathematics competence has transferred from the classroom to all sorts of laboratory situations (sometimes bizarre- the intention was never to show transfer of Mathematics skills (Bassok & Holyoak, 1987; Elio, 1986; Reder & Ritter, 1992). It is not easy to locate the many published demonstrations of Mathematics competence generalizing to novel contexts; these results are not indexed under "context-independence of Mathematics knowledge" because, until recently, this did not seem to be an issue.

The literature on situation-specificity of learning often comes with a value judgment about the merits of knowledge tied to a non-school context relative to school-taught knowledge, and an implied or expressed claim that school knowledge is not legitimate. Lave (1986, 1988) suggests that school-taught Mathematics serves only to justify an arbitrary and unfair class structure. The implication is that school-taught competences do not contribute to on-the-career performance. However, numerous studies show modest to large correlations between school achievement and work performance (Hunter & Hunter, 1984; Brossiere, Knight, & Sabol, 1985) even after partialling out the effects of general ability measures (which are sometimes larger).

In this case, the authors of this theory conclude that action is indeed grounded in the situation where it occurs. They (authors) dissent strongly from some of the supposed implications that have been attached to this claim by proponents of situated action, and they have shown that their dissent has strong empirical support.

Knowledge does not have to be taught in the precise context in which it will be used, and grave inefficiencies in transfer can result from tying knowledge too tightly to specific, narrow contexts. Closer analyses of the task demands to devise teachable procedures that will balance the advantages of generality with the advantages of incorporating enough situational context to make transfer is needed. Individuals also need to study how to increase the application and transfer of knowledge by including ability to transfer as a specific goal in instruction.

This second claim, of the failure of knowledge to transfer, can be seen as a corollary of the first. If knowledge is wholly tied to the context of its acquisition, it will not transfer to other contexts. Even without strong contextual dependence, one could still claim that there is relatively little transfer, beyond nearly identical tasks, to different physical contexts. For instance, while one might be able to do fractional Mathematics in any context, it might not transfer to learning algebra.

The more recent psychological literature is also full of failures to achieve transfer (Gick & Holyoak, 1980; Hayes & Simon, 1977; Reed, Ernst, & Banerji, 1974; Weisberg, DiCamillo, & Phillips, 1985), but it is also full of successful demonstrations of transfer (Brown, 1990; Brown & Campione, 1993; Kotovsky & Fallside, 1989; Schoenfeld, 1985; Singley & Anderson, 1989; Smith, 1986). Indeed, in the same domain, quite different amounts of transfer occur depending on the amount of practice with the target task and on the representation of the transfer task (Kotovsky & Fallside, 1989). In general, representation and degree of practice are critical for determining the transfer from one task to another.

Singley and Anderson (1989) argued that transfer between tasks is a function of the degree to which the tasks share cognitive elements. This hypothesis had also been put forth very early in the development of research on transfer (Thorndike & Woodworth, 1901; Woodworth, 1938), but was hard to test experimentally modern capability for identifying task components was acquired. Singley and Anderson taught subjects several text editors, one after another and sought to predict transfer (savings in learning a new editor when it was not taught first). They found that subjects learned subsequent text editors more rapidly and that the number of procedural elements shared by two text editors predicted the amount of this transfer. In fact, they obtained large transfer across editors that were very different in surface structure but that had common abstract structures. Singley and Anderson also found that similar principles govern transfer of Mathematics competence across multiple domains, although here they had to consider transfer of declarative as well as procedural knowledge. As a general statement of the research reported by Singley and Anderson, transfer varied from one domain to another as a function of the number of symbolic components that were shared. If anything, Singley and Anderson found empirically slightly more transfer than was predicted by their theory.

One of the striking characteristics of such failures of transfer is how relatively transient they are. Gick and Holyoak were able to increase transfer greatly just by suggesting to subjects that they try to use the problem about the general. Exposing subjects to two such analogs also greatly increased transfer. The amount of transfer appeared to depend in large part on where the attention of subjects was directed during the experiment, which suggests that instruction and training on the cues that signal the relevance of an available skill might well deserve more emphasis than they now typically receive.

As a methodological comment, the authors think that there is a tendency to look for transfer in situations where one is least likely to find it. That is, research tends to look for transfer from little practice in one domain to initial performance in another domain. Superficial differences between the two domains will have their largest negative effect when the domains are unfamiliar. This does not require that students show the benefit of one day of Calculus on the first day of Physics. Rather, it is expected that they will be better Physics students at year's end for having had a year's study of Calculus. In other words, if students were taught numerical cognition to restructure their negative thoughts in Mathematics they would perform better. Consequently they would be able to transfer this knowledge to university settings – especially when they are exposed to social science-based or educational statistics.

Representation and degree of practice are critical for determining the transfer from one task to another, and transfer varies from one domain to another as a function of the number of symbolic components that are shared. The amount of transfer depends on where attention is directed during learning. Training on the cues that signal the relevance of an available skill may deserve much more emphasis than they now typically receive in instruction.

Like the second claim, the claim that training by abstraction is of little use is a corollary of the earlier claims. Nonetheless, one might argue for it even if one dismisses the others. The third claim has been extended into an advocacy for apprenticeship training (Brown, Collins, & Duguid, 1989; Collins, Brown, & Newman, 1989). It is argued that, because current performance will be facilitated to the degree that the context closely matches prior experience, the most effective training is an apprenticeship to others in the performance situation. This claim is used more than any other to challenge the legitimacy of school-based instruction.

Abstract instruction can be ineffective if what is taught in the classroom is not what is required in the career situation. Often this is an indictment of the design of the classroom instruction rather than of the idea of abstract instruction in itself. However, sometimes it is an indictment of the career situation. For instance, Los Angeles police after leaving the police academy are frequently told by more experienced officers "now forget everything you learned" (Independent Commission on the Los Angeles Police Department, 1991). The consequence is that police officers are produced who, ignoring their classroom training in the face of contrary influences during apprenticeship, may violate civil rights and make searches without warrants. Clearly, one needs to create a better correspondence between career performance and abstract classroom instruction and sometimes this means changing the nature of the career performance (including the structure of motivations and rewards) and fighting unwanted and deleterious effects of apprenticeship learning. Likewise in this study, students need to be counseled that Mathematics may be useful in any career they might find themselves. This is one of the significances of this theory to the present study. Teachers need to stop teaching Mathematics in abstract but rather practicalize the usefulness of the subject to the real life situations.

The issue of choosing between abstract and very specific instruction can be viewed in the following way. If abstract training is given, learners must also absorb the money and time costs of obtaining supplemental training for each distinct application. But if very specific training is given, they must completely retrain for each application. Which is to be preferred, and to what extent, do they depend on the balance among (a) the cost of the more general abstract training, (b) the cost of the specific training, (c) the cost of the supplemental training for application of abstract training, and (d) the range of careers over which the learner is likely to have occasion to apply what was learned. Someone who will spend years performing a single set of very specific tasks might be well advised to focus on specific training. But if the cost of supplemental training is not large (i.e., if there is substantial transfer over the range of tasks), or if technological or other changes are likely to alter tasks substantially over the years, or if the range of tasks the learner is likely to address over time is substantial, then abstract training with supplemental applications training is clearly preferable. It is easy to work out an exercise of this kind by assigning numbers to the various costs and to the variability of the tasks encountered, and thereby to show that there is no solution that is optimal for all cases.

Most modern information-processing theories are "learning-by-doing" theories which imply that learning would occur best with a combination of abstract instruction and concrete illustrations of the lessons of this instruction. Numerous experiments show combining abstract instruction with specific concrete examples (Cheng, Holyoak, Nisbett, & Oliver, 1986; Fong, Krantz, & Nisbett, 1986; Reed & Actor, 1991) is better than either one alone. One of the most famous studies demonstrating this was performed by Scholckow & Judd (described in Judd, 1908; a conceptual replication by Hendrickson & Schroeder, 1941). They had children practice throwing darts at a target underwater. One group of subjects received an explanation of refraction of light which causes the apparent location of the target to be deceptive. The other group only practiced, receiving no abstract instruction. Both groups did equally well on the practice task which involved a target 12 inches under water, but the group with abstract instruction did much better when asked to transfer to a situation where the target was now under only 4 inches of water.

A variation on the emphasis on apprenticeship training is the emphasis that has been given to using only "authentic" problems (Lesh & Lamon, 1992). What is authentic is typically ill-defined but there seems to be a strong emphasis on having problems be like the problems students might encounter in everyday life. A focus on underlying cognitive process would suggest that this is a superficial requirement. Rather, it is reinstated that the authors would argue as have others (Hiebert, Hearner, Carpenter, Fennema, Fuson, 1994) that the real goal should be to get students motivated and engage in cognitive processes that will transfer. What is important is what cognitive processes problem evokes and not what real-world trappings it might have.

The fourth claim that instruction is only effective in a highly social environment. This claim that instruction is best in a highly social environment comes not from those advocating situated learning, *per se*, but from those advocating the advantages of co-operative learning (Johnson & Johnson, 1989) as an instructional tool. Co-operative learning, also known as "communities of practice" and "group learning", refers to learning environments where people of equal status work together to enhance their individual acquisition of knowledge and skills. This environment or structure is to be contrasted with tutoring (where the tutor and tutee are of unequal knowledge and status) and team training (where the desired outcome is concerned with team or group performance). In a review by the Committee on Techniques for the Enhancement of Human Performance (National Research Council, 1994), it was noted that research on cooperative learning has frequently not being well controlled (e.g., non-random assignments to treatments, uncontrolled "teacher" and treatment effects), that relatively few studies "have successfully demonstrated advantages for cooperative versus individual learning," and that "a number of detrimental effects arising from cooperative learning have been identified – the "free rider," the "sucker," the "status differential," and "ganging up" effects (Salomon and Globerson, 1989).

The author's point is not to say that cooperative learning cannot be successful or sometimes better than individual learning. But that, it is not a panacea that always provides outcomes superior or even equivalent to those of individual training. It has been seen that cooperative learning is still part of numerical cognition and could be very effective in teaching students to learning cooperatively. This particular theory also indicates that it is good to familiarize the students with what they could gain with their learning. There is a strong point that students may prepare their minds on the type of career they would like to do, and which would not require Mathematics at all. In this case this would affect their thinking, perception and attitudes towards Mathematics.

2.2.2 Constructivism Theory

This theory postulates that knowledge is active rather than passive. In other words, learning Mathematics must be an active process. Learning Mathematics requires a change in the learner, which can only be brought about by what the learner does – what he or she attends to, what activities he or she engages in. However, there is a rising interpretation of constructivism that rejects the information-processing approach (Cobb, 1990). Such views are often espoused by those claiming to practice "radical constructivism". Even among radical constructivists, positions vary and some theorists seem to be making philosophical claims about the nature of knowledge rather than empirical claims. Indeed, in the extreme, constructivism denies the relevance of empirical data to educational decisions. However, some of the claims also have clear psychological implications that are not always supported. This study is also supported by the following claims: That knowledge would be viewed as an active, constructive process in which students attempt to resolve problems that arise as they participate in the Mathematics practices of the classroom. Such a view emphasizes that the learning-teaching process is interactive in nature and involves the implicit and explicit negotiation of Mathematics meanings. In the course of these negotiations, the teacher and students elaborate the taken-as-shared Mathematics reality that constitutes the basis for their ongoing communication (Cobb, Yackel, & Wood, 1992).

As an example of this, Cobb, Wood, Yackel, Nicholls, Wheatley, Trigatti, & Pertwitz (1991) describe an effort to teach second graders to count by tens. Rather than telling the students the principle directly, they assigned groups of students the task of counting objects bundled in sets of ten. Invariably, the groups discovered that counting by tens is more efficient than counting by ones. Building a whole second-grade curriculum around such techniques, they found their students doing as well on traditional skills as students from traditional classrooms, transferring more, and expressing better attitudes about Mathematics.

One can readily agree with one part of the constructivist claim: that learning must be an active process. Learning requires a change in the learner, which can only be brought about by what the learner does – what he or she attends to, what activities he or she engages in. The activity of a teacher is relevant to the extent that it causes students to engage in activities they would not otherwise engage in – including, but not limited to, acquiring knowledge provided by the teacher or by books. A teacher may also engage students in tasks, some of which may involve acquisition of skills by working examples. Other tasks include practicing skills to bring them to effective levels, interacting with their fellow students and with the teacher, and so on.

The problem posed to psychology and education is to design a series of experiences for students that will enable them to learn effectively and to motivate them to engage in the corresponding activities. On all of these points, it would be hard to find grounds for disagreement between constructivists and other cognitive psychologists. The more difficult problem, and the one that often leads to different prescriptions, is determining the desirable learning goals and the experiences that, if incorporated in the instructional design, will best enable students to achieve these goals. Of course, arriving at good designs is not a matter for philosophical debate; it requires empirical evidence about how people, and children in particular, actually learn, and what they learn from different educational experiences.

One finds frequent reference to Jean Piaget as providing a scientific basis for constructivism. Piaget has had enormous influence on our understanding of cognitive development and indeed was one of the major figures responsible for the emergence of cognitivism from the earlier behaviourist era in psychology. It is fair to say that many of his specific claims have been seriously questioned, the general influence of his theoretical perspective remains. Key to constructivism is Piaget's distinction between assimilation and accommodation as mechanisms of learning and development. Assimilation is a relatively passive incorporation of experience into a representation already available to the child. However, when the discrepancies between task demands and the child's cognitive structure become too great, the child will reorganize his or her thoughts. This is called accommodation (and often nowadays, "re-representation").

Piaget emphasized how the child internalizes by making changes in mental structure. The constructivists make frequent reference to this analysis, particularly the non-passive accommodation process. (In this respect, constructivism is quite different from situated learning which emphasizes the external bases of cognition.) A more careful understanding of Piaget would have shown that assimilation of knowledge also plays a critical role in setting the stage for accommodation – which the accommodation cannot precede without assimilation.

Some constructivists (Cobb, 1990) have mistakenly implied that modern information-processing theories deal only with assimilation and do not incorporate the more constructive accommodation. Far from this, the learning-by-doing theories that are widely employed in cognitive science are in fact analyses of how cognitive structure accommodates to experience. The authors briefly describe two such analyses, both to correct the misrepresentation of information-processing theory and to establish a more precise framework for discussing the effects of instruction.

In Anderson's (1993) study, one principal learning mechanism is knowledge compilation. When learners come upon problems they do not know how to solve, they can look at an example of how a similar problem is solved (retrieved either from memory or some external source) and try to solve the problem by analogy to this example. Knowledge compilation is the accommodation process by which new procedures (rules) are created to produce more directly the computation that this retrieve-and-analogize process requires.

In Feigenbaum and Simon's (1984) study, learning involves gradually building up discrimination net for recognizing objects and taking appropriate actions. Discrimination net is a sequence of tests that are applied to various features of an object. Gradually, the system develops a complex sensitivity to the situations and stimuli in its environment in a continuing process of re-representation, or accommodation.

These theories provide concrete realizations of what it means for a system to construct knowledge. As such they provide a basis for examining the constructivist's claim that knowledge cannot be instructed. If passive recording is what is meant by "instruct" these learning mechanisms cannot be instructed. However, it is quite wrong to claim that what is learned is not influenced by explicit instruction. For instance, in Anderson's learning by analogy, instruction serves to determine the representation of the examples from which one "constructs" one's understanding, and Pirolli and Anderson (1985) showed in the domain of recursive programming that what one learns from an example is strongly influenced by the instruction that accompanied the example. In Feigenbaum and Simon's (1984) study, which has had extensive success in modeling human learning in a variety of perceptual and verbal learning tasks (Simon & Feigenbaum, 1964), learning is strongly influenced by the sequence of stimuli and the feedback that tells the system when responses are correct, and when they are wrong.

There is a great deal of research showing that, under some circumstances, people are better at remembering information that they create for themselves than information they receive passively (Bobrow & Bower, 1969; Slamecka & Graf, 1972). However, this does not imply that people do not remember what they are told. Indeed, in other cases people remember as well or even better information that is provided than information they create (Slamecka & Katsaiti, 1987; Stern & Bransford, 1979).

When, for whatever reason, students cannot construct the knowledge for themselves, they need some instruction. The argument that knowledge must be constructed is very similar to the earlier arguments that discovery learning is superior to direct instruction. In point of fact, there is very little positive evidence for discovery learning and it is often inferior (Charney, Reder & Kusbit, 1990). Discovery learning, even when successful in acquiring the desired construct, may take a great deal of valuable time that could have been spent practicing this construct if it had been instructed. Because most of the learning in discovery learning only takes place after the construct has been found, when the search is lengthy or unsuccessful, motivation commonly flags. As Ausubel (1968) wrote, summarizing the findings from the research on discovery learning twenty-five years ago:"actual examination of the research literature allegedly supportive of learning by discovery reveals that valid evidence of this nature is virtually nonexistent. It appears that the various enthusiasts of the discovery method have been supporting each other research-wise by taking in each other's laundry, so to speak, that is, by citing each other's opinions and assertions as evidence and by generalizing wildly from equivocal and even negative findings." (p. 497-498)

It is sometimes argued that direct instruction leads to "routinization" of knowledge and drives out understanding: "the more explicit a teacher is about the behaviour he/she wishes his/her students to display, the more likely it is that they will display the behaviour without recourse to the understanding which the behaviour is meant to indicate; that is, the more likely they will take the form for the substance." Brousseau (1984).

An extension of this argument is that excessive practice will also drive out understanding. This criticism of practice (called "drill and kill," as if this phrase constituted empirical evaluation) is prominent in constructivist writings. All evidence, from the laboratory and from extensive case studies of professionals, indicates that real competence only comes with extensive practice (Hayes, 1985; Ericsson, Krampe, Tesche-Romer, 1993). In denying the critical role of practice one is denying children the very thing they need to achieve real competence. The instructional task is not to "kill" motivation by demanding drill, but to find tasks that provide practice while at the same time sustaining interest. Substantial evidence shows that there are a number of ways to do this; learning-from-examples – method, is one such procedure that has been extensively and successfully tested in school situations. The evidence, then, leads to the following conclusions about the role of student and teacher in learning: Learning requires a change in the learner, which can only be brought about by what the learner does. The activity of a teacher is relevant to the extent that it causes students to engage in activities they would not otherwise engage in.

The task is to design a series of experiences for students that will enable them to learn effectively and to motivate them to engage in the corresponding activities. The learning-by-doing theories that are widely employed in cognitive science are analyses of how cognitive structure accumulates to experience. When students cannot construct the knowledge for themselves, they need some instruction. There is very little positive evidence for discovery learning and it is often inferior. In particular, it may be costly in time, and when the search is lengthy or unsuccessful, motivation commonly flags.

People are sometimes better at remembering information that they create for themselves than information they receive passively, but in other cases they remember as well or better information that is provided than information they create. Real competence only comes with extensive practice. The instructional task is not to "kill" motivation by demanding drill, but to find tasks that provide practice while at the same time sustaining interest. There are a number of ways to do this, for instance, by "learning-from-examples."

The claim of the constructivist school that knowledge cannot be represented symbolically is more an epistemological claim in the constructivist's hands than a psychological claim. The claim is that there are subtleties in human understanding that defy representation in terms of a set of rules or other symbol structures (Cobb, 1990). The argument is not really about whether knowledge is actually so represented in the human head, but whether knowledge, by its very nature, can be represented symbolically. Searle's well-known attempt to show that, in principle, a symbolic system cannot understand language (the "Chinese Room" metaphor, Searle, 1980) is an extension of this claim.

Among the misconceptions underlying the claim that knowledge is non-symbolic is the faulty notion that "symbolic" means "expressed in words and sentences, or in equivalent formal structures." Symbols are much more than formal expressions. Any kind of pattern that can be stored and can refer to some other pattern, say, one in the external world, is a symbol, capable of being processed by an information-processing system.

A substantial number of symbolic systems have been built that can store symbol structures representing mental images of external events and can reason about the events pictorially with the help of these structures (Larkin, 1981). Careful comparison with the behaviour of human subjects reasoning about pictures or diagrams shows that these systems capture many of the basic properties and processes of human imagery. Searle's Chinese Room story fails because the inhabitants of his postulated room, unlike humans and other symbolic systems do not have a sensory window on the world – cannot associate a pattern in memory with the external object that can be seen and denoted by that pattern. To know is to represent accurately what is outside the mind; so to understand the possibility and nature of knowledge is to understand the way in which the mind is able to construct such representations (Cobb, Yackel, and Wood, 1992, from Rorty, 1979).

The representational view of mind, as practiced in cognitive psychology, certainly makes no claims that the mind represents the world accurately or completely, and no strong claims about the nature of knowledge as a philosophical issue. The true representational position is compatible with a broad range of notions about the relation of the mind to the world, and about the accuracy or inaccuracy and completeness or incompleteness of our internal representations of the world's features. Its claim simply: Cognitive competence (in this case Mathematics competence) depends on the availability of symbolic structures (e.g., mental patterns or mental images) that are created in response to experience.

The misinterpretation of the representational view leads to much confusion about external Mathematics representations (e.g., equations, graphs, rules, Dienes blocks, etc.) versus internal representations (e.g., production rules, discrimination nets, and mental images). Believing that the representational version of learning records these external representations passively and without transformation into distinct internal representations, constructivists take inadequacies of the external representations as inadequacies of the notion of internal representation. For instance, if a set of rules in a textbook is inadequate this is taken as an inability of production rules to capture the concepts. However, cognitive theories postulate (and provide evidence for) complex processes for transforming (assimilating and accommodating) these external representations to produce internal structures that are not at all isomorphic to the external representations.

While it is true that education has proceeded for centuries without a theory of internal representation, this is no reason to ignore the theories that are now coming from cognitive psychology. Let us consider the analogy of medicine: For thousands of years before there was any real knowledge of human physiology, remedies for some pathological conditions were known and used, sometimes effectively, by both doctors and others. But the far more powerful methods of modern medicine were developed concurrently with the development of modern physiology and biochemistry, and are squarely based on the latter developments. To acquire powerful interventions in disease, we had to deepen our understanding of the mechanisms of disease – of what was going on in the diseased body.

In the same way, human beings have been learning, and have been teaching their offspring, since the dawn of our species. There is a reasonably powerful "folk medicine," based on lecturing and reading and apprenticeship and tutoring, aided by such technology as paper and the blackboard – a folk medicine that does not demand much knowledge about what goes on in the human head during learning and that has not changed radically since schools first emerged. To go beyond these traditional techniques, there is need to follow the example of medicine and build (as we have been doing for the past thirty or forty years) a theory of the information processes that underlie skilled performance and skill acquisition: that is to say, we must have a theory of the ways in which knowledge is represented internally, and the ways in which such internal representations are acquired. In fact, cognitive psychology has now progressed a long way toward such a theory, and, as we have seen, a great deal is already known that can be applied, and is beginning to be applied, to improve learning processes.

In summary, contrary to the claim that knowledge cannot be represented symbolically, the evidence indicates the following actual state of affairs: Symbols are much more than formal expressions. Any kind of pattern that can be stored and can refer to some other pattern, say, one in the external world, is a symbol, capable of being processed by an information-processing system. Cognitive competence (in this case Mathematics competence) depends on the availability of symbolic structures (e.g., mental patterns or mental images) that are created in response to experience. Cognitive theories postulate (and provide evidence for) complex processes for transforming (assimilating and accommodating) these external representations to produce internal structures that are quite different from the external representations.

Today instruction is based in large part on "folk psychology." To go beyond these traditional techniques, there is need to continue to build a theory of the ways in which knowledge is represented internally, and the ways in which such internal representations are acquired.

The third claim by construtivists is that knowledge can only be communicated in complex learning situations. Part of the "magical" property of knowledge asserted in the second claim, that there is something in the nature of knowledge that cannot be represented symbolically, is that no simple instructional situation suffices to convey the knowledge, whatever it may be. This assertion is the final consequence of rejecting decontextualization. Thus, constructivists recommend, for example, that children learn all or nearly all of their Mathematics in the context of complex problems (Lesh & Zawojeski, 1992). This recommendation is put forward without any evidence as to its educational effectiveness.

There are, of course, reasons sometimes to practice skills in their complex setting. Some of the reasons are motivational and some reflect the special skills that are unique to the complex situation. The student who wishes to play violin in an orchestra would have a hard time making progress if all practice were attempted in the orchestra context. On the other hand, if the student never practiced as a member of an orchestra, critical skills unique to the orchestra would not be acquired. The same arguments can be made in the sports context, and motivational arguments can also be made for complex practice in both contexts. A child may not see the point of isolated exercises, but will when they are embedded in the real-world task. Children are motivated to practice sports skills because of the prospect of playing in full-scale games. However, they often spend much more time practicing component skills than full-scale games. It seems important, but this is not a reason to make this the principal mechanism of learning.

While there may be motivational merit to embedding Mathematics practice in complex situations, Geary (1995) notes that there is a lot of reason to doubt how intrinsically motivating complex Mathematics is to most students in any context. The kind of sustained practice required to develop excellence in an advanced domain is not inherently motivating to most individuals and requires substantial family and cultural support (Ericsson, Krampe, & Tesch-Romer, 1993). Geary argues, as have others (Bahrick & Hall, 1991; Stevenson & Stigler, 1992), that it is this difference in cultural support that accounts for the large difference in Mathematics achievement between Asian and American children.

Contrary to the contention that knowledge can always be communicated best in complex learning situations, the evidence shows that: A learner who is having difficulty with components can easily be overwhelmed by the processing demands of a complex task. Further, to the extent that many components are well mastered, the student wastes much time repeating these mastered components to get an opportunity to practice the few components that need additional effort.

There are reasons sometimes to practice skills in their complex setting. Some of the reasons are motivational and some reflect the skills that are unique to the complex situation. While it seems important both to motivation and to learning to practice skills from time to time in full context, it is important to reiterate that this is not a reason to make this the principal mechanism of learning.

The fourth claim is that it is not possible to apply standard evaluations to assess learning. The denial of the possibility of objective evaluation could be the most radical and far-reaching of the constructivist claims. They put it last because it is not clear how radically this principle is interpreted by all constructivists. Certainly, some constructivists have engaged in rather standard evaluations of constructivist learning interventions (Cobb, Wood, Yackel, Nicholls, Wheatley, Trigaitti, & Perlwitz, 1992). However, others are very uncomfortable with the idea of evaluation. As Jonassen (1992) writes: "If you believe, as radical constructivists do, that no objective reality is uniformly interpretable by all learners, then assessing the acquisition of such a reality is not possible. A less radical view suggests that learners will interpret perspectives differently, so evaluation processes should accommodate a wider variety of response options." (p. 144).

In the hands of the most radical constructivists, the fourth claim implies that it is impossible to evaluate any educational hypothesis empirically because any such test necessarily requires a commitment to some arbitrary, culturally-determined, set of values. In the hands of the more moderate constructivists, the claim manifests itself in advocacy of focusing evaluation on the process of learning more than the product, in what are considered "authentic" tasks, and by involving multiple perspectives in the evaluation.

This milder perspective calls for emphasis on more subjective and less precisely defined instruments of evaluation. While the authors share with most educators their instinctive distaste of four-alternative forced-choice questions and they agree that Mathematics assessment should go beyond merely testing computational skills, they question whether the very open-ended assessment being advocated as the proper alternative will lead to either more accurate or more culture-free assessment. The fundamental problem is a failure to specify precisely the competence being tested for and a reliance on subjective judgment instead. The authors then examined a number of recent papers in Wirzup and Streit (1992) addressing this issue. In one of such papers, Resnick, Briars, and Lesgold (1992) presented two examples of answers that are objectively equivalent (and receive equal scores in their objective assessment scheme). However, they are uncomfortable with this equal assessment and feel a subjective component should be added so one answer would receive a higher score because it displayed greater "communication proficiency." Although the "better" answer had neater handwriting, one might well judge it as just more long-winded as the "worse" answer. "Communication proficiency" is very much in the eyes of the beholder. In another paper, Dossey (1992), in explaining the new NAEP open-ended scoring, states that a student will be given 50% (2 points) for the right answer if the justification for the answer is "not understandable" but will be given 100% (4 points) for the wrong answer if it "does not reflect misunderstanding of either the problem or how to implement the strategy, but rather seems to be a copying error or computational error." While they are sympathetic with the sentiments behind such ideas, such subjective judgments will open the door to a great deal of cultural bias in assessment (Rist, 1970). Anytime the word "seems" appears in an assessment, it should be a red flag that the assessors do not know what they are looking for. The information-processing approach would advocate precisely specifying what one is looking for in terms of a cognitive model and then precisely testing for that.

Another sign of the constructivist's discomfort with evaluation manifests itself in the motto that the teacher is the novice and the student the expert (Von Glasersfeld, 1991). The idea is that every student gathers equal value from every learning experience. The teacher's task is to come to understand and value what the student has learned. As Confrey (1991) writes:

> *"Seldom are students' responses careless or capricious. We must seek out their systematic qualities which are typically grounded in the conceptions of the student...frequently when students' responses deviate from our expectations, they possess the seeds of alternative approaches which can be compelling, historically supported and legitimate if we are willing to challenge our own assumptions." (p. 122)*

And also as Cobb, Wood, and Yackel (1991) write:

> *"The approach holds that students are the best judges of what they find problematical and encourages them to construct solutions that they find acceptable given their current ways of knowing." (p. 158).*

If the student is supposed to move, in the course of the learning experiences, from a lower to a higher level of competence, one wonders why the student's judgments of the acceptability of solutions are particularly valid. While the teacher who can appreciate children's individuality, see their insights and motivate them to do their best and to value learning, is also valued, then there must be definite educational goals. More generally, if the "student –as- judge" attitude were to dominate education, it would no longer be clear when instruction had failed and when it had succeeded, when it was moving forward and when moving backward. It is one thing to understand why the student, at a particular stage in understanding, is doing what he or she is doing. It is quite another matter to help the student understand how to move from processes that are "satisfactory" in a limited range of tasks to processes that are more effective over a wider range. As Resnick (1994) argues, many concepts which children naturally come to (e.g., that motion implies force) are not what the culture expects of education and that in these cases "education must follow a different path: still constructivist in the sense that simple telling will not work, but much less dependent on untutored discovery and exploration (p. 489)."

Again, there is an important empirical reason for proceeding in assessment in somewhat different ways from those recommended by constructivists, and particularly, the more radical among them. It is shared by all, an instinctive distaste for four-alternative forced-choice questions, but these are not required to attain validity or reliability in assessment. Accurate and culture-free assessment does requires, however that the competence being tested for to be specified precisely without undue reliance on subjective judgment. Subjective judgments open the door to cultural bias in assessment. It cannot be assumed that students' judgments of the acceptability of solutions are particularly valid and as stated earlier, if the "student –as- judge" view were adopted, it would no longer be clear when instruction had failed and when it had succeeded

2.2.3 Chain Reaction or Cycle Theory

Mathematics anxiety has been explained in terms of a chain reaction or cycle. Spielberger (1972) conceptualised anxiety as a state, trait and a process. As is described by Spielberger (1972), 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) described a Mathematics 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 Mathematics anxiety cycle (Mitchell 1987). This cycle leads to negative educational and societal Mathematics attitudes which often become a self-fulfilling prophecy, and generally leads to Mathematics avoidance (Williams 1988).

2.2.4 Social Cognitive Theory

Social Cognitive Theory is the overarching theoretical framework of the self-efficacy construct (Bandura, 1986). Within this perspective, one's behaviour is constantly under reciprocal influence from cognitive (and other personal factors such as motivation) and environmental influences. Bandura calls this three-way interaction of behavior, cognitive factors, and environmental situations the "triadic reciprocality." Applied to an instructional design perspective, students' academic performances (behavioural factors) are influenced by how learners themselves are affected (cognitive factors) by instructional strategies (environmental factors), which in turn builds on itself in cyclical fashion. The methods for changing students' percepts of efficacy, according to Bandura (1977, 1986), are categorically subsumed under four sources of efficacy information that interact with human nature: (1) enactive attainment, (2) vicarious experience, (3) persuasive information, and (4) physiological state.

The reciprocal nature of the determinants of human functioning in social cognitive theory makes it possible for therapeutic and counseling efforts to be directed at personal, environmental, or behavioural factors. Strategies for increasing well-being can be aimed at improving emotional, cognitive, or motivational processes, increasing behavioural competencies, or altering the social conditions under which people live and work. In school, for example, teachers have the challenge of improving the learning achievement and confidence of the students in their charge. Using social cognitive theory as a framework, teachers can work to improve their students' emotional states and to correct their faulty self-beliefs and habits of thinking (personal factors), improve their academic skills and self-regulatory practices (behaviour), and alter the school and classroom structures that may work to undermine student success (environmental factors).

Bandura's social cognitive theory stands in clear contrast to theories of human functioning that overemphasize the role that environmental factors play in the development of human behaviour and learning. Behaviourist theories, for example, show scant interest in self-processes because theorists assume that human functioning is caused by external stimuli. Because inner processes are viewed as transmitting rather than causing behaviour, they are dismissed as a redundant factor in the cause and effect process of behaviour and unworthy of psychological inquiry. For Bandura, a psychology without introspection cannot aspire to explain the complexities of human functioning. It is by looking into their own conscious mind that people make sense of their own psychological processes. To predict how human behavior is influenced by environmental outcomes, it is critical to understand how the individual cognitively processes and interprets those outcomes. More than a century ago, William James (1890/1981) argued that "introspective observation is what we have to rely on first and foremost and always" (p. 185). For Bandura (1986), "a theory that denies that thoughts can regulate actions does not lend itself readily to the explanation of complex human behaviour" (p. 15).

Similarly, social cognitive theory differs from theories of human functioning that overemphasize the influence of biological factors in human development and adaptation. Although it acknowledges the influence of evolutionary factors in human adaptation and change, it rejects the type of evolutionism that views social behaviour as the product of evolved biology but fails to account for the influence that social and technological innovations that create new environmental selection pressures for adaptiveness have on biological evolution (Bussey & Bandura 1999). Instead, the theory espouses a bidirectional influence in which evolutionary pressures alter human development such that individuals are able to create increasingly complex environmental innovations that, "in turn, create new selection pressures for the evolution of specialized biological systems for functional consciousness, thought, language, and symbolic communication" (p. 683). This bidirectional influence results in the remarkable intercultural and intracultural diversity evident in our planet.

Social cognitive theory is rooted in a view of human agency in which individuals agents are proactively engaged in their own development and can make things happen by their actions. Key to this sense of agency is the fact that, among other personal factors, individuals possess self-beliefs that enable them to exercise a measure of control over their thoughts, feelings, and actions, that "what people think, believe, and feel affects how they behave" (Bandura, 1986). Bandura provided a view of human behaviour in which the beliefs that people have about themselves are critical elements in the exercise of control and personal agency. Thus, individuals are viewed both as products and as producers of their own environments and of their social systems. Because human lives are not lived in isolation, Bandura expanded the conception of human agency to include collective agency. People work together on shared beliefs about their capabilities and common aspirations to better their lives. This conceptual extension makes the theory applicable to human adaptation and change in collectivistically-oriented societies as well as individualistically-oriented ones.

Individuals have self-regulatory mechanisms that provide the potential for self-directed changes in their behaviour. The manner and degree to which people self-regulate their own actions and behaviours involve the accuracy and consistency of their self-observation and self-monitoring, the judgments they make regarding their actions, choices, and attributions, and, finally, the evaluative and tangible reactions they make to their own behaviour through the self-regulatory process. This last subfunction includes evaluations of one's own self (their self-concept, self-esteem, values) and tangible self-motivators that act as personal incentives to behave in self-directed ways. For Bandura (1986), the capability that is most "distinctly human" (p. 21) is that of self-reflection, hence it is a prominent feature of social cognitive theory. Through self-reflection, people make sense of their experiences, explore their own cognitions and self-beliefs, engage in self-evaluation, and alter their thinking and behaviour accordingly.

Of all the thoughts that affect human functioning, and standing at the very core of social cognitive theory, are self-efficacy beliefs, "people's judgments of their capabilities to organize and execute courses of action required attaining designated types of performances" (p. 391). Self-efficacy beliefs provide the foundation for human motivation, well-being, and personal accomplishment. This is because unless people believe that their actions can produce the outcomes they desire, they have little incentive to act or to persevere in the face of difficulties. Much empirical evidence now supports Bandura's contention that self-efficacy beliefs touch virtually every aspect of people's lives—whether they think productively, self-debilitatingly, pessimistically or optimistically; how well they motivate themselves and persevere in the face of adversities; their vulnerability to stress and depression, and the life choices they make. Self-efficacy is also a critical determinant of self-regulation.

Of course, human functioning is influenced by many factors. The success or failure that people experience as they engage the myriad tasks that comprise their life naturally influence the many decisions they must make. Also, the knowledge and skills they possess will certainly play critical roles in what they choose to do and not do. Individuals interpret the results of their attainments, however, just as they make judgments about the quality of the knowledge and skills they posses.

Bandura's (1997) key contentions as regards the role of self-efficacy beliefs in human functioning is that "people's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true" (p. 2). For this reason, how people behave can often be better predicted by the beliefs they hold about their capabilities than by what they are actually capable of accomplishing, for these self-efficacy perceptions help determine what individuals do with the knowledge and skills they have. This helps explain why people's behaviours are sometimes disjoined from their actual capabilities and why their behaviour may differ widely even when they have similar knowledge and skills. For example, many talented people suffer frequent (and sometimes debilitating) bouts of self-doubt about capabilities they clearly possess, just as many individuals are confident about what they can accomplish despite possessing a modest repertoire of skills. Belief and reality are seldom perfectly matched, and individuals are typically guided by their beliefs when they engage the world. As a consequence, people's accomplishments are generally better predicted by their self-efficacy beliefs than by their previous attainments, knowledge, or skills. Of course, no amount of confidence or self-appreciation can produce success when requisite skills and knowledge are absent.

It bears noting that self-efficacy beliefs are themselves critical determinants of how well knowledge and skill are acquired in the first place. The contention that self-efficacy beliefs are a critical ingredient in human functioning is consistent with the view of many theorists and philosophers who have argued that the potent affective, evaluative, and episodic nature of beliefs makes them a filter through which new phenomena are interpreted.

People's self-efficacy beliefs should not be confused with their judgments of the consequences that their behaviour will produce. Typically, of course, self-efficacy beliefs help determine the outcomes one expect. Confident individuals anticipate successful outcomes. Students confident in their social skills anticipate successful social encounters. Those confident in their academic skills expect high marks in exams and expect the quality of their work to reap personal and professional benefits. The opposite is true of those who lack confidence. Students who doubt their social skills often envision rejection or ridicule even before they establish social contact. Those who lack confidence in their academic skills envision a low grade before they begin an examination or enroll in a course. The expected results of these imagined performances will be differently envisioned: social success or greater career options for the former, social isolation or curtailed academic possibilities for the latter.

Because the outcomes we expect are themselves the result of the judgments of what we can accomplish, our outcome expectations are unlikely to contribute to predictions of behaviour. Moreover, efficacy and outcome judgments are sometimes inconsistent. A high sense of efficacy may not result in behaviour consistent with that belief; however, if the individual also believes that the outcome of engaging in that behaviour will have undesired effects. A student highly self-efficacious in her academic capabilities may elect not to apply to a particular university whose entrance requirements are such as to discourage all but the hardiest souls. Low self-efficacy and positive outcome expectations are also possible. For example, students may realize that strong Mathematics skills are essential for a good GRE score and eligibility for graduate school, and this, in turn, may ensure a comfortable lifestyle, but poor confidence in Mathematics abilities are likely to keep them away from certain courses and they may not even bother with the GRE or graduate school. In the social arena, a young man may realize that pleasing social graces and physical attractiveness will be essential for wooing the young lass who has caught his eye, which, in turn, may lead to a romantic interlude and even a lasting relationship. If, however, he has low confidence in his social capabilities and doubts his physical appearance, he will likely shy away from making contact and hence miss a potentially promising opportunity.

Because individuals operate collectively as well as individually, self-efficacy is both a personal and a social construct. Collective systems develop a sense of collective efficacy—a group's shared belief in its capability to attain goals and accomplish desired tasks. For example, schools develop collective beliefs about the capability of their students to learn, of their teachers to teach and otherwise enhance the lives of their students, and of their administrators and policymakers to create environments conducive to these tasks. Organizations with a strong sense of collective efficacy exercise empowering and vitalizing influences on their constituents, and these effects are palpable and evident.

Even average-ability students are sometimes known to do poorly in specific subject areas while performing up to standard in others. This phenomenon is often reflected in the domain of Mathematics. The reasons for this phenomenon no doubt reflect the multivariate nature of school learning. We must also take into account the idiosyncratic nature of diverse learners. When capable learners do not perform up to their potential despite positive environmental conditions, we must give more attention to the self-regulatory processes within individuals that promote or inhibit performance. From the social-cognitive view, self-efficacy is an important factor that resides within the learner and mediates between cognition and affect, and results in changes in academic performance (Zimmerman, Bandura, & Martinez-Pons, 1992). The growth and reduction of self-efficacy is influenced over time by social comparison with peers and is therefore more pronounced as one grows older.

By the time children reach middle school (grades six through eight), the majority of them have made significant judgments regarding their preferences toward certain academic domains. These judgments are no doubt influenced by their perceived capability with regard to the domains, as a result of social comparison with peers and feedback from teachers. This is particularly true in the domain of Mathematics. At this stage, children are already making decisions leading to career directions and choice of classes. By high school, these decisions become more solidified. For educators, the critical time to reduce or prevent Mathematics alienation is in middle school, or early in high school.

Elementary school children usually have greater confidence in their academic capabilities, and this confidence extends equally across gender to both verbal and Mathematics domains of learning. In later years, however, gender differences regarding

Mathematics begin to emerge. Fennema and Sherman (1978) found that there were no significant differences with gender and Mathematics learning, or with gender and motivation for learning, for 1,300 middle school children. There were, however, significant effects on Mathematics confidence and on perceptions of Mathematics as a male domain, with boys reportedly averaging higher on both variables. When these results are compared to previous research by the same authors, using the same design but with high school students (Sherman and Fennema, 1977) the overall results indicate that the gender gap on Mathematics confidence and perceptions begins to widen in middle school and increasingly widens in high school. Although these studies did not measure self-efficacy, *per se*, the significant variables of confidence and gender stereotyping of a domain are contributing sources of self-efficacy information.

Bandura (1977), sought to address the related question of what mediates knowledge and action beginning with his seminal work on self-efficacy. Bandura (1986) defines the performance component of self-efficacy as people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is not concerned with the strategies one has but with judgments of what one can do with whatever strategies one possesses. Students feel self-efficacious when they are able to picture themselves succeeding in challenging situations, which in turn determines their level of effort toward the task (Paris & Byrnes, 1989; Salomon, 1983; 1984).

Bandura (Bandura 1977, 1986) asserts that self-percepts of efficacy highly influence whether students believe they have the coping strategies to successfully deal with challenging situations. One's self-efficacy may also determine whether learners choose to engage themselves in a given activity and may determine the amount of effort learners invest in a given academic task, provided the source and requisite task is perceived as challenging (Salomon, 1983, 1984).

Several researchers have since investigated the relationship of self-efficacy to learning and academic achievement, but research in the area of academic performance is still developing (Lent, Brown, & Larkin, 1986; Multon, Brown & Lent, 1991; Schunk, 1994).

People make judgments about their capabilities based on enactive experience, vicarious experience (observation), persuasive information, and physiological states. In school, children gain knowledge and experiences through experiential activities. They also gain information based on seeing how peers they judge to be similar to themselves perform at various levels and under given circumstances. They also are told by teachers, peers, family and others about their expected capabilities. Children give themselves physiological feedback about their capabilities through symptoms such as soreness or sweating. These sources of efficacy information are not mutually exclusive, but interact in the overall process of self-evaluation. Bandura, Adams, & Beyer (1977) advise that enactive experience is a highly influential source of efficacy information. Successful experiences raise self-efficacy with regard to the target performance while experiences with failure lower it.

Another source of efficacy information is vicarious experience through observation. Observing peers, or peer models, especially those with perceived similar capabilities, carry out target performances which result in evaluative information about one's personal capabilities.

Verbal persuasion or convincing serves as another source of efficacy information. Teachers, for example, can raise or inhibit students' percepts of efficacy by suggesting whether or not they have the capabilities to succeed in a given task (Bouffard-Bouchard, 1989). Models can also be used to demonstrate to self-doubters that personal capabilities are more often a result of effort rather than innate capability. Students often have physical reactions to anticipated events. Many a public speaker testifies to sweaty palms and nervous vocal reactions when performing a speech. These physiological indicators are sources of self-efficacy information as well.

Social cognitive theory postulates that the aforementioned sources of self efficacy information are the most influential determinants of performance. An important assumption of Social Cognitive Theory is that personal determinants, such as forethought and self-reflection, do not have to reside unconsciously within individuals. People can consciously change and develop their cognitive functioning. This is important to the proposition that self-efficacy too can be changed, or enhanced. From this perspective, people are capable of influencing their own motivation and performance according to a model of triadic reciprocality in which personal determinants (such as self-efficacy), environmental conditions (such as treatment conditions), and action (such as practice) are mutually interactive influences. Improving performance, therefore, depends on changing some of these influences.

Within the model of triadic reciprocality, the ability to influence various personal determinants is accorded to five basic human capabilities: 1) symbolizing, 2) forethought, 3) vicarious, 4) self-regulatory, and 5) self-reflective. People are generally gifted with the capability of symbolizing. In an academic context, this allows learners to process abstract experiences into models that guide their learning and performance. For example, observing someone on computer or videotape vocalize a computational algorithm for calculating may serve as an adequate instructional representation of performing that procedure. One can learn how to perform the strategy in this manner, and may even gain in self-efficacy by observing a peer model that this procedure is within the scope of one's own capabilities.

Forethought, the cognitive representation of future events, is also a powerful causal influence on one's learning. For example, watching a self-efficacious model perform a Mathematics calculation using a particular strategy may lead the observer to foresee this within the scope of his or her own capabilities and consequently expect to perform the procedure with success.

Vicarious capability occurs by observing others and vicariously experiencing what they do. According to Bandura (1986), if we had to directly experience everything we learn, we would not have adequate time and opportunity to learn very much. Observing a model's thinking through text-based soliloquy, for example, can direct the observer on how to conceptualize a Mathematics calculation or overcome self-doubts about successful performance. Students typically self-regulate by determining what capabilities they have with regard to a given task and in effect compare those capabilities against a set of standards they maintain for themselves. Students who believe that they can achieve a high grade in a Mathematics course may persist in their efforts to achieve the grade. Conversely, low self-efficacy pertaining to a given task may inhibit one's effort and persistence (Bouffard-Bouchard, 1989).

People compare their performance with that of their peers in various contexts, especially the classroom. The accuracy of their assessments determines whether they overestimate or underestimate their capabilities. Consequently, accurate self-reflection is critical to the development of self-efficacy.

2.3 EMPIRICAL BACKGROUND

2.3.1 Numerical Cognition and Mathematics Anxiety

There is paucity of literature on numerical cognition and Mathematics anxiety. So there is no much available literatures on the domain of behaviour. In a study by Hopko *et al* (1999) it was found that Mathematics-anxious individuals have a deficient inhibition mechanism whereby working memory resources are consumed by task-irrelevant distracters. A consequence of this deficiency was that explicit memory performance was poorer for high-anxious individuals. They also found no relationship between competence and Mathematics anxiety. There are a great many causes postulated for Mathematics anxiety. In a study of eight adult learners, Zopp (1999) found that unrelated life events, trigger events in education and a lack of support contributed to Mathematics anxiety in her subjects. In addition, parents with Mathematics anxiety pass it along to their children, while teachers with Mathematics anxiety pass it along to their students (Fiore 1999). Jackson et al (1999) studied 157 students in a senior-level elementary education Mathematics class in college by giving them the prompt, "Describe your worst or most challenging Mathematics classroom experience from kindergarten through college". They were also asked to describe factors that would have made their experiences more positive. These subjects were above average in academic achievement, highly motivated with an average age of 26.

Mathematics anxiety and performance across several initial studies, have found substantial evidence for performance differences as a function of Mathematics anxiety. These differences typically are not observed on the basic whole-number facts of simple addition or multiplication (e.g., 7 + 9, 6 X 8) but are prominent when somewhat more difficult arithmetic problems are tested. In particular, Ashcraft and Faust (1994; also Faust, Ashcraft, & Fleck, 1996) have shown that high-Mathematics-anxiety participants have particular difficulty on two-column addition problems (e.g., 27 + 18), owing largely to the carry operation. When such problems were answered correctly, the time estimate for the embedded carry operation was nearly three times as long for high-anxiety participants as it was for low-anxiety participants (Faust *et al*., 1996). Thus, high-Mathematics-anxiety participants showed slower, more effortful processing on a procedural aspect of performance, performing the carry operation (for suggestive evidence on Mathematics affect and procedural performance in a numerical estimation task, (LeFevre, Greenham, & Waheed, 1993). Furthermore, their higher error rates on these problems, often showing classic speed-accuracy tradeoffs when confronted with relatively difficult arithmetic, indicated a willingness to sacrifice accuracy on especially difficult trials, either to avoid having to deal with the stimulus problem or merely to speed the experimental session along.

An interpretation, of course, is that high-anxiety participants are simply less competent in Mathematics, unable to perform the necessary calculations at the same level of accuracy as low-anxiety individuals. The literature documents that there is indeed a significant relationship between Mathematics anxiety and Mathematics competence or achievement in Hembree's (1990) meta-analysis. If the correlation holds across all levels of problem difficulty, then competence and Mathematics anxiety are completely confounded, and performance differences cannot be uniquely attributed to either factor. Results reported elsewhere, however, suggest that there is not a complete confounding of Mathematics anxiety and Mathematics competence.

Faust *et al*. (1996), for instance, showed equivalent performance across Mathematics-anxiety groups to simple one- and two-column addition and multiplication problems when those problems were tested in an untimed, pencil-and-paper format. It is important to note that the larger of these problems had shown Mathematics-anxiety effects in laboratory tasks, suggesting strongly that the on-line anxiety reaction had compromised participants' ability to demonstrate their basic competence. Ashcraft and Kirk (1998) examined Mathematics competence and Mathematics anxiety more thoroughly in a study that administered a standardized Mathematics achievement test. Simple whole-number arithmetic problems showed no Mathematics anxiety effects at all, whereas accuracy for the higher Mathematics-anxiety groups did decline more on the later test lines at which more difficult arithmetic (e.g., mixed fractions) and Mathematics problems (e.g., factoring) were tested.

Finally, Hembree (1990) noted an interesting outcome in his meta-analysis on Mathematics anxiety. Reports on the most effective treatment interventions for Mathematics anxiety, behavioral and cognitive-behavioral approaches, also presented evidence of post treatment increases in Mathematics achievement or competence scores to levels "approaching the level of students with low Mathematics anxiety" (p. 43). Because the treatments did not involve instruction or practice in Mathematics, it is quite improbable that treatment itself improved individuals' Mathematics competence. Instead, it seems very likely that the low pretreatment achievement scores of high-Mathematics-anxiety individuals were depressed by Mathematics anxiety during the assessment itself and that relief from Mathematics anxiety then permitted a more accurate assessment of Mathematics achievement and competence.

On the basis of such evidence, it would appear that lower Mathematics competence cannot be offered as a simple, wholesale explanation for all the performance decrements associated with high Mathematics anxiety (see Ashcraft & Kirk, 1998, for a full discussion of this argument). Instead, these performance decrements seem to call for an explanation involving numerical cognitive processing. A growing body of evidence attests to the centrality of working memory to processes such as reading and reading comprehension (Just & Carpenter, 1992), reasoning (Baddeley & Hitch, 1974; Jonides, 1995), and retrieval from long-term memory (Conway & Engle, 1994; Rosen & Engle, 1997; Richardson *et al*., 1996).

The various components of these mental processes are often attributed to one or another of the three major subcomponents—the central executive, the auditory rehearsal loop, or the visuo-spatial sketchpad—in Baddeley's (1986, 1992) well-known model. There is a supportive although not extensive literature on the role of working memory in Mathematics cognition. Since Hitch's (1978) early article on multistep arithmetic problem solving, there have been several reports on the critical role of working memory in Mathematics performance. As an example, Geary and Widaman (1992) demonstrated that working memory capacity was closely related to skill in arithmetic problem solving and, in particular, to the speed of both fact retrieval and execution of the carry operation. In both cases, the higher the capacity of working memory, the faster were the component processes (Ashcraft, 1992, 1995; Lemaire, Abdi, & Fayol, 1996; Widaman, Geary, Cormier, & Little, 1989). So, for example, executing the carry operation is thought to be controlled by working memory, thus placing significant demands on the capacity of the working memory system (Ashcraft, Copeland, Vavro, & Falk, 1999; Hitch, 1978; Logie, Gilhooly, & Wynn, 1994). Accordingly, they hypothesized that a major contributor to the performance deficits found for high-Mathematics-anxiety participants involves working memory. In particular, such deficits are predicted to stem from that portion of working memory, presumably the central executive that applies the various procedures of arithmetic during problem solving (Ashcraft *et al*., 1999; Butterworth, Cipolotti, & Warrington, 1996; Darke, 1988, and Sorg & Whitney, 1992).

More generally, Eysenck and Calvo (1992) have proposed an overall model of the anxiety-to-performance relationship in cognitive tasks, which is called the processing efficiency theory. Their most relevant prediction for the present topic is that performance deficits due to generalized anxiety will be prominent in exactly those tasks that tap the limited capacity of working memory. In their theory, the intrusive thoughts and worry characteristic of high anxiety are thought to compete with the ongoing cognitive task for the limited processing resources of working memory. The result of such competition is either a slowing of performance or a decline in accuracy—in other words, lower cognitive efficiency. Because high-anxiety individuals must expend greater cognitive effort to attain the same level of performance achieved by low-anxiety individuals, processing efficiency is lower for high-anxiety individuals. Most of Eysenck's work (Eysenck, 1992) is based on results with either generalized anxiety disorder individuals or individuals who exhibit high trait anxiety.

Eysenck (1992) discusses a whole range of anxiety-related phenomena, for instance, increased physiological arousal, selective attention, and distractibility. For the tasks under consideration here, however, the consequences of anxiety that affect working memory processes are the most relevant function of Mathematics anxiety, especially on tasks that require intensive processing within working memory. We do not test the specifics of Eysenck and Calvo's (1992) prediction here, which states that it is intrusive thoughts and worry (in this case, about Mathematics) that detract from available working memory capacity. Instead, we assess the more general prediction that Mathematics anxiety disrupts working memory processing when the cognitive task involves arithmetic or Mathematics-related processes.

Regarding Mathematics intervention, some researchers, Seethaler and Fuchs (2005) analyze the literature in terms of the efficacy of studies completed. In a similar research, Augustyniak, Murphy and Phillips (2005) argue that the research on the definition of a Mathematics disability is lacking with respect to identification of core deficits. They identify the core areas needing further explanation as numerical skills, visual/spatial deficits, cognitive skill development (memory retrieval, working memory, speed of processing, attention regulation, problem solving) and social cognition. Mazzocco (2005) reviewed research regarding practices of early identification and intervention for students with Mathematics difficulties. The commentary discusses the criteria and nature of Mathematics difficulties and notes the need for additional research.

Butler, Beckingham, and Lauscher (2005) report on three case studies regarding the support of students with Mathematics learning challenges. Three 8th grade students were given assistance in self-regulating their learning. General strategies found to be successful included: engaging the students in constructive conversation; supporting students in reflection on their learning; and, the need for teachers to engage in dynamic, curriculum-based forms of assessment.

Fuchs, Fuchs, and Hamlett (2006) report on the validation of an intervention to improve Mathematics problem solving in third grade. The intervention (HotMathematics) involved explicit instructions, self-regulation strategies, and tutoring. Results indicated positive, short-term results for problem-solving skills.

2.3.2 Numerical Cognition and Mathematics Achievement

Although different theoretical orientations of researchers have often caused differing operational definitions, the common conceptualization of numerical cognition learners is that they are active participants in their own learning (Zimmerman, 1990). The research agrees on at least two major findings with respect to Numerical Cognition and academic achievement: Numerical Cognition is comprised of several components, such as cognitive strategies and effort (Miller, Behrens, Greene, & Newman, 1993) or metacognition and effort (Pintrich & De Groot; 1990; Yap, 1993), although the specific components were not always identical; and students who employ metacognition and exert effort perform more successfully (Pintrich & De Groot, 1990; Zimmerman, 1986; Zimmerman & Martinez-Pons, 1986, 1988). To make a summary of the key features in most definitions of Numerical Cognition is the systematic use of metacognitive, motivational, and/or behavioral strategies. Moreover, numerical cognition learners are distinguished by both awareness of the relationship between strategic regulatory processes and learning outcomes, and the use of these strategies to achieve academic goals (Zimmerman, 1990).

Although there have been numerous theoretical and empirical articles about Numerical Cognition (Garcia, 1995; Garcia & Pintrich, 1991, 1994, 1995; Pintrich & Garcia, 1991; Schunk & Zimmerman, 1994; Zimmerman, 1994), few have explicitly linked the components of Numerical Cognition to academic achievement in Mathematically-gifted students and to each other. In those studies that have explicitly investigated these components, the correlational relationships tend to be small (e.g., Pintrich & De Groot, 1990, Yap, 1993). In this study, Numerical Cognition conjoins two major constructs: (a) metacognition, consisting of awareness (consciousness), planning (goal setting), self-checking (monitoring), and the cognitive strategies students use to learn, remember, and understand; and (b) management and control of effort. This study additionally investigated the relationship of learning goal orientation, self-efficacy, and worry to high-stakes Mathematics achievement and with each other. Each of the study's variables was discussed in greater detail.

In their review of the research, Alexander, Carr, and Schwanenflugel (1995) found that gifted children possessed greater metacognition than the general cohort. Schwanenflugel, Moore Stevens, and Carr (1997) also found that children who made causal metacognitive comments were likely to be more strategic in their cognitive processing. "Express" [gifted] pupils employed effective retention strategies more frequently than "normal" students (Chang, 1989). Although metacognition is thought to differ from other cognitive learning strategies such as rehearsal, elaboration, and organization, there is mixed evidence about the extent to which respondents can actually distinguish their use of metacognitive and cognitive strategies. According to Boufard-Bouchard, Parent, and Larivee (1993), gifted learners monitor comprehension more effectively than non-gifted students. They also use more strategies in a flexible manner. Some researchers found distinct cognitive and metacognitive factors using exploratory factor analyses (Pokay & Blumenfeld, 1990; Pintrich & De Groot, 1990). However, the correlations between the scales measuring these factors were high ($r = .60$ and $r = .83$) in these two studies respectively, and neither correlation was corrected for measurement error, thus raising concerns about the extent to which students can accurately distinguish their use of the various strategies. Further, Yap (1993) found that a composite index of cognitive strategies correlated very high with three commonly used indices of metacognitive strategies, awareness (.97), planning (.95), and self-checking (.96). The present study sheds further light on this debate.

With respect to effort, both Bandura (1993) and Schunk (1984) see effort as both being directly influenced by self-efficacy and directly affecting skill or performance. Bandura (1993) suggested that self-regulatory skills are meaningless if students cannot apply themselves in a persistent manner in the face of difficulties, distractions, and stress, and that "self-directed learning requires motivation as well as cognitive and metacognitive strategies" (p. 136). Zimmerman (1990) also observed that self-regulated learners display extraordinary effort and persistence during learning and report high self-efficacy, self-attributions, and intrinsic motivation. Additionally, Bandura (1993) posited that "self-efficacy beliefs contribute to motivation in several ways. They determine the goals people set for themselves, how much effort they expend and how long they persevere in the face of failures" (p. 131).

There is some debate in the literature concerning the distinction between effort and metacognition. Although conceptually it makes sense to distinguish a generalized motivational disposition (i.e., effort) from more specific metacognitive strategies (e.g., planning, self-checking, awareness), there is some evidence that individuals themselves cannot distinguish these strategies through self-report. In their correlational study of Numerical Cognition in 7th-graders, Pintrich and De Groot (1990) originally intended to treat effort management and Numerical Cognition as separate constructs, but a preliminary exploratory factor analysis did not support the construction of two separate scales. Along the same lines, Yap (1993) used a confirmatory statistics to examine the effort/metacognition distinction in a diverse sample of 640 12th-grade students and found that self-report scales for effort and metacognition lacked discriminant validity. In contrast, Pokay and Blumenfeld (1990) report a small zero-order correlation between effort management and metacognitive strategy used early ($r = .34$) and late ($r = .39$) in the semester in a sample of 283 high school students. This study posits that Numerical Cognition is comprised of effort and metacognition, and one of its goals is to further examine the effort/ metacognition distinction.

Chang (1989) found that gifted students expressed greater enjoyment in learning a subject than normal students. The question is whether these students become gifted because they enjoyed learning in that particular domain. Determining cause and effect on questions such as these will have interesting and profound implications for practitioners in this field. According to Dweck (1986, 1990), children who believe in intelligence as a fixed trait or entity tend to orient towards performance goals, whereas those who believe intelligence is incremental and malleable tend to orient towards learning goals. Her research indicated that when seeking performance type goals, children based their task choice and pursuit process around ability. With learning goals, however, the choice and pursuit process was focused on progress and mastery through effort.

Low performing students believed that ability is a fixed trait, whereas gifted students were more likely to believe that ability to learn can be improved (Schommer &

Dunnell, 1997). Students who adopted a learning or mastery orientation increased perceptions of self-confidence (self-efficacy) and success in their courses (Dweck & Leggett, 1988). A number of studies clearly show that students demonstrate high levels of Numerical Cognition when they are oriented toward learning goals (e.g., Meece, 1994; Schunk, 1994). Weiner (1986) found that children with low perceived ability were still mastery-oriented when their goal was to learn rather than to perform. Bandura (1993) emphasized that learning environments that accept ability as a skill that may be acquired and de-emphasize competition and social comparison are well suited for building self-efficacy and promoting academic achievement. Furthermore, Dweck's (1986) research indicated that students whose focus is based on ability judgments tend to withdraw from challenges, "whereas a focus on progress through effort creates a tendency to seek and be energized by challenge" (p. 1041). The adaptive motivational pattern studied by Dweck (1986) "is characterized by challenge seeking and high, effective persistence in the face of obstacles" (p 1040). Dweck contended that children with learning goals use these obstacles as a cue to increase their effort or to analyze and vary their strategies. Based on the assumption that gifted students will be more learning-goal-oriented for this study, it was hypothesized that the results will agree with those of Dweck (1986) and Schunk (1994); that is, learning goal orientation would be positively related to Numerical Cognition and self-efficacy.

Bandura (1986) defined self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance" (p. 391). Implicitly, self-efficacy refers to people's specific beliefs about their capability to perform certain actions or to bring about intended outcomes in a domain or to otherwise exert control over their lives (Bandura, 1986, 1993; Boekaerts, 1992; Schunk, 1990). Data on self-efficacy were collected in this study to determine the relationship between the proposed factors of Numerical Cognition and their relationship with worry and high-stakes Mathematics achievement for a gifted sample. The focus was test performance. Collins (1984) and Pintrich and Schrauben (1992) noted that more efficacious students monitored their performance and applied more effort than students who were low in self-efficacy. Bandura (1993) said that people with high self-efficacy "heighten and sustain their efforts in the face of failure. And also they attribute failure to insufficient effort or deficient knowledge and skills that are acquirable" (p. 144). An excellent review of self-efficacy research is provided by Pajares (1996b). Research of the gifted (Bogie & Buckholt, 1987; Chan, 1988; Feldhusen & Nimlos-Hippen, 1992; Vallerand, Gagne, Senecal, & Pelletier, 1994; Zimmerman & Martinez-Pons, 1990) examined self-perceptions of competence in gifted students. In general, these studies indicated "that gifted students perceive themselves as more competent and are more intrinsically motivated toward school tasks" (Chan, 1996, p. 184) than their peers.

In their path model, Zimmerman, Bandura, and Martinez-Pons (1992) showed that self-efficacy for Numerical Cognition influenced self-efficacy for academic achievement; self-efficacy for academic achievement then influenced final grades via student goals for their grades. The combined direct and indirect effect of self-efficacy for academic achievement on final grades was ([Beta] = .37, p [is less than] .05). Zimmerman and Bandura (1994) found essentially the same results in their study ([Beta] = .38). In their path model, Garcia and Pintrich (1991) found that intrinsic motivation (comparable to learning goal orientation in this study) had a substantial effect on self-efficacy ([Beta] = .36), and that both intrinsic motivation and self-efficacy had moderate effects on Numerical Cognition ([Beta] = .24 and [Beta] = .26, respectively). This study did not investigate the role of these motivational effects on academic achievement, but did posit that self-efficacy will be strongly and positively related to Numerical Cognition and Mathematics achievement.

Most research has shown that high worry is associated with low cognitive performance (Hembree, 1988, 1990; Pajares & Urdan, 1996; Seipp, 1991). However, a few studies showed no relationship (e.g., Wigfield & Meece, 1988). Anxiety, on the other hand, may be differentiated into two components: worry (cognitive) and emotionality (physiological/affective) (Hembree, 1988; Hong, 1998, O'Neil & Fukumura, 1992). In several studies, worry has had a stronger negative correlation with achievement than emotionality; in response, Seipp (1991) recommended that studies predicting academic achievement would be better served by using only the worry component. It was hypothesized that worry would be negatively related to Numerical Cognition, self-efficacy, learning goal orientation, and high-stakes Mathematics achievement.

The research on certain types of Mathematics continues to support gender differences in favor of males (Fennema & Carpenter, 1998), although there is evidence indicating "that females' achievement is similar to males in all but the most advanced levels of Mathematics" (National Science Foundation, 1996). According to Seegers and Boekaerts (1996), there have been, and continue to be, significant gender differences in performance on complex Mathematics tasks (Fennema & Carpenter, 1998). This study used the Advanced Placement in calculus as the performance indicator. It was hypothesized that males would outperform females.
In summary, self-regulated learners are students who plan and check their work, are aware of their thought processes, use cognitive strategies to achieve their goals, and exert effort. This study investigated Numerical Cognition and the effects of self-efficacy, learning goal orientation, and worry on achievement in a sample of mathematically gifted high school students in an Advanced Placement Program course in Mathematics. The study's objectives were to extend the theoretical and empirical research on goal orientation, self-efficacy, and Numerical Cognition by determining whether learning goal orientation and self-efficacy are related to Numerical Cognition, documenting their relationships to worry and high-stakes Mathematics achievement, and controlling for the effects of gender.

Pintrich and De Groot (1990) found that although self-efficacy facilitated cognitive engagement, the cognitive engagement variables were more directly tied to performance. They also found a negative relationship between worry and self-efficacy but no significant relationship of test anxiety (worry) with Numerical Cognition. In this study, self-efficacy was more tied to performance than were Numerical Cognition and its concomitant variables, and that worry had a significant negative relationship with both self-efficacy and Numerical Cognition. Using the Motivated Strategies for Learning Questionnaire (MSLQ), Pintrich and De Groot (1990) found that students with higher self-efficacy, intrinsic value (learning goal orientation), cognitive strategy use, and use of self-regulating strategies (metacognition/effort) had significantly higher grades, better seatwork, and better scores in exams/quizzes and essays/reports. Even though the methodologies used by Pintrich and De Groot (1990) and criterion variables were different, many of their results were comparable; in particular, they both found empirical evidence "for the importance of considering both motivational and Numerical Cognition components in thier models of classroom academic performance" (p. 38).

Schunk (1984) determined that self-efficacy had both a direct and indirect (as mediated by persistence) path of influence to cognitive skill development. Emphasizing that the goal was to learn to solve problems (rather than simply completing them) can raise self-efficacy for learning and increase Numerical Cognition and persistence in 4th-grade children (Schunk, 1995). In 1994, Schunk posited that "students who adopt a learning goal are apt to experience a sense of self-efficacy for skill improvement and engage in activities they believe enhance learning (e.g., expend effort, persist, use effective strategies)" (p. 89). However, Pintrich and De Groot (1990) found a non-significant relationship between learning goal orientation and self-efficacy. All of their other findings, with this one exception, were comparable to Schunk's (1995).

With a group of high school students, Pajares and Kranzler (1995) found significant positive direct paths from self-efficacy to Mathematics performance and a significant negative path to anxiety. Pajares and Kranzler found no gender effects for these students, either on self-efficacy or performance. A significant correlation between Mathematics self-efficacy and problem-solving performance was indicated in college students (Pajares & Miller, 1994, 1995). Pajares and Miller (1994) found a gender effect favoring the Mathematics self-efficacy of male undergraduates but found no gender effect on problem-solving performance.

In a study of Mathematics self-efficacy in 8th-grade students, Pajares (1996a) found a direct effect of gender on self-efficacy for regular education students but no direct effect of gender on performance (boys had higher self-efficacy). For gifted students, there was a direct effect of self-efficacy and gender on performance (girls had higher performance), but no gender effect on self-efficacy. Pysher (1996) also found no significant gender differences in Mathematics test scores, goals, or self-efficacy. Pintrich and De Groot (1990)’s findings with Mathematically-gifted students generally agree with these authors: A significant direct path was indicated both from self-efficacy to Mathematics performance and from self-efficacy to worry; and whereas no significant gender effects on performance were found, there was a significant effect on self-efficacy.

2.3.3 Emotional Freedom Technique and Mathematics Anxiety

Previous research (Salas, 2000; Wells, *et al*., 2003), theoretical writings (Arenson, 2001, Callahan, 1985, Durlacher, 1994, Flint, 1999, Gallo, 2002, Hover-Kramer, 2002, Lake & Wells, 2003, Lambrou & Pratt, 2000, and Rowe, 2003), and many case reports have suggested that energy psychology is an effective psychotherapy treatment that improves psychological functioning. Research evidence for efficacy of EFT and related therapies is only beginning to emerge. Research (Church, 2008) has noted frequent co-occurrence of psychological symptoms such as anxiety and depression with addiction. This study examined the psychological conditions of 28 adults at an addictions workshop at which participants learned EFT (Emotional Freedom Techniques), a widely practiced form of energy psychology. The study employed a time-series, within-subjects repeated measures design to evaluate symptoms at the start of the workshop, at the end of the workshop, and, to determine long-term effects, 90 days later. A statistically significant decrease in the two global scales, the global severity index and positive symptom total, as well as the anxiety, and obsessive-compulsive symptom scales was observed with gains maintained at follow-up. Improvement in somatization was found at posttest only, while improvement in interpersonal sensitivity occurred at the 90-day follow-up. These findings suggest EFT may be an effective adjunct to addiction treatment by reducing the severity of general psychological distress, and in particular, anxiety and obsessive-compulsive symptoms. Rowe's (2005) study was to measure any changes in psychological functioning that might result from participation in an experiential Emotional Freedom Techniques (EFT) workshop and to examine the long-term effects.

Brattberg (2008) carried out a study to examine if self-administered EFT (Emotional Freedom Techniques) leads to reduced pain perception, increased acceptance, coping ability and health-related quality of life in individuals with fibromyalgia. 86 women, diagnosed with fibromyalgia and on sick leave for at least 3 months, were randomly assigned to a treatment group or a waiting list group. An eight-week EFT treatment program was administered via the Internet. Upon completion of the program, statistically significant improvements were observed in the intervention group (n=26) in comparison with the waiting list group (n=36) for variables such as pain, anxiety, depression, vitality, social function, mental health, performance problems involving work or other activities due to physical as well as emotional reasons, and stress symptoms. Pain catastrophizing measures, such as rumination, magnification and helplessness, were significantly reduced, and the activity level was significantly increased.

Wells, Polglase, Andrews, Carrington and Banker (2003) explored whether a Emotional-freedom-based procedure, Emotional Freedom Techniques (EFT), can reduce specific phobias of small animals under laboratory-controlled conditions. Randomly assigned participants were treated individually for 30 minutes with EFT (n = 18) or a comparison condition, Diaphragmatic Breathing (DB) (n = 17). Findings revealed that EFT produced significantly greater improvement than did DB behaviorally and on three self-report measures, but not on pulse rate. The greater improvement for EFT was maintained, and possibly enhanced, at 6 - 9 months follow-up on the behavioral measure. These findings suggest that a single treatment session using EFT to reduce specific phobias can produce valid behavioral and subjective effects.

A research (Swingle, Pulos & Swingle, 2005), studied the effects of EFT on auto accident victims suffering from post traumatic stress disorder -- an extremely disabling condition that involves unreasonable fears and often panic attacks, physiological symptoms of stress, nightmares, flashbacks, and other disabling symptoms. These researchers found that three months after they had taught EFT (in two sessions) those auto accident victims who reported continued significant symptom relief also showed significant positive changes in their brain waves. It was assumed that the clients showing the continued positive benefits were those who continued with home practice of self-administered EFT.

Feinsten (2008b) utilizes cognitive operations such as imaginal exposure to traumatic memories or visualization of optimal performance scenarios—combined with physical interventions derived from acupuncture, yoga, and related systems—for inducing psychological change. While a controversial approach, this combination purportedly brings about, with unusual speed and precision, therapeutic shifts in affective, cognitive, and behavioral patterns that underlie a range of psychological concerns. Four tiers of energy psychology interventions include 1) immediate relief/stabilization, 2) extinguishing conditioned responses, 3) overcoming complex psychological problems, and 4) promoting optimal functioning. The first tier is most pertinent in psychological first aid immediately following a disaster, with the subsequent tiers progressively being introduced over time with complex stress reactions and chronic disorders.

Feinsten (2008) utilizes imaginal and narrative-generated exposure, paired with interventions that reduce hyperarousal through acupressure and related techniques. According to practitioners, this leads to treatment outcomes that are more rapid, powerful, and precise than the strategies used in other exposure-based treatments such as relaxation or diaphragmatic breathing. The method has been exceedingly controversial. It relies on unfamiliar procedures adapted from non- Western cultures, posits unverified mechanisms of action, and early claims of unusual speed and therapeutic power ran far ahead of initial empirical support. The study reviews a hierarchy of evidence regarding the efficacy of energy psychology, from anecdotal reports to randomized clinical trials.

Benor, Ledger, Toussaint and Zaccaro (2008) explored test anxiety benefits of Wholistic Hybrid, Emotional Freedom Techniques (EFT), and Cognitive Behavioural Therapy. Participants including Canadian university students with severe or moderate test anxiety participated. A double-blind, controlled trial was conducted. Standardized anxiety measures included: the Test Anxiety Inventory (TAI) and Hopkins Symptom Checklist (HSCL-21). Despite small sample size, significant reductions on the TAI and HSCL-21 were found for WHEE; on the TAI for EFT; and on the HSCL-21 for CBT. There were no significant differences between the scores for the three treatments. In only two sessions WHEE and EFT achieved the equivalent benefits to those achieved by CBT in five sessions. Participants reported high satisfaction with all treatments. EFT and WHEE students successfully transferred their self-treatment skills to other stressful areas of their lives. WHEE and EFT show promise as effective treatments for test anxiety.

Church (2008a) examined a cross section of 194 healthcare professionals, including physicians, nurses, psychotherapists, chiropractors, psychiatrists, alternative medicine practitioners, and allied professionals. The study examined whether self-intervention with Emotional Freedom Techniques (EFT), a brief exposure therapy that combines a cognitive and a somatic element, had an effect on subjects' levels of anxiety, depression, and other psychological symptoms. The study utilizes within-subjects, time-series, repeated measures design. Besides measuring the breadth and intensity of psychological distress, this instrument has nine subscales for specific conditions, including anxiety and depression. It was administered to subjects before and after an EFT demonstration and self-application that lasted about 90 minutes. Subjects also self-reported physical pain, emotional distress, and cravings on a 10 point Likert-type scale. Subjects received a single page homework EFT reminder sheet, and their frequency of practice was tracked at follow up. EFT self-application resulted in statistically significant decreases in pain, emotional distress, and cravings, and improvements for all nine subscales. On the two general scales, symptom severity dropped by 34%, and symptom breadth by 40% relative to normal baselines (both $p<.001$). Also pain scores dropped by 68%, the intensity of traumatic memories by 83%, and cravings by 83% (all $p<.001$).

Callahan (1985) developed a causal diagnostic procedure gleaned in part from the insights and discoveries of chiropractor George Goodheart, D.C., who related neuromuscular function and organ system health to the acupuncture Emotional-freedom system. Callahan (1985) utilized muscle testing methods found in Goodheart's Applied Kinesiology, and John Diamond's Behavioral Kinesiology (Diamond, 1979) to therapy localize (identify) which acupuncture Emotional-freedoms were involved in psychological issues. Once identified, Callahan has the patient repeatedly tap fingers on a designated treatment point along that acupuncture Emotional-freedom to effect change or restore balance in that Emotional-freedom. Frequently, the causal diagnostic methods produce a sequence of acupuncture Emotional-freedom points to be tapped. As an outgrowth of the success of The Callahan Techniques", tapping as treatment on the acupuncture Emotional-freedoms has continued, and has been incorporated into other acupuncture Emotional-freedom based psychotherapies. Callahan (1985) asserted that the tapping provides an external source of energy which, when done correctly, at the right spot, with the mind tuned to the problem being treated, balances the energy in a particular energy system in the body which is suffering from a deficiency or imbalance. A couple of years later Callahan (1992) commented on his practical and theoretical ideas related to tapping. He asserted that the points being tapped are related to the ancient Emotional-freedoms of acupuncture. Tapping the proper point when the person is thinking of the problem is quite effective. He then stressed that these points are transducers of energy; where the physical energy of tapping can be transduced into the appropriate (probably electromagnetic) energy of the body so that the person with a problem can be put into proper balance by a knowledgeable person.

Callahan's decision to tap acupoints originated in a procedure introduced by Goodheart in Applied Kinesiology (Callahan, 1985; Gallo, 1999). In the Five Minute Phobia Cure Callahan wrote asserted that rhythmic tapping at a specific point on a Emotional-freedom will improve the condition of the associated vital organ. This, they say, occurs because the "energy flow" within that Emotional-freedom is freed to move again." (p. 32)

Walther (1988) described a Emotional-freedom technique in AK called the "Beginning and Ending Technique" (B and E) which involves tapping the beginning or ending acupoints of the Yang Emotional-freedoms. Nearly all the treatment points in The Callahan Techniques are at or close to the beginning or end points of the involved Emotional-freedoms. While describing the AK Melzack-Wall pain treatment, Walther (1988) stated that the most productive tapping is when there is a bony backup to the tonification point. If possible, direct the tapping to obtain a bony backup (Walther, 1988, p.263). Accordingly, it is speculated that tapping may cause a piezoelectric effect due to bone stimulation at the acupuncture points. The piezoelectric effect occurs when tiny amounts of generated electrical current result from stimulating the crystallized calcium in the bone, and thus impacts the Emotional-freedom system (Gallo, 1999). Use of cold lasers, rubbing, imaging of tapping, and pressure holding of the acupuncture points, in Emotional-freedom based psychotherapy, were also reported by Gallo to be "effective at times" when used. Gallo however provided no further explanation about the effective times or related circumstances but opined that, in most instances, percussing appears to more profoundly stimulate the acupoint and produce more rapid results. (Gallo,1999,p.150). Walther (1988), however, writes an interesting hypothesis about when tapping fails to yield results (in pain reduction). He asserts that, another factor that may cause less than adequate results with the Melzack-Wall technique is tapping at an improper frequency. It is often necessary to reduce the tapping rate. Two to four Hz appears to be the most productive (p. 263).

As Callahan followed Goodheart, Walther and Blaich, other interested energy therapists now follow Callahan in the continuation of the tapping treatment to effect change via the acupuncture Emotional-freedoms. However, there is no empirical evidence from experimental studies to establish that it is the tapping that works in the treatment of psychological problems. This author has studied with both Callahan and Gallo, and has exposure to the other similar Emotional-freedom based psychotherapies. Like many others who have studied Thought Field Therapy, this author has tapped his way to psychotherapeutic success hundreds and hundreds of times. Tapping does work, as evidenced in clinical treatment and the multitude of anecdotal reports and patient testimonials. While it is true that nothing succeeds like success, this author believes that the time has come to empirically validate the tapping approach to treatment, and to explore and evaluate alternate treatment approaches.

Traditional acupuncture Emotional-freedom theory holds that ‘Chi’ is a form of bodily energy which is, in part, generated in internal organs and systems (Tsuei, 1996). Further it is believed that Chi enters the body from the outside through breathing and the numerous acupuncture points. Chi, often called the Life Force, combines with breath to circulate throughout the body along complex pathways called Emotional-freedoms and vessels. In essence, breath facilitates the flow of Chi in its most natural state. Imbalance of flow or distribution of Chi throughout the body is the blueprint for physical and/or psychological problems. Such imbalances become evident at the acupuncture points through definite changes in electrical activity and possibly, tenderness.

The pioneering work of Reinhold Voll (1975) revealed that acupuncture points show a dramatic decrease in electrical resistance on the skin compared to non-acupuncture points on the body. In addition, Voll and his colleagues found that each acupoint seemed to have a standard measurement for individuals in good health, and notable changes when health deteriorated (Voll, 1975). Becker (1990, 1985) reasoned from his research that not only does an electrical current flow along the Emotional-freedoms, but that the acupoints functioned as amplifiers which boost the electrical signals as they move across the body.

More recently, the research and theories of William (1997), have shed more light on the interplay among mind, body, spirit and subtle energies. His work is particularly relevant to the applicability of Touch and Breathe for use with Emotional-freedom based psychotherapies. Considering the complex array of electrical and electromagnetic circuitry in and around the body, Tiller theorizes that the body can be thought of as a type of transmitting / receiving antenna. (p. 107)

Tiller cites the autonomic nervous system (ANS) as a signal carrier, waveguide, and signal conductor utilizing both sympathetic and parasympathetic branches. He describes the acupuncture points as a set of antenna elements that "...provide an exquisitely rich array with capabilities exceeding the most advanced radar system available today. These sensitive points are coupled to the ANS via the fourteen known acupuncture Emotional-freedoms" (p. 117). Walther (1988) also reported that Goodheart observed "an antenna effect" regarding the acupoints, which he believed, could be easily demonstrated.

From the above it could be argued that the body's acupoints have the potential to transmit and receive Chi, depending on the need of the Emotional-freedom system to restore balance. This author hypothesizes that insertion of acupuncture needles serve as literal antenna / transmitter extensions of the acupoints. When we touch an acupoint we perturb it and stimulate ion flow "...which reacts at the etheric level to unclog the Emotional-freedom flow channel" (Tiller, 1997,p. 121). In maintaining the contact by touch we extend the antenna / transmitter capacity of the body system with a direct feed to the held acupoint. In contrast, while tapping perturbs, it also connects then disconnects the circuits, thus creating an inconsistent and disrupted signal to the body. In TAB, the use of one complete respiration (one easy inhalation and exhalation) is the natural vehicle of Chi circulation, which also creates a piezoelectric effect via vibration and sound (sonic resonance).

Tiller (1972) observed and reported that variations in mental alertness caused significant changes in the electrical characteristics of the acupuncture skin points. This author suspects that this reflects the influence and impact of intentional thought attunement which is paramount in TFT and the other Emotional-freedom based psychotherapies. Tiller's experiments from 1977-1979 (several thousand) revealed that mind direction or intentionality is evident and measurable, and was not indicative of a "classical electromagnetic energy..."(p. 10) Accordingly, this author hypothesizes that treatment of therapy localized acupuncture Emotional-freedoms, diagnosed while attuned to the specific problem, will be more profound using the TAB approach than tapping or pressure alone.

In addition, there have been therapist reports to this author that tapping was completely out of the question for some victims of abuse who refused to tap on themselves. Having said all these, the vast majority of patients, however, do perform the tapping, as it is a requirement of successful treatment. Watching patients while they tapped proved most interesting. Often it was observed that a full breath or sigh accompanied the tapping procedures. Additionally, when patients were not reminded about the number of taps to do, it was observed that they would tap as many times as matched a full respiration before inquiring or looking for guidance. In response to these observations, the author began to experiment and develop the Touch and Breathe approach to treatment. Much to this author's surprise, every single patient preferred the TAB approach to the tapping, and they reported more profound, comfortable, and relaxing effects. Consequently this author has exclusively employed TAB over the last 15 months while working within the TFT framework in doing psychotherapy. In addition, this author has demonstrated and shared the TAB approach over the past year with over a hundred therapists for use with their patients. Again, the patients were reported to respond in similar positive form, as did the therapists when they were treated using TAB.

In a study, Swingle (2008) used EFT as a treatment for children diagnosed with epilepsy. The children were administered EFT by their parents every time each day that the parents suspected a seizure might occur. Swingle found significant reductions in seizure frequency among these very young children, as well as extensive clinical improvement in the children's E. E. G. readings after exposure to two weeks of daily in-home EFT treatment

In preliminary clinical trials involving more than 29,000 patients from 11 allied treatment centers in South America during a 14-year period, a variety of randomized, double-blind pilot studies were conducted by Feinstein (2008). In one of these, approximately 5,000 patients diagnosed at intake with an anxiety disorder were randomly assigned to an experimental group (tapping) or a control group (cognitive behavior therapy /medication). Ratings were given by independent clinicians who interviewed each patient at the close of therapy, at 1 month, at 3 months, at 6 months, and at 12 months. The raters made a determination of complete remission of symptoms, partial remission of symptoms, or no clinical response. The raters did not know if the patient received CBT/medication or tapping. They knew only the initial diagnosis, the symptoms, and the severity, as judged by the intake staff. At the close of therapy: 63% of the control group was judged as having improved; 90% of the experimental groups were judged as having improved. 51% of the control group was judged as being symptom free; 76% of the experimental group was judged as symptom free.

At one-year follow-up, the patients receiving the tapping treatments were substantially less prone to relapse or partial relapse than those with CBT/medication, as indicated by the independent raters assessments and corroborated by brain imaging and neurotransmitter profiles. In a related pilot study by the same team, the length of treatment was substantially shorter with energy therapy and associated methods than with CBT/medication. If subsequent research corroborates these early findings, it will be a notable development since CBT/medication is currently the established standard of care for anxiety disorders and the greater effectiveness of the energy approach suggested by this study would be highly significant.

Despite its odd-seeming procedures and eye-raising claims, evidence is accumulating that energy-based psychotherapy, which involves stimulating acupuncture points or other energy systems while bringing troubling emotions or situations to mind, is more effective in the treatment of anxiety disorders than the current standard of care, which utilizes a combination of medication and cognitive behavior therapy.

The clinical trials were conducted for the purpose of internal validation of the procedures as protocols were being developed. When acupoint stimulation methods were introduced to the clinical team, many questions were raised, and a decision was made to conduct clinical trials comparing the new methods with the CBT/medication approach that was already in place for the treatment of anxiety. These were pilot studies, viewed as possible precursors for future research, but were not themselves designed with publication in mind. Specifically, not all the variables that need to be controlled in robust research were tracked, not all criteria were defined with rigorous precision, the record-keeping was relatively informal, and source data were not always maintained. Nonetheless, the studies all used randomized samples, control groups, and double blind assessment. The findings were so striking that the research team decided to make them more widely available.

Standard medications for anxiety (benzodiazepines, including diazepam, alprazolam, and clonazepan) were given to 30 patients with generalized anxiety disorder (the three drugs were randomly assigned to subgroups of 10 patients each). Outcomes were compared with 34 generalized anxiety disorder patients who received tapping treatment. The medication group had 70 percent positive responses compared with 78.5 percent for the tapping group. About half the medication patients suffered from side effects and rebounds upon discontinuing the medication. There were no side effects in the tapping group, though one patient had a paradoxical response (increase of anxiety).

Specific elements of the treatment were also investigated. The order that the points must be stimulated, for instance, was investigated by treating 60 phobic patients with a standard 5-point protocol while varying the order in which the points were stimulated with a second group of 60 phobic patients. Positive clinical responses for the two groups were 76.6 percent and 71.6 percent, respectively, showing no significant difference for the order in which the points were stimulated. In other studies, varying the number of points that were stimulated, the specific points, and the inclusion of typical auxiliary interventions such as the 9 Gamut Procedure did not result in significant differences between groups, although diagnosis of which energy points were involved in the problem led to treatments that had slightly more favorable outcomes.

In a study comparing tapping with acupuncture needles, 40 panic patients received tapping treatments on pre-selected acupuncture points. A group of 38 panic patients received acupuncture stimulation using needles on the same points. Positive responses were found for 78.5 percent from the tapping group, 50 percent from the needle group. The follow-up data on the 29,000 patients coming from the 11 centers in South America included subjective scores after the termination of treatment by independent raters. The ratings, based on a scale of 1 to 5, estimated the effectiveness of the energy interventions as contrasted with other methods that might have been used. The numbers indicate that the rater believed that the energy interventions produced:

1. Much better results than expected with other methods.
2. Better results than expected with other methods.
3. Similar results to those expected with other methods.
4. Lesser results than expected with other methods (only used in conjunction with other therapies).
5. No clinical improvement at all or contraindicated.

It must be emphasized that the following indications and contraindications for energy therapy are tentative guidelines based largely on the initial exploratory research and these informal assessments. In addition, the outcome studies have not been precisely replicated in other settings, and the degree to which the findings can be generalized is uncertain. Nonetheless, based upon the use of tapping techniques with a large and varied clinical population in 11 settings in two countries over a 14-year period, the following impressions can serve as a preliminary guide for selecting which clients are good candidates for acupoint tapping. There is also considerable overlap between these tentative guidelines and other published reports.

2.3.4 Emotional Freedom Technique and Mathematics Achievement

Daniel, Brenor, Karen and Loren (2005) explored test anxiety benefits of Wholistic Hybrid derived from Emotional Freedom Techniques (EFT), and Cognitive Behavioral Therapy. Participants include Canadian university students with severe or moderate test anxiety. A double-blind, controlled trial of EFT, and CBT was conducted.

Standardized anxiety measures included the Test Anxiety Inventory (TAI) and Hopkins Symptom Checklist (HSCL-21). The result of their study showed that Emotional Freedom Technique was better than Cognitive Behavioural Technique. In only two sessions WHEE and EFT achieved the equivalent benefits to those achieved by CBT in five sessions. Participants reported high satisfaction with all treatments. EFT and WHEE students successfully transferred their self-treatment skills to other stressful areas of their lives.

Nilhan and Bahar (2006) investigated the effect on test anxiety with Emotional Freedom Techniques (EFT), a brief exposure therapy with somatic and cognitive components. A group of 312 high school students enrolled at a private academy was evaluated using the Test Anxiety Inventory (TAI), which contains subscales for worry and emotionality. Scores for 70 demonstrated high levels of test anxiety; these students were randomized into control and experimental groups. A statistically significant decrease occurred in the test anxiety scores of both the experimental and control groups. The EFT group had a significantly greater decrease than the PMR group. The scores of the EFT group were lower on the emotionality and worry subscales. Both groups scored higher on the test examinations after treatment; though the improvement was greater for the EFT group, the difference was not statistically significant.

2.3.5 Mathematics Efficacy and Mathematics Anxiety

In one study of 350 college students, Pajares and Miller (1994c) examined the hypothesized mediational role and predictive power of self-efficacy in Mathematics problem solving. Using previously validated measures, the researchers ran several Mathematics-related independent variables in relation to Mathematics problem solving. Results show that self-efficacy held greater predictive power for problem solving success than did Mathematics self-concept, background in Mathematics, perceived usefulness of Mathematics, and gender. The effects of background and gender, however, were significantly related to self-efficacy, supporting Bandura's assertion of the mediational role of self-efficacy on performance. Simply put, background and gender are not independently strong predictors of Mathematics performance, but they are influential sources of Mathematics self-efficacy which is highly predictive and plays a strong mediational role on performance.

Self-efficacy is a domain-specific construct in academics. Many, including Bandura, argue that it is also task-specific, and attempts to measure self-efficacy at the domain level often result in ambiguous or uninterpretable results (Bandura, 1986; Pajares & Miller, 1994c, 1995). Many of the studies that show self-efficacy to account for lesser variance than other personal determinants often stray from Bandura's prescriptions for a microanalytic strategy. Often these studies assess self-efficacy globally with just a few scale items; that is, they ask participants to report on their confidence or efficacy with regard to a specific academic domain, and not a specific performance task. At this level of self-reporting, it is expected that self-efficacy cannot reliably be separated from other personal determinants such as self-concept, anxiety, self-confidence, and background. It thus raises the question of whether one is actually measuring self-efficacy, or more generally measuring attitudes and other common mechanisms toward a given academic domain. Of course, the latter are important in some areas of educational research, but do not always give sufficient evaluative information for performance on specific, criterial tasks. One possible lens from which to view self-efficacy within the context of instructional technology is to consider one's judgments of personal capabilities to authentically accomplish a specific performance objective. Self-efficacy and performance are inextricably related, and in the domain of Mathematics both are often correlated with gender.

2.3.6 Mathematics Efficacy and Mathematics Achievement

Researchers have been successful in demonstrating that self-efficacy is positively related to, and influences, Mathematics achievement. A meta-analysis published between 1977 and 1988 revealed that self-efficacy was positively related to Mathematics achievement. (Multon, Brown and Lent, 1991). Self-efficacy beliefs were related to academic outcomes and accounted for approximately 14% of the variance. Effects were stronger for high school and college students than for elementary students. How the constructs were operationalised also influenced findings. The strongest effects were obtained where achievement indexes were assessed with basic skills measures or classroom-based indices such as grades than with standardized achievement tests, a finding that supports the context – specific nature of self-efficacy. As with self-concept, researchers have demonstrated that, when self-efficacy beliefs correspond to the academic outcome with which they are compared, prediction is enhanced and the relationship between self-efficacy and academic performance is positive and strong (Pajares and Miller, 1994; Pajares and Kranzler, 1995).

Correlations between self-efficacy and academic performances in investigations in which self-efficacy is analysed at the item or task specific level and closely corresponds to the criteria task have ranged from .49 to .70; direct effects in path analytic studies have ranged from .349 to .545. Results tend to be higher in studies of Mathematics than of other academic areas such as reading or writing, but even in these areas, relationship are considerably higher than previously obtained if the criteria by which students rate their self-efficacy judgments are used as the criteria for scoring essays or assessing reading comprehension (Pajares, Miller and Johnson 2001; Pajares and Valiante, 2000).

Zimmerman (1998) and his associates have been instrumental to tracing the relationships among self-efficacy perceptions, academic self-regulatory processes, and Mathematics achievement. This line of inquiry has demonstrated that self-efficacy influences self-regulatory processes such as goal-setting, self-monitoring, self-evaluation, and strategy use (Zimmerman, 1989, 1990, 1994; Zimmerman and Bandura, 1994; Zimmerman and Martinez – Pons, 1990). Self-efficacious students embrace more challenging goals (Zimmerman, Bonner, and Kovach, 1996). Students with high self-efficacy also engage in more effective self-regulatory strategies at different levels of ability, and self-efficacy enhances students' memory performance by enhancing persistence (Bouffard-Bouchard, Parents and Larivee, 2003). In studies of college students who pursue science and engineering courses, high self-efficacy has been demonstrated to influence the academic persistence necessary to maintain high Mathematics achievement (Lent, Brown and Larken 1996; Hacket, 1995).

Self-efficacy is also related to self-regulated learning variables and use of learning strategies (Feather 2002; Fincham and Cain, 1986; Paris and Oka, 1986; Pokay and Blumenfeld, 2003; Schunk, 1985; Zimmerman and Martinez-Pons, 1990). Students who believe they are capable of performing tasks use more cognitive and meta-cognitive strategies and persist longer at those tasks than those who do not. Academic self-efficacy influences cognitive strategy and use self-regulation through the use of meta-cognitive strategies, and it is correlated with in-class seat work, and homework, examinations, quizzes, essays and reports. Pintrich and DeGroot (1990) suggested that self-efficacy plays a facilitative role in the process of cognitive engagement, that raising self-efficacy beliefs might lead to increased use of cognitive strategies and, thereby, higher achievement. In addition, students need to have both the will and the skill to be successful in classrooms. Students with similar previous achievement and cognitive skills may differ in subsequent achievement as a result of differing self-efficacy perceptions because these perceptions mediate between prior attainments and Mathematics achievement.

As a consequence, such performances are generally better predicted by self-efficacy than by prior attainments. Collins (1982) identified children of low, middle and high Mathematics ability who had, within each ability level, either high or low Mathematics self-efficacy. After instruction, the children were given new problems to solve and an opportunity to rework those they missed. Collins reported that ability was related to performance, but that regardless of ability level, children with high self-efficacy completed more problems correctly and reworked more of the ones they missed. When researchers tested the joint contribution to Mathematics performance of Mathematics self-efficacy and general mental ability (the variable typically acknowledged as the most powerful predictor of academic performances), they found that, despite the influence of mental ability, self-efficacy made a powerful and independent contribution to the prediction of performance (Pajares and Valiante, 2000). Clearly, it is not a matter of how capable one is, but how capable one believed oneself to be. Schunk (1989, 1991) has suggested that variables such as perceived control, outcome expectations, perceived value outcomes, attributions, goals and self-concept may provide a type of cue used by individuals to access their efficacy beliefs.

2.3.7 Gender and Mathematics Anxiety

In 1992, researchers at the University of Florida circulated a questionnaire to 9,093 students and found that 25.9% had a moderate to high need of help with Mathematics anxiety (Jones 2001). According to Burns (1998) 2/3 of Americans fear and loathe Mathematics (see Furner page 68). According to Zaslavsky (1994), people of all races and economic backgrounds fear Mathematics, but women and minorities are most hindered by it. She reported research which points out that around the seventh grade girls begin to doubt their ability to do Mathematics. Since self-confidence and Mathematics performance are so closely related, it plays a major role in girls' choices to continue Mathematics into high school.

Preis & Biggs (2001) cite research that finds that women, in particular older women, often experience more Mathematics anxiety. However, in a recent CBS News story (May 23, 2003), some people are concerned that boys are not performing as well as girls: "Girls are being told, "Go for it, you can do it. Go for it, you can do it." They are getting an immense amount of support," (Dr. Michael Thompson, a noted author on the subject) says. "Boys hear that the way to shine is athletically. And boys get a lot of mixed messages about what it means to be masculine and what it means to be a student. Does being a good student make you a real man? I don't think so…It is not cool." Whether this perceived lower performance is attributable to anxiety is questionable, but must be determined.

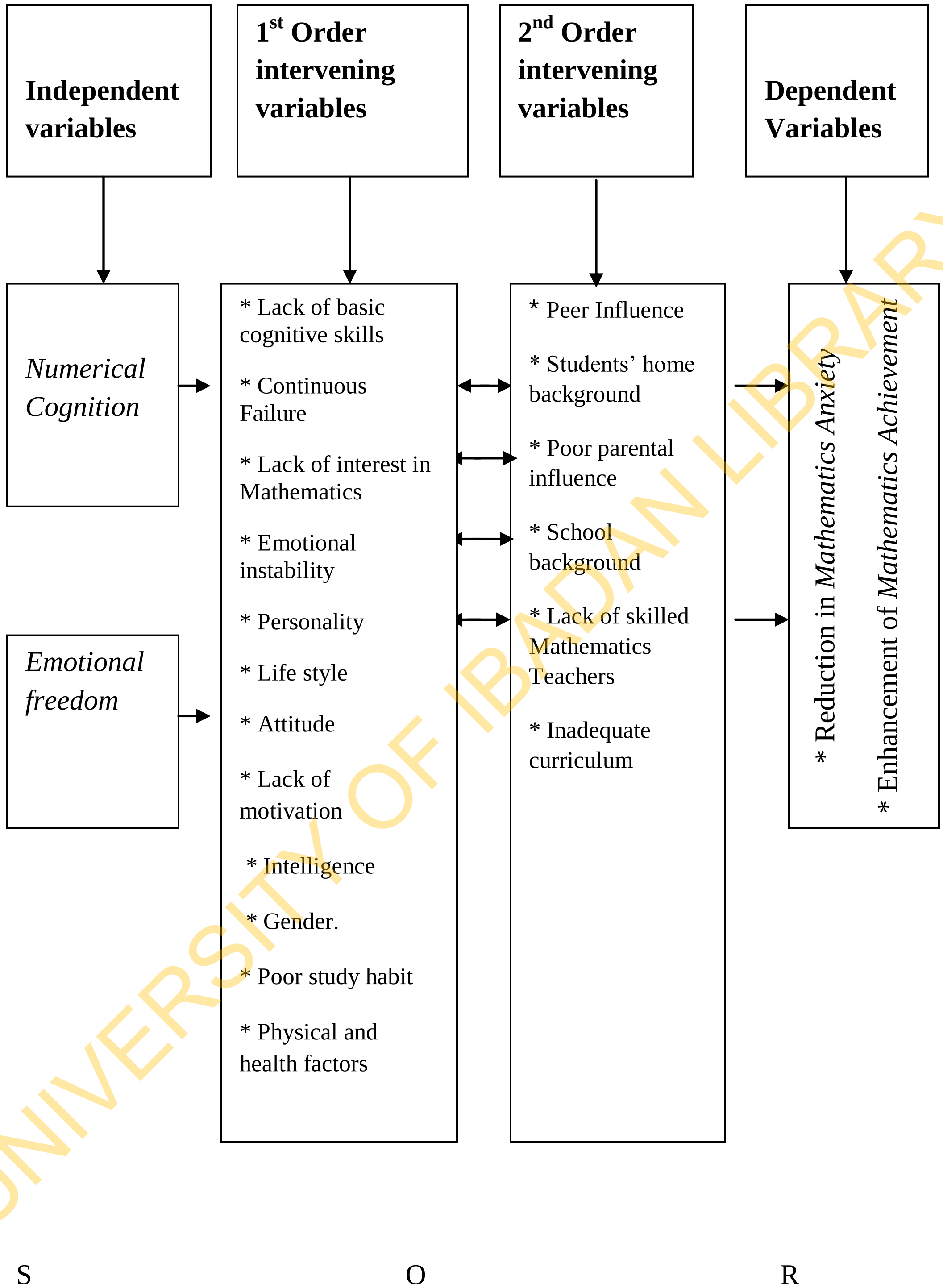
Race may also play a role in Mathematics anxiety: African American, Hispanic, Asian and Native American males had high Mathematics anxiety while African American and Hispanic females rated high as well. In the Bernstein, Reilly and Cote-Bonanno study cited in Preis & Biggs (2001), Asian and Native American male college students had higher Mathematics anxiety than did the females, while Caucasian females scored higher than Caucasian males. However, Lusser (1996) failed to find a significant relationship between gender and Mathematics anxiety, stating that Mathematics background had to be considered. Developmental Mathematics students were found to be more Mathematics anxious than other college students, while nontraditional students have more anxiety about college in general, including Mathematics (Preis & Biggs 2001). However, the correlation between Mathematics anxiety and verbal achievement or aptitude is -0.06 and -.17 with IQ (Ashcraft & Kirk 2001).

It seems that all learners have some degree of Mathematics anxiety, which is related to gender, ethnic background, age, attitude towards Mathematics & previous Mathematics experience. Apparently we all fear Mathematics to some degree.

2.3.8 Gender and Mathematic Achievement

There is a potential gender effect in Mathematics learning and Mathematics self-efficacy. Fennema and Sherman (1977) and Sherman and Fennema (1978) found that Mathematics confidence and gender stereotyping are significant predictors of Mathematics performance for middle and high school students. Studies with college students show that gender influences self efficacy in Mathematics-related actions, such as academic major and career decisions (Hackett, 1985; Lent, Lopez, & Beischke, 1991; Matsui, Ikeda & Ohnishi, 1989; Matsui, Matsui & Ohnishi, 1990). Other studies found that gender is an influential source of efficacy information in modeling (for example, Schunk, Hanson & Cox, 1987; Schunk, 1987). In personalization studies, Murphy and Ross (1990) found gender to be an influential factor in determining Mathematics success for eighth graders. Other researchers (Lopez, 1989; Lopez & Sullivan, 1992) found that personalization significantly benefited seventh-grade Hispanic boys in performing Mathematics calculations. Together, these lineages of research suggest that gender maintains a significant influence on Mathematics self-efficacy.

2.4 CONCEPTUAL MODEL FOR THE STUDY



2.4.1 Explanation of Conceptual Model for the study

A model is a framework applied to the field of study to aid the understanding of how the target behaviour is to be managed. The model for this study consists of the independent variables (i.e. numerical cognition and emotional freedom) to be manipulated by the researcher to see their effectiveness on the dependent variables which are Mathematics anxiety and Mathematics achievement.

In-between the independent and dependent variables are the intervening variables. An intervening variable is one that surfaces between the time the independent variables operate to influence the dependent variables. There is thus a time dimension to the intervening variables. The intervening variables are those factors which account for internal and unobservable psychological processes that, in turn, may affect the outcome of the treatment. They are divided into organismic and environmental factors.

(a) **Organismic factors**

These are the first order intervening variables inherent in the individual. They, among others, include basic cognitive skills, physical and health factors, lack of interest in school work or poor study habit, continuous failure, intelligence, age, emotional instability, gender, lack of motivation, etc.

(b) **Environmental factors**

These are second order intervening variables inherent in the environment. They include peer influence, student' home background, poor parental influence, school background, lack of skilled Mathematics teachers, inadequate curriculum, poor study habit, poor moral development, etc.

Dependent variables are measurable behavioural outcomes that are expected to be brought about by the manipulation of the independent variables. The dependent variables in this study are Mathematics anxiety and achievement.

The behavioural equation S-O-R represents the total interaction of various variables in the study (Kanfer & Phillips, 1970).

S - Stimulus (i.e. the independent variables)

O - Organism (i.e. the intervening variables inherent in the organism)

R - Response (i.e. the dependent variables which are the resultant effects of independent variables).

Many things determine the Mathematics anxiety and achievement of an individual among which are: student's home background, factor resident in the child, school background could contribute both negatively and positively to the achievement in Mathematics of an individual, the society and government policy all contribute to achievement in Mathematics of students whether positively or negatively. There are some factors which could be used to explain this. These factors are: nature of home discipline, the way an individual is being trained matter a lot. It is associated with the socialization and eventual achievement of adolescence in school; discipline in the home could be authoritarian permissive or democratic. Harsh authoritarian discipline produces a child that is insecure, uninquisitive and lacking in initiative. These traits affect negatively the school performance and mathematics achievement. Students who receive democratic type of discipline are better adjusted to their school work because they are emotionally stable, law abiding, more motivated to pursue school work without duress and therefore achieve better academically. Other factors under family or home background are: family relationship, level of cognitive stimulation, lack of role model, available financial and medical facilities, etc. The factors resident in the child include: basic cognitive skills, physical and health factors, psycho-emotional factor, lack of interest in school work or poor study habit, continuous failure, etc. Factors resident in the school include: deficient school environment in terms of school location, school building, school topography, quality of teaching staff, existence or non- existence of teachers, evaluation of learning, poor condition of service, inadequate curriculum. Causal resident in the society are: ethnic and inter-tribal wars, class differences, inadequate medical facilities and so on. Mathematics achievement is a significant decision that often resolves the identity problem and the much perceived pertinent question "who am I", which is a reflection of self worth and a practical understanding of the self. A combination of interest and concentration in study will enable one to achieve integrated learning that will operate most effectively in the solution of problems. Aremu (2004, 2002 and 2000) is acknowledged for the above factors. Thus, if all the above intervening factors were properly controlled, the end result would be reduction of anxiety and enhancement of Mathematics achievement.

2.5 Hypotheses

The following hypotheses will be tested for the purpose of this study at 0.01 level of significance.

1. There is no significant main effect of treatment on mathematics anxiety of secondary school students.

2. There is no significant main effect of mathematics efficacy on mathematics anxiety test score of secondary school students.

3. There is no significant main effect of gender on mathematics anxiety test score of secondary school students.

4. There is no significant interactive effect of treatment and mathematics efficacy on mathematics anxiety test score of secondary school students.

5. There is no significant interactive effect of treatment and gender efficacy on mathematics anxiety test score of secondary school students

6. There is no significant interactive effect of mathematics efficacy and gender on mathematics anxiety test score of secondary school students

7. There is no significant interactive effect of treatment, mathematics efficacy and gender on mathematics anxiety test score of secondary school students.

8. There is no significant main effect of treatment on Mathematics achievement of secondary school students.

9. There is no significant main effect of mathematics efficacy on mathematics achievement test score of secondary school students.

10. There is no significant main effect of gender on mathematics achievement test score of secondary school students

11. There is no significant interactive effect of treatment and mathematics efficacy on mathematics achievement test score of secondary school students.

12. There is no significant interactive effect of treatment and gender on mathematics achievement test score of secondary school students.

13. There is no significant interactive effect of mathematics efficacy and gender on mathematics achievement test score of secondary school students

14. There is no significant interactive effect of treatment, mathematics efficacy and gender on mathematics achievement test score of secondary school students

CHAPTER THREE

METHODOLOGY

This chapter presented the methodology on which the study leans. This involves the design that was adopted for the study, population, sample and sampling technique, instruments, validity of the instrument, procedure for data collection and method of data analysis.

3.1 Research Design

The study adopted a pre-test post-test control group design using a 3 x 2 x 2 experiment. The factorial method consists of the two experimental groups (Numerical cognition, Emotional-freedom) and control group; gender of the participants varying at two levels: male and female and Mathematics efficacy of the participants varying at two levels: high and low.

Table 3.1:

3 x 2 x 2 Factorial experiment for the psychological treatment of Mathematics anxiety and achievement

Treatment	Gender and Mathematics efficacy			
	Male		Female	
	High	Low	High	Low
Numerical Cognition	n = 8	n = 12	**n** = 7	**n** = 13
Emotional Freedom	**n** = 9	**n** = 11	**n** = 6	**n** = 14
Control	**n** = 9	**n** = 11	**n** = 10	**n** = 10

3.2 Population

The target population for this study consisted of the senior secondary students (SS1) in some selected public secondary schools in Ibadan who had consistent records of low achievement in Mathematics. These records were obtained from the schools of the study's participants with the permission and cooperation of the school authorities. These records were obtained from at least three sessions of academic records of the identified participants.

3.3 Sample and sampling techniques

The sample for this study comprised one hundred and twenty (120) Senior Secondary One (SS I) students drawn from three selected public secondary schools in Ibadan through random sampling technique. Initial selection of the participants was done through stratified random sampling. Stratified random sampling was done by stratifying the population into strata according to gender, age and class of the participants. Two secondary schools were selected in each local government for the experiment. Final selection of participants was preceded by a preliminary investigation for selecting the low achievers in Mathematics in the selected secondary schools that were used for the experiment.

All the schools operate a common policy of conducting two continuous assessment tests each term of the session totaling six continuous assessment scores. All schools also conduct the end-of-term examination making up three examinations. The two continuous assessment scores have a weight of 40%, while the terminal examination has a weight of 60% totaling 100% for each candidate in every subject offered. At the end of the session, the average of the three terms scores are computed for each student to determine suitability for promotion. This practice of cumulating and averaging offers a consistent picture of each student's academic status as to whether he/she is high, average or low in the subject.

Accordingly, subject grade in all the schools is based on the number of percentage passed in the subject thus:

(a) 75 and above = A1.
(b) 70 – 74 = B2
(c) 65 – 69 = B3
(d) 60 – 64 = C4
(e) 55 – 59 = C5
(f) 50 – 54 = C6

(g) 45 – 49 = P7

(h) 40 – 44 = P8

(i) 39 and below = F9

Participants for this study would be selected from categories G to I

3.14 Inclusion/Exclusion Criteria

Only participants who met the following criteria were enlisted for participation:

a. Participants were SS1 with consistent records of low achievement in Mathematics.

b. Participants were willing and interested in participating.

c. School authorities consent was sought and presentation of letter from the department was approved.

d. Parental consent was sought after sending parental consent form to parents through participants.

3.15 Instrumentation

The four assessment scales that were used in this study are Mathematics Anxiety Scale (MAS), Mathematics Efficacy Scale (MES), Mathematics Achievement Test and Pseudo-dyscalculia Scale (PDS).

a. Mathematics Anxiety Scale

Mathematics Anxiety Scale was a paper and pencil psychological instrument developed by Betz (1978) with coefficient alpha of 0.90 to assess students' Mathematics Anxiety level. The items include statements on the factors to which students attribute their predicaments in Mathematics. It was a 14-item scale with response format ranging from strongly agree = 5 to strongly disagree = 1. Participants made to tick the option that best describes their Mathematics Anxiety level. The items were added to give a total score of 70 and a minimum of 14. A score of 42 and above reveals that the participants' Mathematics Anxiety is high, while a score below the norm reveals low anxiety. The items were coded because there were both positive and negative statements which were reversed. The psychometric property of the instrument was established through a pilot study on a sample of 30 students. The Cronbach Coefficient observed was 0.89 and internal consistency of the instrument ranges between 0.46 and 0.75. The scale was adapted to suit the culture of the participants by ensuring its face and content validity by the researcher's supervisor.

b. Mathematics Achievement Scale

This measuring instrument was developed by the researcher. This has to do with some items that test Mathematical skill. This is a 30-item instrument developed from the Mathematics curriculum by Mathematics teachers. The psychometric property of the instrument was established through a pilot study on a sample of 20 students. Kuder Richardson 20 (KR 20), which measures achievement test, was used to determine the overall coefficient of the instrument. Item analysis was also used to carry out the difficulty index and discriminatory power of the test. This was done between the higher achievers and lower achievers in Mathematics. During the process of item analysis, ten (10) items were removed as too easy or too difficult while twenty two (20) items were retained. However the coefficient got from KR 20 was 0.90, which means that the achievement scale was reliable.

c. Mathematics Efficacy Scale

The Mathematics Efficacy Scale was adapted from Betz and Hackett (1983) with coefficient alpha of 0.88. The version adapted by the researcher was tailored for use in the Nigerian Secondary Schools students. It spans such areas as: problem-solving; performance accomplishment; verbal persuasion and other areas of mathematical abilities. The scale comprises 16 items spread over two sections A and B with A containing personal information and B containing items on Mathematics Efficacy. The items were scored as follows: Strongly Agree = 5, Agree = 4, Not sure = 3, Disagree = 2 and Strongly Disagree = 1. The points that were scored on all items were summed up to give participant's score on the scale. The items were also coded because there were both negative and positive statements which was be reversed. Scores on the scale ranged between 16 and 80. A score above 48 indicated high Mathematics-efficacy and score below the norm indicated low Mathematics-efficacy. The psychometric property of the instrument was established through a pilot study on a sample of 30 students. The Cronbach Coefficient Alpha of 0.86 was observed with internal consistency ranging between 0.46 and 0.69.

d. Pseudo-dyscalculia Scale

This measuring instrument was also developed by the researcher. This has to do with 40-item instrument that measure individual's false belief in mathematical skills. This scale was used to identify participants with pseudo-dyscalculia or false belief in Mathematics. A norm was established to indicate participants who have high and low pseudo-dyscalculia. Participants with high pseudo-dyscalculia would be used for the study while those with low pseudo dyscalculia would be dropped. Psychometric properties of the scale were established on a sample of 30 students. Reliability techniques that were adopted were Cronbach Coefficient Alpha, and Split half reliability. Method of validity involved content, convergence construct, discriminant and concurrent validity. The Factor analysis was used to establish the factor structure of the scale. Principal component analysis was used with Varimax Rotation, iteration method and Kaiser Normalization. Eigen value was determined and overall variance of the scale was observed. The initial coefficient alpha was 0.67. The analysis removed 14 items that were not internally consistent (items with less than 0.3) and this increased the overall coefficient to 0.88. After this procedure, some items (8 items) still reported negative correlation and removed. This later increased the coefficient to 0.93. The Correlation between forms from the split half method was 0.79, Equal length Spearman Brown was 0.84, Unequal length was also 0.86, Guttman Split-half was 0.88, Alpha for part 1 was 0.79, alpha for part 2 was 0.80. Factor analysis was carried out using extraction method (Principal Component Analysis). The overall total variance explained was 61.76% meaning that the scale describes the domain of behaviour. The initial eigen-values were between 0.54 and 4.763. Three components were extracted initially using extraction method of principal component analysis. The factors were later rotated using varimax with Kaiser Normalization. The rotation converged in 8 iterations and all factors: False beliefs, environmental factors, inappropriate concentration, fear or anxiety, negative emotion, avoidance, inability to follow systematic instruction and low self efficacy were loaded in factor 1 (Pseudo dyscalculia). The correlations between the initial and extraction were between 0.51 and 0.68 meaning that the items are really describing the domain of behaviour.

3.6 Procedure for the Experiment

The research experiment spanned through a period of ten weeks during which time there was researcher-participants' interactions. There were four main phases: randomization, pretest, treatment and post-treatment evaluations. Permission was sought and obtained to involve both staff and students in the study. Accordingly, the principals assigned members of staff –the vice-principal or the counsellor (s) who could assist the researcher. A pseudo-dyscalculia scale was used to identify people with anxiety in Mathematics. Mathematics efficacy scale was used to identify those students with high and low mathematics efficacy. The researcher and his assistants met and agreed on the day of the week and time for the therapeutic sessions in each of the schools where there were sessions. The control group met only twice i.e. during pretest and post-test.

3.7 Objectives of the Therapeutic Packages

The objectives of the treatment sessions are:

- To enable participants identify what actually lead to their anxiety in Mathematics and help them to reduce such.
- To enhance Mathematics-efficacy of participants and thus reduce their state of learned helplessness.
- To equip participants with learning skills in order to improve their academic performance in the subject.
- To reduce negative emotions of the students in Mathematics.
- To enable the students to restructure their bad cognition and emotion with positive self statements.
- To help the participants learn self-respect and self-esteem

- To enable them overcome feelings of helplessness
- To promote a generalized sense of capability
- To equip students with the right problem solving skills
- To promote resiliency and solution-focused problem solving
- To help them shift away from emphasizing problems
- To help them discover considerable power and possibilities they have in themselves.

3.8 Numerical Cognition Outline

Session I	:	Recruitment and Introduction
Session II	:	General orientation and administration of instrument to obtain baseline information (pre-treatment measures) from the participants.
Session III	:	Introduction of the concept of numerical cognition with illustrations
Session IV	:	Explaining cognitive distortions in Mathematics.
Session V	:	Identifying participants' problems in Mathematics and replacing their cognitive distortions through numerical cognition technique.
Session VI	:	Evaluation of the participants.
Session VII	:	Generalization to other subject/setting and allowing higher level of critical thinking to occur. Conclusion and Summary delivery.
Session VIII	:	Post-treatment and refreshment.

3.9 Numerical Cognition Group

Session I : Recruitment and Introduction

With the help of members of school staff of the school, the researcher specified the category of participants desired for the experiment – low achievers in Mathematics. This category were students with Mathematics anxiety or poor Mathematics achievement. Accordingly, the assistants helped to identify this category of students with their previous academic records in Mathematics. A pseudo-dyscalculia scale was administered to the participants to identify those with Mathematics disabilities. Thereafter, a mathematics efficacy questionnaire was administered to the participants to dichotomize them into high and low mathematics efficacy. An average score on mathematics efficacy indicated the norm or reference point for classifying them into high or low mathematics efficacy i.e participants who fell above average point were considered high while those below were considered low on mathematics efficacy. The participants included a mixture of students who were promoted on trial to SS I and those asked to repeat SS I class. On meeting the students, there was exchange of pleasantries followed by writing of names to avoid ghost participants. The day and time of meeting were agreed upon. The researcher and his assistants dwelled much on cooperation for the period of the experiment.

Session II: General Orientation and Administration of Instrument to obtain baseline information (pretreatment measures).

- The research assistants assisted the researcher to assemble participants at the provided venue and at the time earlier agreed upon.
- The researcher then explained the nature and objectives of the programme emphasizing that most of the things they were to learn were new to them.
- The researcher also stressed the importance of confidentiality.
- Participants were acquainted with the benefits derivable from the programme – it created in them a new thinking cap that changed their erstwhile lukewarm attitude to studies in Mathematics and made them act right to have improved academic performance in the subject.
- Regular attendance was emphasised. The need to adhere to all instructions and complete the sessions was emphasized. Participants were encouraged to feel free and ask questions for clarifications.
- The researcher then distributed the scales on mathematics efficacy to assess their level of mathematics efficacy, Mathematics anxiety scale to assess their level of anxiety in the subject before the treatment, Mathematics achievement scale to assess their level of achievement in Mathematics before the introduction of the treatment packages. The researchers also appealed for objectivity and

independence of completion as well as ensure that all participants complete the scales.

- Thereafter, the researcher enlisted the cooperation of participants to the effect that proceedings of subsequent sessions were video-recorded by the cameramen standing in front of them. The researcher also elicitd their cooperation and seriousness in terms of attendance and attentiveness. He would also explain that the sessions would be cumulative, any gap resulting from absenteeism disrupted outcome and put the absentee at a disadvantage – entrapping himself/herself in the old habit of Mathematical situation. Participants were promised tokens for full attendance.
- A take-home assignment was given to them. They were asked to state some reasons why many students perform poorly in Mathematics and suggest things to do to overcome the problems. The reason is also to get some baseline information on their deficiencies in Mathematics and address such.

Session III: Introduction of the concept of numerical cognition with illustrations (This and subsequent sessions were video-recorded).

- The researcher welcomed the participants and thanked them for making themselves available to improve their Mathematic deficiencies.
- The researcher then allowed the participants to identify various problems they have been having in Mathematics. This reveals if the participants were aware of the factors for poor Mathematics performance and appropriate remedies.
- The researcher then introduced the term "numerical cognition" explaining that it is a treatment approach that is based on the concept that the way we think affects how we respond/act. It deals with how students acquire an understanding of numbers, and how much is inborn. It also has to do with how students associate linguistic symbols with numerical quantities. This brings the knowledge of how these capacities underlie their ability to perform complex calculations. The researcher then added that students could interpret the same life event differently leading to many and varied emotional and behavioural consequences. Such consequences could lead to wrong

interpretations, lack of self confidence, both of which could lead to poor Mathematics performance.

Session IV: Explaining Cognitive Distortions

- The researcher thereafter asked the participants how well they have understood the concept of numerical cognition and in what ways they have analysed the illustration.
- The researcher further shed more light on what the participants came up with.
- The researcher further added that it is not actually the event or situation that directly impacts on how we feel and behave but rather the thoughts about the event. If a student failed a class test in Mathematics for example, it was not the poor mark that would make him fail further but what he thought about the poor mark. The student could feel that for one reason or the other, the teacher disliked him. He could feel he was not up to the task (lack of self-efficacy). He could feel his sadness was responsible (negative emotion). He could blame the enemy/devil for being at work. He could feel no matter what he wrote in the subject, he would still fail (lack of self-efficacy).
- The researcher then explained that these negative thoughts were unhelpful thoughts and beliefs, which were significant factors in the development of depression, anxiety, anger, low self-esteem, self-defeating behaviours, difficulty with coping, negative emotion and lack of Mathematics efficacy.
- Based on the foregoing, participants were asked to make a list of their cognitive distortions and unhelpful beliefs.

Session V: Identifying participants' problems in Mathematics and replacing their cognitive distortions through numerical cognition technique.

The researcher welcomed the participants to the session and demand for the assignment given. This would be discussed.

- The researcher then tried to identify participants' problems in Mathematics. This was enhanced by the previous administration of Mathematics Anxiety and Mathematics Efficacy Scales. Numerical cognition skills were used to train the participants as follows:

- Discover the sign: The researcher trained the participants to discover Mathematical signs and operations. The step includes the participants:
    - Scanning the problem;
    - Circling and saying name of operation sign; and
    - Saying what the sign meant
- Decoding figures and translating them into expression: Here, the researcher explained to the participants the importance of transforming the figures to expression. This was to help the participants verbalize Mathematical operation in the way they could understand it.
- Read the problem: The research trained the participants to be able to:
    - Read the whole problem;
    - Say the problem aloud as they read it; and
    - Deliver feedback swiftly and systematically.

Here the participants would be trained to ask the following questions:

- What is the problem?
- What are some plans?
- How is my plan working?
- How did I do?

- The researcher was supportive and highlighted shining moments, encourage participants to self-evaluate strengths.
- The researcher then trained the participants to become self-aware and self-observant (*e.g., "how do you feel about…? you must be proud that …")*
- The researcher also trained the participants to develop a new, positive behaviour to replace negative ones.
- Logical procedures to answer or draw and check: The participants were trained to:
    - Answer problem, if they know how to solve it, whenever it arises;
    - Or draw pictures to solve it;
    - State the problem;
    - Develop some plans;
    - Explore the plans;

- Ask themselves if the plan is working; and
- See if they are successful.

Problem Solving Plans in Numerical Cognition were in four Steps:

1. Clues:

- Read the problem carefully.
- Underline clue words.
- Ask yourself if you've seen a problem similar to this one. If so, what is similar about it?
- What did you need to do?
- What facts are you given?
- What do you need to find out?

2. Game Plan:

- Define your game plan.
- Have you seen a problem like this before?
- Identify what you did.
- Define your strategies to solve this problem.
- Try out your strategies. (Using formulas, simplifying, use sketches, guess and check, look for a pattern, etc.)
- If your strategy doesn't work, it may lead you to an '*aha*' moment and to a strategy that does work.

3. Solve:

- Use your strategies to solve the problem.

4. Reflect:

- This part is critical. Look over your solution.
- Does it seem probable?
- Did you answer the question?
- Are you sure?
- Did you answer using the language in the question?
- Same units?

Clue Words:

When deciding on methods or procedures to use to solve problems, the first thing you will do is look for a clue which is one of the most important skills in solving problems in Mathematics. If you begin to solve problems by looking for clue words, you will find that these 'words' often indicate an operation.

For instance:

Clue Words for Addition

- sum
- total
- in all
- perimeter

Clue Words for Subtraction

- difference
- how much more
- exceed

Clue Words for Multiplication

- product
- total
- area
- times

Clue Words for Division

- share
- distribute
- quotient
- average

The participants were also trained to familiarize themselves with the problem situation. This enabled them to be able to collect the appropriate information, identify strategies and utilize the strategies appropriately.

The package helped the participants to:

- Learn self-respect and self-esteem;

- Overcome feelings of helplessness;
- Promote a generalised sense of capability;
- Equip students with the right problem solving skills;
- Promote resilience and solution-focused problem solving;
- Shift away from emphasizing problems;
- Discover considerable power and possibilities they have in themselves;
- Set goals;
- Monitor their progress;
- Use comprehension strategies to translate the linguistic and numerical information in the problem and come up with a solution; and
- Identify the important information and even underline parts of the problem.

Session VI: Evaluation of the participants

Numerical Cognition perspective emphasizes that participants can become stuck by focusing on their past and current "bad" behaviours and failures versus focusing on future solutions. This therapy tried to increase student performance by removing obstacles to student learning. Students accomplished more when they concentrated on their successes and strengths rather than their failures and deficits. There are so many advantages for students who know how to constructively solve problems. Students should be looked at as being good and capable of rational thought but without any influence from teachers or significant adults a student will likely focus more on their own negative side.

Once the therapist or researcher begins to shift to the positives of the good things that are going on in a student's life, the students usually will switch to that, open up and talk about it too. Students do have the capacity to act on common sense if given the opportunity to identify common sense problem-solving strategies. Solution-focused problem solving in numerical cognition is based on the theory that small changes in behavior lead to bigger changes in behavior. The therapy would emphasize a role shift for students. Small shifts in role by a student will cause shifts in other places. In this regards, teachers will also be focused to develop an alliance with the student and work together to determine the problem and the cause. Identify the student's strength, and then they can build strengths and foundations which will lead to positive changes. When the plan does not seem to be working and the student seems to be repeating the same pattern or does not have the ability to control compulsive behaviors then the educator has to watch for a pattern and reinforce with positive.

This therapy pursues the positive and students are more likely to find a solution to a problem when they concentrate on their successes rather than their failures. Students must realize that they play a huge part in the success of their problem solving process and that change will occur. Once the changes begin to happen then the student will realize that their lives can be very different. Then it is time to have the students set goals and then monitors their progress. The therapist then tries to use comprehension strategies to translate the linguistic and numerical information in the problem and come up with a solution. For example, the therapist may read the problem more than once and may reread parts of the problem as they progress and think through the problem.

Session VII: Generalization to other subject/setting and allowing higher level of critical thinking to occur. Conclusion and Summary delivery.

Session VIII: Post-test

- The researcher tried to summarize all that had transpired during the therapeutic sessions.

- Participants were given the two instruments – Mathematics Anxiety and Mathematics Achievement Scales – to complete again as post-test.

- The researcher then expressed gratitude and prayed for the participants.
  - Refreshment was served.
  - Gifts were distributed
  - The researcher gave the participants his phone number for further follow-up.

3.10 Emotional-freedom-based intervention Outline

Session I	:	Recruitment and Introduction
Session II	:	General orientation and administration of instrument to obtain baseline information (pre-treatment measures) from the participants

Session III	:	Introduction of the concept of Emotional Freedom Techniques with illustrations
Session IV	:	Explaining negative emotions in Mathematics
Session V	:	Identifying participants' problems in Mathematics and replacing their negative emotions through Emotional Freedom Technique
Session VI	:	Evaluation of the participants
Session VII	:	Conclusion and Summary delivery
Session VIII	:	Post-treatment and refreshment

3.11 Emotional Freedom Technique Group

Session I : Recruitment and Introduction

With the help of members of school staff of the school, the researcher specified the category of participants desired for the experiment – low achievers in Mathematics. These were junior students with Mathematics anxiety. A pseudo-dyscalculia scale was administered to identify the participants with Mathematics disabilities. Accordingly, the assistants also helped identify this category of students based on their previous academic records in Mathematics. A Mathematics efficacy questionnaire was then administered to the participants to dichotomize them into high and low Mathematics efficacy. An average score on Mathematics efficacy scale indicated the norm or reference point to classify them into high or low Mathematics efficacy i.e participants who fell above average point were considered high while those below were considered low on Mathematics efficacy scale. The participants included a mixture of students who were promoted on trial to SS I and those asked to repeat SS I class. On meeting the students, there was exchange of pleasantries followed by writing of names to avoid ghost participants. The day and time of meeting were agreed upon. The researcher and his assistants dwelled much on cooperation for the period of the experiment.

Session II: General Orientation and Administration of Instrument to obtain baseline information (pre-treatment measures).

- The research assistants assisted to assemble participants at a venue and at the time earlier agreed upon.

- The researcher then explained the nature and objectives of the programme emphasizing that most of the things they were to learn would be new to them.
- The researcher then stressed the importance of confidentiality.
- Participants were acquainted with the benefits derivable from the programme – it will create in them a new thinking cap that would change their erstwhile lukewarm attitude to studies in Mathematics and make them act right to have improved academic performance in the subject.
- Regular attendance was emphasized. The need to adhere to all instructions and complete the sessions were also emphasized. Participants were encouraged to feel free and ask questions for clarifications.
- The researcher then distributed the Mathematics efficacy scale to assess their level of Mathematics efficacy, Mathematics Anxiety Scale to assess their level of anxiety in the subject before the treatment, Mathematics Efficacy Scale to assess their level of efficacy in Mathematics before the introduction of the treatment packages. The researcher appealed for objectivity and independence of completion as well as ensured that all participants completed the three scales.
- Thereafter the researcher enlisted the cooperation of participants to the effect that proceedings of subsequent sessions were video-recorded by the cameramen standing in front of them.
- The researcher elicited their cooperation and seriousness in terms of attendance and attentiveness. He also explained that the sessions would be cumulative, any gap resulting from absenteeism would disrupt outcome and put the absentee at a disadvantage – entrapping him/her in the old habit of Mathematical situation. Participants were promised tokens for full attendance.
- A take-home assignment was given to them. They were asked to state some reasons why many students perform poorly in Mathematics and also suggested what things to do to overcome the problems. The reason was to get some baseline information on their deficiencies in Mathematics and address such.

Session III: Introduction of the concept of emotional freedom with illustrations

(This and subsequent sessions would be video-recorded).

- The researcher welcomed the participants and thanked them for making themselves available to improve their Mathematic deficiencies.
- The assignment given was discussed. This was to reveal if the participants were aware of the factors for poor Mathematics performance and appropriate remedies.

The researcher then introduced the term "emotional freedom" explaining that the cause of all negative emotions is a disruption in the body's energy system. Negative emotions come about because you are tuned into certain thoughts or circumstances which, in turn, cause your energy system to disrupt. Otherwise, you function normally.

- The researcher added that students could interpret the same life event differently leading to many and varied emotional and behavioural consequences. Such consequences could lead to wrong interpretations, lack of self confidence, both of which could lead to poor Mathematics performance.

Session IV: Explaining negative emotion

- The researcher asked the participants how well they have understood the concept of emotional freedom and in what ways they have analysed the illustration.
- The researcher further shed more light on what the participants come up with.
- The researcher went on to add that it is not actually the event or situation that directly impacts on how we feel and behave; but rather the thoughts about the event. If a student failed a class test in Mathematics for example, it was not the poor mark that would make him fail further; but what he thought about the poor mark. The student could feel that for one reason or the other, the teacher disliked him. He could feel he was not up to the task (lack of self-efficacy). He could feel his sadness was responsible (negative emotion). He could blame the enemy/devil for being at work. He could feel no matter what he wrote in the subject, he would still fail (lack of self-efficacy).
- The researcher then explained that these negative emotions are unhelpful thoughts and beliefs, which are significant factors in the development of depression, anxiety, anger, low self-esteem, self-defeating behaviours, difficulty with coping, negative emotion and lack of Mathematics efficacy.

- Based on the foregoing, participants were then asked to make a list of their negative emotions.

Session V: Identifying participants' problems in Mathematics and replacing their negative emotion through emotional freedom technique.

The researcher welcomed the participants to the session and demanded for the assignment given.

- The researcher then tried to identify participants' problems in Mathematics. This was enhanced by the previous administration of Mathematics Anxiety, Pseudo-dyscalculia and Mathematics Efficacy Scales. An Emotional Freedom package was used to train the participants. The full Basic Recipe consists of four techniques, two of which are identical. They are:
    1. The Setup
    2. The Sequence
    3. The 9 Gamut Procedure
    4. The Sequence again

They would be treated in detail below:

1. The Setup

Our energy system is subject to a form of electrical interference which can block the balancing effect of these tapping procedures. When present, this interfering blockage must be removed. Technically speaking, this interfering blockage takes the form of a polarity reversal within the energy system. This polarity reversal is also called Psychological Reversal and represents a fascinating discovery with wide ranging applications in all areas of healing and personal performance.

It is the reason why some diseases are chronic and respond very poorly to conventional treatments. It is also the reason why some people have such a difficult time to cope with Mathematics anxiety and other Mathematics related course like Statistics. It is, quite literally, the cause of self sabotage. Psychological Reversal is caused by self defeating, negative thinking which often occurs subconsciously and thus outside of our awareness. Some people have very little of it (this is rare) while others are beset by it most of the time (this also is rare). Most people fall somewhere in between these two extremes.

This is the way Setup works. There are two parts to it.

1. You repeat an affirmation 3 times while you
2. Rub the "Sore Spot" or, alternatively, tap the "Karate Chop" point.

The Affirmation

Since the cause of Psychological Reversal involves negative thinking it should be no surprise that the correction for it includes a neutralizing affirmation. Such is the case and here it is.

Even though I have this anxiety of Mathematics, I deeply and completely accept myself.

All of these affirmations are correct because they follow the same general format. That is they acknowledge the problem and create self acceptance despite the existence of the problem. That is what is necessary for the affirmation to be effective.

Now here are some interesting points about the affirmation.

*It doesn't matter whether a participant believes the affirmation or not just say it. *It is better to say it with feeling and emphasis but saying it routinely will usually do the career. *It is best to say it out loud but if you are in a social situation where you prefer to mutter it under your breath or do it silently then go ahead. It will probably be effective.

To add to the effectiveness of the affirmation, The Setup also includes the simultaneous rubbing of a "Sore Spot" or tapping on the "Karate Chop" point.

The Sore Spot

Instruction: There are two Sore Spots and it doesn't matter which one the participant use. They are located in the upper left and right portions of the chest and you find them as follows:

Go to the base of the throat about where a man would knot his tie. Poke around in this area and you will find a U shaped notch at the top of your sternum (breastbone). From the top of that notch go down 3 inches toward your navel and over 3 inches to your left (or right). You should now be in the upper left (or right) portion of your chest. If you press vigorously in that area (within a 2 inch radius) you will find a "Sore Spot." This is the place you will need to rub while saying the affirmation. This spot is sore when you rub it vigorously because lymphatic congestion occurs there. When you rub it, you are dispersing that congestion. Fortunately, after a few episodes the congestion is all dispersed and the soreness goes away. Then you can rub it with no discomfort whatsoever.

This is not to overplay the soreness you may feel. It's not like you will have massive, intense pain by rubbing this Sore Spot. It is certainly bearable and should cause no undue discomfort. If it does, then lighten up your pressure a little. Also, if you've had some kind of operation in that area of the chest or if there's any medical reason whatsoever why you shouldn't be probing around in that specific area then switch to the other side. Both sides are equally effective. In any case, if there is any doubt, consult your health practitioner before proceeding or tap the "Karate Chop" point instead.

The Karate Chop Point

The Karate Chop point (abbreviated KC) is located at the center of the fleshy part of the outside of your hand (either hand) between the top of the wrist and the base of the baby finger or stated differently the part of your hand you would use to deliver a karate chop. Instead of rubbing it as you would the Sore Spot, you vigorously tap the Karate Chop point with the fingertips of the index finger and middle finger of the other hand. While you could use the Karate Chop point of either hand, it is usually most convenient to tap the Karate Chop point of the non-dominant hand with the two fingertips of the dominant hand. If you are right handed, for example, you would tap the Karate Chop point on the left hand with the fingertips of the right hand.

Stepping Through It

The participants would be asked to create a word or short phrase to fill in the blank in the affirmation and then...simply repeat the affirmation, with emphasis, 3 times while continuously rubbing the Sore Spot or tapping the Karate Chop point. After a few practice rounds, you should be able to perform The Setup in 8 seconds or so.

2. The Sequence

The Sequence is very simple in concept. It involves tapping on the end points of the major energy Emotional-freedoms in the body and is the method by which the "zzzzzt" in the energy system is balanced out. Before locating these points for you, however, you need a few tips on how to carry out the tapping process.

Tapping tips: You can tap with either hand but it is usually more convenient to do so with your dominant hand (e.g. right hand if you are right handed). Tap with the fingertips of your index finger and middle finger. This covers a little larger area than just tapping with one fingertip and allows you to cover the tapping points more easily. Tap solidly but never so hard as to hurt or bruise yourself. Tap about 7 times on each of the tapping points. I say about 7 times because you will be repeating a "reminder phrase" (covered later) while tapping and it will be difficult to count at the same time. If you are a little over or a little under 7 (5 to 9, for example) that will be sufficient.

Most of the tapping points exist on either side of the body. It doesn't matter which side you use nor does it matter if you switch sides during The Sequence. For example, you can tap under your right eye and, later in The Sequence, tap under your left arm.

The points: Each energy Emotional-freedom has two end points. You need only tap on one end to balance out any disruptions that may exist in it. These end points are near the surface of the body and are thus more readily accessed than other points along the Emotional-freedoms that may be more deeply buried. What follows are instructions on how to locate the end points of those Emotional-freedoms that are important to the Basic Recipe.

**At the beginning of the eyebrow, just above and to one side of the nose. This point is abbreviated EB for beginning of the EyeBrow.

**On the bone bordering the outside corner of the eye. This point is abbreviated SE for Side of the Eye.

**On the bone under an eye about 1 inch below your pupil. This point is abbreviated UE for Under the Eye.

**On the small area between the bottom of your nose and the top of your upper lip. This point is abbreviated UN for Under the Nose.

**Midway between the point of your chin and the bottom of your lower lip. Even though it is not directly on the point of the chin, we call it the chin point because it is descriptive enough for people to understand easily. This point is abbreviated Ch for Chin.

**The junction where the sternum (breastbone), collarbone and the first rib meet. To locate it, first place your forefinger on the U-shaped notch at the top of the breastbone (about where a man would knot his tie). From the bottom of the U, move your forefinger down toward the navel 1 inch and then go to the left (or right) 1 inch. This point is abbreviated CB for Collar Bone even though it is not on the collarbone (or clavicle) per se. It is at the beginning of the collarbone and we call it the collarbone point because that is a lot easier to say than "the junction where the sternum (breastbone), collarbone and the first rib meet."

**On the side of the body, at a point even with the nipple (for men) or in the middle of the bra strap (for women). It is about 4 inches below the armpit. This point is abbreviated UA for Under the Arm.

**For men, one inch below the nipple. For ladies, where the underskin of the breast meets the chest wall. This point is abbreviated BN for Below Nipple.

**On the outside edge of your thumb at a point even with the base of the thumbnail. This point is abbreviated Th for Thumb.

**On the side of your index finger (the side facing your thumb) at a point even with the base of the fingernail. This point is abbreviated IF for Index Finger.

**On the side of your middle finger (the side closest to your thumb) at a point even with the base of the fingernail. This point is abbreviated MF for Middle Finger.

**On the inside of your baby finger (the side closest to your thumb) at a point even with the base of the fingernail. This point is abbreviated BF for Baby Finger.

**The last point is the karate chop point....which has been previously described under the section on The Setup. It is located in the middle of the fleshy part on the outside of the hand between the top of the wrist bone and the base of the baby finger. It is abbreviated KC for Karate Chop.

The abbreviations for these points are summarized below in the same order as given above.

EB = Beginning of the EyeBrow

SE = **S**ide of the Eye

UE = Under the Eye

UN = Under the Nose

Ch = Chin

CB = Beginning of the CollarBone

UA = Under the Arm

BN = Below the Nipple

Th = Thumb

IF = Index Finger

MF = Middle Finger

BF = Baby Finger

KC = Karate Chop

Please notice that these tapping points proceed down the body. That is, each tapping point is below the one before it. That should make it a snap to memorize.

3. The 9 Gamut Procedure

The 9 Gamut Procedure is, perhaps, the most bizarre looking process within EFT. Its purpose is to "fine tune" the brain and it does so via some eye movements and some humming and counting. Through connecting nerves, certain parts of the brain are stimulated when the eyes are moved. Likewise the right side of the brain (the creative side) is engaged when you hum a song and the left side (the digital side) is engaged when you count.

The 9 Gamut Procedure is a 10 second process wherein 9 of these "brain stimulating" actions are performed while continuously tapping on one of the body's energy points.....the Gamut point. It has been found, after years of experience, that this routine can add efficiency to EFT and hastens your progress towards emotional freedom especially when sandwiched between 2 trips through The Sequence.

One way to help memorize The Basic Recipe is to look at it as though it was a ham sandwich. The Setup is the preparation for the ham sandwich and the sandwich itself consists of two slices of bread (The Sequence) with the ham, or middle portion, as the 9 Gamut Procedure. It looks like this...

	The Setup
The Ham Sandwich	**The Sequence (Bread)**
	9 Gamut (Ham)
	The Sequence (Bread)

To do the 9 Gamut Procedure, you must first locate the Gamut point. It is on the back of either hand and is 1/2 inch behind the midpoint between the knuckles at the base of the ring finger and the little finger. If you draw an imaginary line between the knuckles at the base of the ring finger and little finger and consider that line to be the base of an equilateral triangle whose other sides converge to a point (apex) in the direction of the wrist, then the gamut point would be located at the apex of the triangle.

Next, you must perform 9 different actions while tapping the Gamut point continuously. The 9 Gamut actions are:

1. Eyes closed.
2. Eyes open.
3. Eyes hard down right while holding the head steady.
4. Eyes hard down left while holding the head steady.
5. Roll eyes in a circle as though your nose was at the center of a clock and you were trying to see all the numbers in order.
6. Same as 5 only reverse the direction in which you roll your eyes.
7. Hum 2 seconds of a song (suggest Happy Birthday).
8. Count rapidly from 1 to 5.

9. Hum 2 seconds of a song again.

Note that these 9 actions are presented in a certain order and the author suggests that you memorize them in the order given. However, you can mix the order up if you wish so long as you do all 9 of them and you perform 7, 8 and 9 as a unit. That is, you hum 2 seconds of a song...then count...then hum the song again, in that order. Years of experience have proven this to be important.

Also, note that for some people humming Happy Birthday causes resistance because it brings up memories of unhappy birthdays. In this case, you can either use EFT on those unhappy memories and resolve them or you can side step this issue for now by having them hum some other song.

4. The Sequence (again)

The fourth and last technique is like the Basic Recipe that was mentioned above. It is an identical trip through The Sequence.

The Reminder Phrase

Once memorized, The Basic Recipe becomes a lifetime friend. It can be applied to an almost endless list of emotional and physical problems and provides relief from most of them. However, there's one more concept we need to develop before we can apply The Basic Recipe to a given problem. It is called the Reminder Phrase.

When a football quarterback throws a pass, he aims it at a particular receiver. He doesn't just throw the ball in the air and hope someone will catch it. Likewise, The Basic Recipe needs to be aimed at a specific problem. Otherwise, it will bounce around aimlessly with little or no effect.

You "aim" The Basic Recipe by applying it while "tuned in" to the problem from which you want relief. This tells your system which problem needs to be the receiver. Remember the discovery statement which states...

"The cause of all negative emotions is a disruption in the body's energy system."

Negative emotions come about because you are tuned into certain thoughts or circumstances which, in turn, cause your energy system to disrupt. Otherwise, you function normally. One's fear of heights is not present, for example, while one is reading the comic section of the Sunday newspaper (and therefore not tuned in to the problem).

Tuning in to a problem can be done by simply thinking about it, in fact, tuning in means thinking about it. Thinking about the problem will bring about the energy disruptions involved which then and only then can be balanced by applying The Basic Recipe. Without tuning in to the problem thereby creating those energy disruptions the Basic Recipe does nothing. Tuning in is seemingly a very simple process. You merely think about the problem while applying the Basic Recipe.

However, you may find it a bit difficult to consciously think about the problem while you are tapping, humming, counting, etc. That's why the author introduced a Reminder Phrase that you can repeat continually while you are performing the Basic Recipe.

The Reminder Phrase is simply a word or short phrase that describes the problem and that you repeat out loud each time you tap one of the points in The Sequence. In this way you continually "remind" your system about the problem you are working on.

The best Reminder Phrase to use is usually identical to what you choose for the affirmation you use in The Setup. For example, if you are working on a fear of public speaking, The Setup affirmation would go like this....

Even though I have this fear of public speaking, I deeply and completely accept myself.

Within this affirmation, the words ‘fear of public speaking’ are ideal candidates for use as the Reminder Phrase. For your purposes, however, you can simplify your life by just using the identical words for the Reminder Phrase as you use for the affirmation in The Setup. That way you will minimize any possibility for error.

Session VI: Evaluation of the participants

The researcher would ask the participants to evaluate the extent of their Mathematics problem on a scale of 0 to 10 (where 10 represents maximum intensity and 0 represents no intensity whatsoever). This provides a benchmark against which to measure your progress. You might start at a 6, for instance, and then go to a 3....and then a 1....and finally to 0....as various rounds of the Basic Recipe are applied.

The participants would be trained to always measure the intensity as it exists NOW....as they think about it....and not as they think it would be in the actual situation. Remember, The Basic Recipe balances the disruptions in your energy system as they exist NOW while you are tuned in to the thought or circumstance.

Here's an example of how it works. Let's say an individual has a fear for Mathematics that he/she would like to put behind. If there is no Mathematical problems present to cause him/her any emotional intensity then he/she will be asked to close eyes and imagine given Mathematical operation to work or imagine a past time when an equation scared him/her. Participants will be asked to assess their intensity on a scale of 0 to 10 *as it exists NOW* while they think about it. If you estimate it at a 7, for example, then you have a benchmark against which to measure your progress.

Participants will be asked to do one round of the Basic Recipe and imagine the equation again. If they can get no trace whatsoever of their previous emotional intensity then the therapy is done. If, on the other hand, the intensity go to, let's say, a 4 then the therapist need to perform subsequent rounds until 0 is reached.

Session VII: Conclusion and Summary delivery.

Session VIII: Post-test

- The researcher summarized all that had transpired during the therapeutic sessions.

- Participants were then given the two instruments – Mathematics Anxiety and Mathematics Achievement Scales – to complete again as post-test.

- The researcher expressed gratitude and prayed for the participants.
  - Refreshment was then served.
  - Gifts were distributed
  - The researcher gave the participants his phone number for further follow-up.

3.12 The Control Group

- This group received placebo effect or no treatment at all.
- The group administered pretest and posttest measures like their counterparts in schools A and B within a period of eight weeks interval.

3.13 Data Analysis

Quantitative data from the experiment was statistically tested using Analysis of Covariance (ANCOVA), Multiple Classification Analysis and post hoc comparison. ANCOVA was used for the experimental effect because of its robustness, its ability to control extraneous variables, adjust treatment means, estimate missing data, increase precision in randomized experiments, correct initial mean differences between the experimental groups, take correlation between pre-and post-test measures into account. It was also used to remove from the treatment means those differences which could be linearly correlated with the covariate and to adjust the post-test means of differences between the two groups in the experiment.

CHAPTER FOUR

RESULTS

This chapter presents the result of the findings of data collected from the participants of the study. Fourteen hypotheses were stated in this study and tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The summaries of the analyses were presented in tables for each of the hypotheses.

Hypothesis one: There is no significant main effect of treatment on mathematics anxiety of secondary school students

Table 4.1
A 3 x 2 x 2 Analysis of Covariance (ANCOVA) Summary table on the treatment

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	30016.519[a]	10	3001.652	59.135	.000	.844
Intercept	90.738	1	90.738	1.788	.184	.016
premath_anx	6744.220	1	6744.220	132.866	.000	.549
Group	17564.828	2	8782.414	173.020	.000	.760
mathefficacy_lev	1775.207	1	1775.207	34.973	.000	.243
Gender	154.305	1	154.305	3.040	.084	.027
group * mathefficacy_lev	1339.741	1	1339.741	26.394	.000	.195
group * gender	115.123	2	57.561	1.134	.326	.020
mathefficacy_lev * gender	315.882	2	315.882	6.223	.014	.054
group * mathefficacy_lev * gender	371.896	2	371.896	7.327	.008	.063
Error	5532.781	109	50.759			
Total	319568.000	120				
Corrected Total	35549.300	119				

Table 4.1 reveals that there was a significant main effect of treatment (Numerical Cognition, Emotional-freedom Based Intervention and Control group) on Mathematics anxiety of secondary school students; ($F_{(2,109)}$ =173.020, $p<0.001$, ŋ =.760).Therefore the null hypothesis is rejected. The table further reveals that the groups had large effect on the mathematics anxiety posttest score variations, which implies that the differences in the groups accounted for 76% (ŋ=.760) in the variation of the posttest score. In order to provide some indicators of the performance of each group, a Multiple Classification Analysis was computed. The results are presented in table 4.7

Table 4.2
Multiple Classification Analysis (MCA) on post test Mean Score of Mathematics Anxiety

Source of variation	**N**	**Unadjusted Variation**	**Eta**	**Adjusted Variation**	**Beta**
Grand Mean=48.65					
Treatment Group					
1.Numerical cognition group	40	-3.3		-9.27	
2.Emotional-freedom Based group	40	-14.87	.633	-15.2	.777
3.Control group	40	18.18		16.68	
Mathematic Self efficacy					
1 High	49	-4.31		1.514	
2 Low	71	11.85		-2.91	
Gender					
1 male	60	-1.4		-1.4	
2 female	60	0.93		0.88	
Multiple R^2					.844
Adjusted R^2					.830

The MCA as shown in table 4.2 reveals that mathematics anxiety of all the participants exposed to Emotional-freedom based technique had the least mean score (33.78), followed by Numerical cognition group (45.35) and control group which had the highest mean score (66.83).Since the treatment was meant to reduce students mathematics anxiety, the lesser the mean score the more effective the treatment. This therefore implies that in reducing students mathematics anxiety, Emotional-freedom based technique is more effective than Numerical cognition technique. However, to determine the actual source of the observed significance difference as indicated in the ANCOVA, Bonferonni Post-Hoc Test was carried out on the adjusted mean score of the groups, this is presented in table 4.3

Table 4.3

Bonferonni Post-Hoc Test (Pairwise Comparison) showing the nature of difference in students Mathematics anxiety

(I) intervention	(J) intervention	Mean Difference (I-J)	Std. Error	Sig.
Numerical Cognition Group	Emotional-freedom Based Group	5.481*	2.032	.024
	Control Group	-26.399*	2.079	.000
Emotional-freedom Based Group	Numerical Cognition Group	-5.481*	2.032	.024
	Control group	-31.880*	1.692	.000
Control Group	Numerical Cognition Group	26.399*	2.079	.000
	Emotional-freedom Based Group	31.880*	1.692	.000

Table 4.3 reveals that after controlling for the effect of pre-mathematics anxiety score. The posttest mathematics anxiety score of control group (mean=65.33) was significantly higher than that of the Numerical Cognition group (mean=38.93) and Emotional-freedom based group (mean=33.45). The intervention (Numerical Cognition) accounted for the reduction in the mathematics anxiety posttest score of the experimental group 1 (mean=26.399).While intervention (Emotional-freedom based) accounted for much more reduction in the mathematics anxiety posttest score of experimental group 2 (mean=31.88). This implies that the Emotional-freedom-based intervention was more effective in reducing students' mathematics anxiety than numerical-cognition

intervention. The coefficient of determination adjusted R-Squared= .830 revealed that the groups accounted for 83.0% in the overall variation of the mathematics anxiety test scores of the students.

Hypothesis two: There is no significant main effect of mathematics efficacy on mathematics anxiety test score of secondary school students

Table 4.1: shows that there was significant main effect of Mathematics efficacy on Mathematics anxiety of secondary school students; ($F_{(1,109)}$ =34.973, p<0.001, ŋ =.243).Therefore the null hypothesis is rejected. The table further reveals that Mathematics efficacy had large effect on the mathematics anxiety posttest score variations, which implies that the differences in the level of mathematics efficacy accounted for 24.3% (ŋ =.243) in the variation of the posttest score.

Hypothesis three: There is no significant main effect of gender on mathematics anxiety test score of secondary school students

Table 4.1 shows that there was no significant main effect of gender on Mathematics anxiety of secondary school students; ($F_{(1,109)}$ = 3.040, p>0.05, ŋ =.027).Therefore the null hypothesis is accepted. The table further reveals that gender had very small effect on the mathematics anxiety posttest score variations.

Hypothesis four: There is no significant interactive effect of treatment and mathematics efficacy on mathematics anxiety test score of secondary school students

Table 4.1 shows that there was significant interactive effect of treatment and mathematics efficacy on Mathematics anxiety of secondary school students; ($F_{(1,109)}$ =26.394, p<0.001, ŋ =.195).Therefore the null hypothesis is rejected. The table further reveals that treatment and mathematics efficacy had large effect on the mathematics anxiety posttest score variations, that is, mathematics efficacy significantly moderated the influence of treatment on mathematics anxiety posttest score variances. This indicates that the differences that occur as a result of the interactive effect accounted for 19.5% (ŋ =.195) in the variation of the posttest score. To further understand the point of difference the Bonferonni Post-Hoc Test

(Pairwise comparison) was computed.

Table 4.4

Bonferonni Post-Hoc Test (Pairwise Comparison) showing the nature of difference in students Mathematics anxiety with respect to the interaction between intervention and mathematics efficacy.

Intervention	Math Efficacy Level	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Numerical Cognition Group	High Efficacy	26.861	3.233	48.418	53.580
	Low Efficacy	50.999[a]	1.302	20.454	33.268
Emotional-freedom Based Group	high Efficacy	23.449[a]	1.140	31.190	35.708
	low Efficacy	53.67.[a,b]	1.013	36.901	22.762
Control Group	high Efficacy	64.614[a]	1.578	62.198	69.888
	low Efficacy	66.043[a]	1.940	61.486	67.741

Table 4.4 reveals that after controlling for the effect of pre-mathematics anxiety score. The posttest mathematics anxiety score of the three groups differ with respect to their level of mathematics efficacy except Emotional-freedom group that did not record any score for student with low efficacy because all the students in the group displayed high mathematics efficacy after been exposed to the intervention. Comparing the level of mathematics anxiety posttest score of the three group among students with high mathematics efficacy; control group had the highest mathematics anxiety mean score (mean= 64.614), followed by Numerical Cognition group (mean=26.86) and Emotional-

freedom Based group (mean= 23.449). The intervention (Numerical Cognition) accounted for the reduction in the mathematics anxiety posttest score of the experimental group 1 (mean=-37.754 $_{(26.86-64.614)}$).While intervention (Emotional-freedom based) accounted for much more reduction in the mathematics anxiety posttest score of experimental group 2 (mean=-41.165 $_{(23.449-64.614)}$). This implies that the Emotional-freedom-based intervention was more effective in reducing mathematics anxiety score than numerical-cognition intervention especially among students with high mathematics efficacy.

Hypothesis five: There is no significant interactive effect of treatment and gender efficacy on mathematics anxiety test score of secondary school students

Table 4.1 shows that there was no significant interactive effect of treatment and gender on Mathematics anxiety of secondary school students; ($F_{(2,109)}$ =1.134, $p>0.05$, ŋ =.020).Therefore the null hypothesis is accepted. This implies that gender did not significantly moderate the effect of treatment on mathematics anxiety posttest score variations.

Hypothesis six: There is no significant interactive effect of mathematics efficacy and gender on mathematics anxiety test score of secondary school students

Table 4.1 shows that there was a significant interactive effect of mathematics efficacy and gender on Mathematics anxiety of secondary school students; ($F_{(1,109)}$ =6.223, $p<0.05$, ŋ =.054).Therefore the null hypothesis is rejected. This implies that gender significantly moderated the influence of mathematics efficacy on mathematics anxiety posttest score variations. This indicates that the differences that occur as a result of the interactive effect accounted for 5.4% (ŋ =.054) in the variation of the posttest score.

Hypothesis seven: There is no significant interactive effect of treatment, mathematics efficacy and gender on mathematics anxiety test score of secondary school students

Table 4.1 shows that there was a significant interactive effect of treatment mathematics efficacy and gender on Mathematics anxiety of secondary school students; ($F_{(1,109)}$ =7.327, $p<0.05$, ŋ =.063).Therefore the null hypothesis is rejected. This implies that gender and mathematics efficacy simultaneously moderated the effect of treatment on mathematics anxiety posttest score variations. This indicates that the differences that occur as a result of the interactive effect accounted for 6.3% (ŋ =.063) in the variation of the posttest score. To further understand the point of difference the Bonferonni Post-Hoc Test (Pairwise comparison) was computed.

Table 4.5
Bonferonni Post-Hoc Test (Pairwise Comparison) showing the nature of difference on students' Mathematics anxiety with respect to the interaction between treatment mathematics efficacy and gender.

Intervention	Math Efficacy level	Gender	Mean	Std. Error
Numerical Cognition Group	high Efficacy	Male	54.745[a]	2.099
		Female	47.252[a]	1.596
	low Efficacy	male	19.238[a]	5.365
		female	34.484[a]	3.563
Emotional-freedom Based group	High Efficacy	male	32.593[a]	1.731
		female	34.305[a]	1.486
	Low Efficacy	male	.[a,b]	.
		female	.[a,b]	.
Control Group	High Efficacy	male	65.382[a]	2.521
		female	66.705[a]	2.936
	Low Efficacy	male	64.299[a]	2.694
		female	64.928[a]	1.638

Table 4.5 reveals that after controlling for the effect of pre-mathematics anxiety test score. The three group displayed different level of mathematics anxiety with respect to mathematics efficacy level and gender except Emotional-freedom group that had no participants with low mathematics efficacy after been exposed to the intervention.

However, when comparing the three group mathematics anxiety considering students with high mathematics efficacy and gender; Control group had the highest mathematics anxiety mean score (male= 65.38, Female= 66.71), followed by Numerical Cognition group (male=54.75, female=47.25) and Emotional-freedom Based group which had the least mathematics anxiety mean score (male=32.59, female=34.31). Gender mathematics anxiety mean score differ after been exposed to intervention; Male students with high mathematics efficacy displayed relatively higher mathematics anxiety score (mean=54.75) than female students counterpart (mean= 47.25) after exposure to Numerical Cognition Intervention. While Male students with high mathematics efficacy displayed relatively lower mathematics anxiety score (mean=32.59) than female students counterpart (mean= 34.31). This implies that irrespective of level of mathematics efficacy and gender Emotional-freedom Based Intervention is the most effective in the reduction of mathematics anxiety followed by Numerical cognition. Although both interventions are equally moderated by mathematics efficacy and gender but at different levels.

Hypothesis eight: There will be no significant main effect of treatment on Mathematics achievement of secondary school students**.**

Table 4.6
A 3 x 2 x 2 Analysis of Covariance (ANCOVA) Summary table on Mathematics Achievement

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	40484.689[a]	10	4048.469	44.704	.000	.804
Intercept	5212.358	1	5212.358	57.556	.000	.346
premath_ach	3764.409	1	3764.409	41.567	.000	.276
Group	7636.355	2	3818.177	42.161	.000	.436
mathefficacy_lev	1901.937	1	1901.937	21.001	.000	.162
Gender	39.689	1	39.689	.438	.509	.004
group * math efficacy level	553.880	1	553.880	6.116	.015	.053
group * gender	114.646	2	57.323	.633	.533	.011
Math efficacy level * gender	30.032	1	30.032	.332	.566	.003
group * math efficacy level * gender	6.248	1	6.248	.069	.793	.001
Error	9871.278	109	90.562			
Total	420208.000	120				
Corrected Total	50355.967	119				

R Squared = .804 (Adjusted R Squared = .786)

Table 4.6 reveals that there was a significant main effect of treatment (Numerical Cognition, Emotional-freedom Based Intervention and Control group) on Mathematics achievement of secondary school students; ($F_{(2,109)}$ =42.161, p<0.001, ŋ =.432).Therefore the null hypothesis is rejected. The table further reveals that the groups had large effect on the mathematics achievement posttest score variations, which implies that the differences in the groups accounted for 43.2% (ŋ =.432) in the variation of the posttest score. In order to provide some indicators of the performance of each group, a Multiple Classification Analysis was computed. The results are presented in table 4.9

Table 4.7

Multiple Classification Analysis (MCA) on post test Mean Score

Source of variation	N	Unadjusted Variation	Eta	Adjusted Variation	Beta
Grand Mean=55.52					
Treatment Group					
1.Numerical cognition group	40	3.78		-4.359	
2.Emotional-freedom Based group	40	16.16	.535	16.15	.679
3.Control group	40	-19.94		-17.84	
Mathematic Self efficacy					
1 High	49	9.73		2.95	
2 Low	71	-26.77		-18.54	
Gender					
1 male	60	2.75		-5.08	
2 female	60	-1.84		-6.22	
Multiple R^2					.804
Adjusted R^2					.786

The MCA as shown in table 4.7 reveals that mathematics achievement of all the participants exposed to Emotional-freedom based technique had the highest mean score (71.68), followed by Numerical cognition group (59.30) and control group which had the least mean score (35.58).Since the treatment was meant to improve students mathematics achievement, the higher the mean score the more effective the treatment. This therefore implies that in improving students mathematics achievement, Emotional-freedom based technique is more effective than Numerical cognition technique. To determine the actual source of the observed significance difference as indicated in the ANCOVA, Bonferonni Post-Hoc Test is carried out on the adjusted mean score of the groups, this is presented in table 4.8

Table 4.8

Bonferonni Post-Hoc Test (Pairwise Comparison) showing the nature of difference in students Mathematics achievement

(I) intervention	(J) intervention	Mean Difference (I-J)	Std. Error	Sig.[b]
numerical cognition group	Emotional-freedom Based group	-20.508*,a	2.728	.000
	control group	13.477*	2.841	.000
Emotional-freedom Based group	numerical cognition group	20.508*,c	2.728	.000
	control group	33.985*,c	2.260	.000
control group	numerical cognition group	-13.477*	2.841	.000
	Emotional-freedom Based group	-33.985*,a	2.260	.000

Table 4.8 reveals that after controlling for the effect of pre-mathematics achievement score. The posttest mathematics achievement score of control group (mean=37.68) was significantly lower than that of the Numerical Cognition group (mean=51.16) and Emotional-freedom based group (mean=71.67). The intervention (Numerical Cognition) accounted for the increase in the mathematics achievement posttest score of the

experimental group 1 (mean=13.477).While intervention (Emotional-freedom based) accounted for much more increase in the mathematics achievement posttest score of experimental group 2 (mean=20.508). This implies that the Emotional-freedom-based intervention was more effective in boosting students' mathematics achievement score than numerical-cognition intervention. The coefficient of determination adjusted R-Squared= .786 revealed that the groups accounted for 78.6% in the overall variation of the mathematics achievement test scores of the students.

Hypothesis nine: There is no significant main effect of mathematics efficacy on mathematics achievement test score of secondary school students

Table 4.7 shows that there was significant main effect of Mathematics efficacy on Mathematics achievement of secondary school students; ($F_{(1,109)}$ =21.00, $p<0.001$, ŋ =.162).Therefore the null hypothesis is rejected. The table further reveals that Mathematics efficacy had large effect on the mathematics achievement posttest score variations, which implies that the differences in the level of mathematics efficacy accounted for 16.2% (ŋ =.162) in the variation of the posttest score.

Hypothesis ten: There is no significant main effect of gender on mathematics achievement test score of secondary school students

Table 4.7 shows that there was no significant main effect of gender on Mathematics achievement of secondary school students; ($F_{(1,109)}$ =.438, $p>0.05$, ŋ =.004).Therefore the null hypothesis is accepted. The table further reveals that gender had very small effect on the mathematics achievement posttest score variations, which implies that gender accounted for 0.4% (ŋ =.004) in the variation of the posttest score.

Hypothesis eleven: There is no significant interactive effect of treatment and mathematics efficacy on mathematics achievement test score of secondary school students

Table 4.7 shows that there was significant interactive effect of treatment and mathematics efficacy on Mathematics achievement of secondary school students; ($F_{(1,109)}$ =6.116, p<0.05, ŋ =.053).Therefore the null hypothesis is rejected. The table further reveals that treatment and mathematics efficacy had small effect on the mathematics achievement posttest score variations, that is, mathematics efficacy slightly moderated the influence of treatment on mathematics posttest score variances. This indicates that the differences that occur as a result of the interactive effect accounted for 5.3% (ŋ =.053) in the variation of the posttest score. To further understand the point of difference the Bonferonni Post-Hoc Test (Pairwise comparison) was computed.

Table 4.9

Bonferonni Post-Hoc Test (Pairwise Comparison) showing the nature of difference in students Mathematics achievement with respect to the interaction between intervention and mathematics efficacy.

Intervention	Math Efficacy level	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Numerical Cognition Group	High Efficacy	62.076[a]	1.676	58.754	65.397
	Low Efficacy	40.246[a]	4.247	31.829	48.663
Emotional-freedom Based Group	High Efficacy	71.669[a]	1.523	68.651	74.687
	Low Efficacy	.[a,b]	.	.	.
Control Group	High Efficacy	41.661[a]	2.874	35.965	47.357
	Low Efficacy	33.706[a]	2.262	29.223	38.190

Table 4.9 reveals that after controlling for the effect of pre-mathematics achievement score. The posttest mathematics achievement score of the three groups differ with respect to their level of mathematics efficacy except Emotional-freedom group that did not record any score for student with low efficacy because all the students in the group displayed high mathematics efficacy after been exposed to the intervention. Comparing the level of mathematics achievement posttest score of the three group among students

with high mathematics efficacy; control group had the least mathematics achievement mean score (41.66), followed by Numerical Cognition group (mean=62.08) and Emotional-freedom Based group (mean= 71.67). The intervention (Numerical Cognition) accounted for the increase in the mathematics achievement posttest score of the experimental group 1 (mean=$20.415_{(62.076-41.661)}$).While intervention (Emotional-freedom based) accounted for much more increase in the mathematics achievement posttest score of experimental group 2 (mean=$30.01_{(71.67-41.66)}$). This implies that the Emotional-freedom-based intervention was more effective in boosting mathematics achievement score than numerical-cognition intervention especially among students with high mathematics efficacy.

Hypothesis twelve: There is no significant interactive effect of treatment and gender on mathematics achievement test score of secondary school students

Table 4.7 shows that there was no significant interactive effect of treatment and gender on Mathematics achievement of secondary school students; ($F_{(2,109)}$ =.633, $p>0.05$, ŋ =.011).Therefore the null hypothesis is accepted. This implies that gender did not significantly moderate the effect of treatment on mathematics achievement posttest score variations.

Hypothesis thirteen: There is no significant interactive effect of mathematics efficacy and gender on mathematics achievement test score of secondary school students

Table 4.7 shows that there was no significant interactive effect of mathematics efficacy and gender on Mathematics achievement of secondary school students; ($F_{(1,109)}$ =.332, $p>0.05$, ŋ =.003).Therefore the null hypothesis is accepted. This implies that gender did not significantly moderate the influence of mathematics efficacy on mathematics achievement posttest score variations.

Hypothesis fourteen: There is no significant interactive effect of treatment, mathematics efficacy and gender on mathematics achievement test score of secondary school students

Table 4.7 shows that there was no significant interactive effect of treatment, mathematics efficacy and gender on Mathematics achievement of secondary school students; ($F_{(1,109)}$ =.069, $p>0.05$, ŋ =.001). Therefore the null hypothesis is accepted. This implies that gender and mathematics efficacy could not simultaneously moderate the effect of treatment on mathematics achievement posttest score variations.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

This chapter presents the discussion, conclusion and recommendations of the findings. The discussion was done by relating the findings to existing literature review or empirical findings from notable studies. The conclusion was done based on the findings of the study and recommendations were made thereafter.

5.1 Discussion

Hypothesis One

Hypothesis one, which stated that there is no significant main effect of treatment on Mathematics anxiety of secondary school students, was significant (see table 1). The findings revealed that the treatment effects were very effective in reducing Mathematics anxiety among the participants. This implies that Numerical Cognition and Emotional Freedom reduced Mathematics anxiety among the study participants. The significant differences, made by these two techniques over the control group, accounted for 76.9% variance in the reduction of Mathematics anxiety. The above percentage is the explained variances that could be deduced from these two techniques. The rest percentage i.e 23.1% are unexplained variances that are outside the context of this study. In all, Numerical Cognition and Emotional Freedom were able to account for changes in Mathematics anxiety of the participants.

However, there was a greater mean differences observed in Emotional-freedom-based intervention compared to Numerical cognition in the reduction of Mathematics anxiety among the participants. This implies that the intervention was more effective in reducing students' mathematics anxiety level than numerical-cognition intervention. This finding corroborated the study of Hopko et al (1999) which found that Numerical Cognition intervention could lead to reduction in Mathematics anxiety. Their study postulated that Mathematics-anxious individuals have a deficient inhibition mechanism, so exposure to numerical cognition training could moderate the anxiety level in the subject.

Mathematics anxiety and numerical cognition across several initial studies, have found substantial evidence for performance differences as a function of Mathematics anxiety. For example, Ashcraft and Faust (1994; also Faust, Ashcraft, & Fleck, 1996) have shown that high-Mathematics-anxiety participants have particular difficulty on two-column addition problems owing largely to the carry operation. When such problems were answered correctly, the time estimate for the embedded carry operation was nearly three times as long for high-anxiety participants as it was for low-anxiety participants (Faust *et al.*, 1996). Thus, high-Mathematics-anxiety participants showed slower, more effortful processing on a procedural aspect of performance, performing the carry operation for suggestive evidence on Mathematics affect and procedural performance in a numerical estimation task, (LeFevre, Greenham, & Waheed, 1993).

On account of significant differences observed on Emotional Freedom intervention and Mathematics Anxiety, the participants showed much lower reduction in Mathematics anxiety than their counterparts in Numerical Cognition group. In line with this finding, Callahan (1985) found that EFT was superior to other CBT therapies used in his study to solve test anxiety problem. He asserted that the tapping provides an external source of energy which, when done correctly, at the right spot, with the mind tuned to the problem being treated, balances the energy in a particular energy system in the body which is suffering from a deficiency or imbalance. A couple of years later Callahan (1992) commented on his practical and theoretical ideas related to tapping. He found that EFT is most significant among the techniques used to solve test anxiety level. He asserted that the points being tapped are related to the ancient Emotional-freedoms of acupuncture. Tapping the proper point when the person is thinking of the problem is quite effective. He then stressed that these points are transducers of energy; where the physical energy of tapping can be transduced into the appropriate (probably electromagnetic) energy of the body so that the person with a problem can be put into proper balance by a knowledgeable person.

This finding also supported the study conducted by Benor et al (2008) which found a significant causal effect between EFT and other technique in reducing test anxiety. Benor, Ledger, Toussaint and Zaccaro (2008) explored test anxiety benefits of Wholistic Hybrid, Emotional Freedom Techniques (EFT), and Cognitive Behavioural Therapy. Participants including Canadian university students with severe or moderate test anxiety participated. A double-blind, controlled trial was conducted. Their study found no significant differences between the scores for the three treatments. In only two sessions WHEE and EFT achieved the equivalent benefits to those achieved by CBT in five sessions. Participants reported high satisfaction with all treatments. EFT and WHEE students successfully transferred their self-treatment skills to other stressful areas of their lives. WHEE and EFT show promise as effective treatments for test anxiety.

Hypothesis two

Findings on hypothesis two revealed main significant effect of Mathematics efficacy on Mathematics anxiety of secondary school students. It was found (table 1) that Mathematics efficacy had large effect on the Mathematics anxiety posttest score variations, which shows that the differences in the level of mathematics efficacy accounted for 24.3% (Partial Eta Squared=.243) in the variation of the posttest score. This then implies that Mathematics efficacy is very important in moderating anxiety level perceived by students on Mathematics. Self-efficacy refers to people's specific beliefs about their capability to perform certain actions or to bring about intended outcomes in a domain or to otherwise exert control over their lives (Bandura, 1986, 1993; Boekaerts, 1992; Schunk, 1990).When students have high efficacy in Mathematics, their anxiety level would reduce on the subject than when they have low efficacy in the subject. This finding corroborated the study of Collins (1984) and Pintrich and Schrauben (1992) which noted that more efficacious students monitored their performance and applied more effort than students who were low in self-efficacy. Similarly, this finding corroborated Bandura (1993) who asserted that people with high self-efficacy "heighten and sustain their efforts in the face of failure. And also they attribute failure to insufficient effort or deficient knowledge and skills that are acquirable" (p. 144).

Hypothesis three

Findings on the above hypothesis revealed that there was no significant main effect of gender on Mathematics anxiety of secondary school students. It was further revealed (table 1) that gender had very small effect on the mathematics anxiety posttest score variations. This then implies that gender of the participants could not have any effect on the anxiety level in Mathematics in this study. This shows that male and female students used in this study experienced the same anxiety level in Mathematics. In line with this finding, Pajares and Kranzler have found no gender effects on test anxiety and performance on test. Pajares and Miller (1994) found a gender effect favoring the Mathematics self-efficacy of male undergraduates but found no gender effect on problem-solving performance.

Hypothesis four

Findings on the above hypothesis showed that there was significant interactive effect of treatment and mathematics efficacy on Mathematics anxiety of secondary school students. It was revealed (table 1) that treatment and mathematics efficacy had large effect on the mathematics anxiety posttest score variations. This means that Mathematics efficacy significantly moderated the influence of treatment on mathematics anxiety posttest score variances. This indicates that the differences that occur as a result of the interactive effect accounted for 19.5% (Partial Eta Squared=.195) in the variation of the posttest score. In line with this finding, researches have shown that high worry is associated with low cognitive performance (Hembree, 1988, 1990; Pajares & Urdan, 1996; Seipp, 1991). Pintrich and De Groot (1990) found that students with higher self-efficacy, intrinsic value (learning goal orientation), cognitive strategy use, and use of self-regulating strategies (metacognition/effort) had significantly higher grades, better seatwork, and better scores in exams/quizzes and essays/reports.

Hypothesis five

Findings on the above hypothesis showed that there was no significant interactive effect of treatment and gender on Mathematics anxiety of secondary school students. This implies that gender did not significantly moderate the effect of treatment on mathematics anxiety posttest score variations. In a similar study, Pysher (1996) also found no significant gender differences in Mathematics test anxiety, goals, or self-efficacy. Another study consistent with this finding is Fennema and Sherman (1978) which found that there were no significant differences with gender and Mathematics learning, nor with gender and motivation for learning, for 1,300 middle school children.

Hypothesis six

It was found (table 4.1) that there was a significant interactive effect of mathematics efficacy and gender on Mathematics anxiety of secondary school students. This implies that gender significantly moderated the influence of mathematics efficacy on mathematics anxiety posttest score variations. The indication is that the differences that occur as a result of the interactive effect accounted for 5.4% in the variation of the posttest score. Students feel self-efficacious when they are able to picture themselves succeeding in challenging situations, which in turn determines their level of effort toward the task (Paris & Byrnes, 1989; Salomon, 1983; 1984). In line with this finding, Bandura (Bandura 1977, 1986) asserts that self-percepts of efficacy highly influence whether students believe they have the coping strategies to successfully deal with challenging situations. One's self-efficacy may also determine whether learners choose to engage themselves in a given activity and may determine the amount of effort learners invest in a given academic task, provided the source and requisite task is perceived as challenging (Salomon, 1983, 1984).

Hypothesis seven

Findings of the above hypothesis revealed that there was a significant interactive effect of treatment mathematics efficacy and gender on Mathematics anxiety of secondary school students. This implies that gender and mathematics efficacy simultaneously moderated the effect of treatment on mathematics anxiety posttest score variations. This indicates that the differences that occur as a result of the interactive effect accounted for 6.3% in the variation of the posttest score. In contrary to this finding, with a group of high school students, Pajares and Kranzler (1995) found significant positive direct paths from self-efficacy to Mathematics performance and a significant negative path to anxiety. Pajares and Kranzler found no gender effects for these students, either on self-efficacy or performance. But in line with this finding, a significant correlation between Mathematics self-efficacy and problem-solving performance was indicated in college students (Pajares & Miller, 1994, 1995). Pajares and Miller (1994) found a gender effect favoring the Mathematics self-efficacy of male undergraduates but found no gender effect on problem-solving performance. In a study of Mathematics self-efficacy in 8th-grade students, Pajares (1996a) found a direct effect of gender on self-efficacy for regular education students but no direct effect of gender on performance (boys had higher self-efficacy).

Hypothesis eight

It was revealed (table 4.7) that there was a significant main effect of treatment (Numerical Cognition, Emotional-freedom Based Intervention and Control group) on Mathematics achievement of secondary school students. It was revealed (table 4.7) that there was a significant difference in the mathematics achievement scores of participants in the groups (Numerical Cognition, Emotional-freedom Based Intervention and Control group). Therefore the null hypothesis is rejected. The table further reveals that the groups had large effect on the mathematics achievement posttest score variations, which implies that the differences in the groups accounted for 74.5% in the overall variation of the mathematics achievement of the students. This implies that the treatment were very effective in enhancing Mathematics achievement among the study participants.

However, Numerical Cognition intervention accounted for the increase in the mathematics achievement posttest score of the participants (mean = 22.00) while Emotional Freedom/Emotional-freedom based intervention accounted for much more increase in the mathematics achievement among the participants (mean=34.66). This implies that the Emotional-freedom-based intervention was more effective in boosting students' mathematics achievement score than numerical-cognition intervention.

Although there have been numerous theoretical and empirical articles about Numerical Cognition (Garcia, 1995; Garcia & Pintrich, 1991, 1994, 1995; Pintrich & Garcia, 1991; Schunk & Zimmerman, 1994; Zimmerman, 1994), few have explicitly linked the components of Numerical Cognition to academic achievement in Mathematically-gifted and non-gifted students.

Researchers agree on at least two major findings with respect to Numerical Cognition and academic achievement: Numerical Cognition is comprised of several components, such as cognitive strategies and effort (Miller, Behrens, Greene, & Newman, 1993) or metacognition and effort (Pintrich & De Groot; 1990; Yap, 1993), although the specific components were not always identical; and students who employ metacognition and exert effort perform more successfully (Pintrich & De Groot, 1990; Zimmerman, 1986; Zimmerman & Martinez-Pons, 1986, 1988).

A number of studies, in line with this finding, have clearly shown that students demonstrate high levels of Numerical Cognition when they are oriented toward learning goals (e.g., Meece, 1994; Schunk, 1994). Weiner (1986) found that children with low perceived ability were still mastery-oriented when their goal was to learn rather than to perform.

On account of significant differences that exists between Emotional Freedom and Mathematics achievement, the findings revealed that participants in this group showed better performance in Mathematics than their counterpart in Numerical Cognition group. In line with this finding, Daniel, Brenor, Karen and Loren (2005) explored test anxiety benefits of Wholistic Hybrid derived from Emotional Freedom Techniques (EFT), and Cognitive Behavioral Therapy. Participants include Canadian university students with severe or moderate test anxiety. A double-blind, controlled trial of EFT, and CBT was conducted. The result of their study showed that Emotional Freedom Technique was better than Cognitive Behavioural Technique.

Hypothesis nine

Findings on the above hypothesis revealed that there was significant main effect of Mathematics efficacy on Mathematics achievement of secondary school students. It was revealed (table 4.7) that Mathematics efficacy had large effect on the mathematics achievement posttest score variations, which implies that the differences in the level of mathematics efficacy accounted for 16.2% in the variation of the posttest score. self-efficacy beliefs help determine the outcomes one expects. Confident individuals anticipate successful outcomes. Students confident in their social skills anticipate successful social encounters. Those confident in their academic skills expect high marks on exams and expect the quality of their work to reap personal and professional benefits. The opposite is true of those who lack confidence. Students who doubt their social skills often envision rejection or ridicule even before they establish social contact. Those who lack confidence in their academic skills envision a low grade before they begin an examination or enroll in a course. In line with this finding, Pajares and Kranzler (1995) found significant positive direct paths from self-efficacy to Mathematics performance and a significant negative path to anxiety. Similarly, Pajares and Kranzler (1995) found significant positive direct paths from self-efficacy to Mathematics performance and a significant negative path to anxiety.

Hypothesis ten

Finding on the above hypothesis revealed no significant main effect of gender on Mathematics achievement of secondary school students. It was further revealed (table 4.7) that gender had very small effect on the mathematics achievement posttest score variations, which implies that gender accounted for 0.4% in the variation of the posttest score. This finding also supported the study of Lusser (1996) which found no significant difference between gender and Mathematics achievement. His study pointed to the fact no variation existed in the Mathematics performance of male and female participants.

Hypothesis eleven

Findings on the above hypothesis revealed a significant interactive effect of treatment and mathematics efficacy on Mathematics achievement of secondary school students. It was further revealed (table 4.7) that treatment and mathematics efficacy had small effect on the mathematics achievement posttest score variations, that is, mathematics efficacy slightly moderated the influence of treatment on mathematics posttest score variances. This indicates that the differences that occur as a result of the interactive effect accounted for 5.3% in the variation of the posttest score. This then implies that Mathematics efficacy is a significant and important factor that could enhance achievement in Mathematics. Self-efficacy beliefs provide the foundation for human motivation, well-being, and personal accomplishment. This is because unless people believe that their actions can produce the outcomes they desire, they have little incentive to act or to persevere in the face of difficulties. Much empirical evidence now supports Bandura's contention that self-efficacy beliefs touch virtually every aspect of people's lives—whether they think productively, self-debilitatingly, pessimistically or optimistically; how well they motivate themselves and persevere in the face of adversities; their vulnerability to stress and depression, and the life choices they make. This finding is in line with Pajares and Kranzler (1995) who found significant positive direct paths from self-efficacy to Mathematics performance. In a similar study, a significant correlation between Mathematics self-efficacy and problem-solving performance was indicated in college students (Pajares & Miller, 1994, 1995).

Hypothesis twelve

Findings on the above hypothesis revealed no significant interactive effect of treatment and gender on Mathematics achievement of secondary school students. This implies that gender did not significantly moderate the effect of treatment on mathematics achievement posttest score variations. This finding also supported the study of Lusser (1996) which found no significant difference between gender and Mathematics achievement. His study pointed to the fact no variation existed in the Mathematics performance of male and female participants. This finding has been supported by previous literatures. In a study of Mathematics self-efficacy in 8th-grade students, Pajares (1996a) found a direct effect of gender on self-efficacy for regular education students but no direct effect of gender on performance (boys had higher self-efficacy).

Hypothesis thirteen

Findings on the above hypothesis showed that there was no significant interactive effect of mathematics efficacy and gender on Mathematics achievement of secondary school students This implies that gender did not significantly moderate the influence of mathematics efficacy on mathematics achievement posttest score variations. One explanation that could be given to this is that, gender and Mathematics efficacy could not moderate the treatment when it comes to Mathematics achievement. The reason is that gender was a stumbling block when taken with Mathematics efficacy to moderate the treatment in enhancing Mathematics achievement. This finding is not in line with Murphy and Ross (1990) who found gender to be an influential factor in determining Mathematics success for eighth graders. The finding is not also in line with Fennema and Sherman (1977) who found that gender has a correlation with Mathematics performance.

Hypothesis fourteen

The hypothesis which stated that there will be no significant interactive effect of treatment, gender and Mathematics efficacy on Mathematics achievement of secondary school students was not significant. It was revealed (table 4.7) that there was no significant interactive effect of treatment, gender and mathematics efficacy on mathematics anxiety posttest scores of participants. Therefore the null hypothesis is accepted. This implies that gender and mathematics efficacy level could significantly moderate the influence of interventions on group post mathematics anxiety scores. The table further reveals that there is a significant main effect of group variances (Numerical cognition, Emotional-freedom Based and Control Group) on mathematics anxiety posttest scores, which implies that group variances had large effect on the differences that exist in their mathematics anxiety posttest scores.

The explanation to this finding is similar to hypothesis five, that gender was not a good match to moderate the treatment with Mathematics efficacy. This finding has supported previous literatures. In a study of Mathematics self-efficacy in 8th-grade students, Pajares (1996a) found a direct effect of gender on self-efficacy for regular education students but no direct effect of gender on performance (boys had higher self-efficacy). For gifted students, there was a direct effect of self-efficacy and gender on performance (girls had higher performance), but no gender effect on self-efficacy. Pysher (1996) also found no significant gender differences in Mathematics test scores, goals, or self-efficacy. Pintrich and De Groot (1990)'s findings with Mathematically-gifted students generally agree with these authors: A significant direct path was indicated both from self-efficacy to Mathematics performance and from self-efficacy to worry; and whereas no significant gender effects on performance were found, there was a significant effect on self-efficacy.

Similarly, with a group of high school students, Pajares and Kranzler (1995) found significant positive direct paths from self-efficacy to Mathematics performance and a significant negative path to anxiety. Pajares and Kranzler found no gender effects for these students, either on self-efficacy or performance. A significant correlation between Mathematics self-efficacy and problem-solving performance was indicated in college students (Pajares & Miller, 1994, 1995).

5.2 Limitations of the study

The study, in its unique contribution to knowledge, has used two therapeutic techniques in reducing Mathematics anxiety and enhancing Mathematics achievement of the students. However, the study encountered a lot of limitations in the course of the study. A limited number of students (120) may not be enough to make generalizations on the population of the study. This limited number of participants was used due to administrative, logistics, time and financial constraints to achieve the objectives of the study; a greater number could have achieved a better result. Another similar limitation observed was that the study was carried out in Ibadan metropolis, this may also affect the generalization of the findings.

The researcher has used gender and Mathematics efficacy as the moderating variables in the study. Although, Mathematics efficacy had significant interactive effect with the two therapeutic techniques; but this interactive effect was not significant when it comes to 3-way interaction with gender. This is because gender was having negative effect on academic efficacy and no significant effect on Mathematics anxiety and achievement, thus limiting the findings of this study.

This research work was limited because it was carried out on public secondary school students in urban areas in Ibadan metropolis. So the study could not establish a comparative analysis between public and private schools, and between urban and rural secondary schools within the setting of the study. Whereas, the initial observation that the researcher made was that background of the study students could affect their academic performance. So, students from private school have solid background than public secondary schools. This could have made this research work a robust one if the research had also examined the students from private schools.

Moreso, one important limitation observed in the course of this study was paucity of literatures. The research could not get enough literature to back his findings on numerical cognition and emotional freedom in relation to the Mathematics anxiety and Mathematics achievement.

5.3 Implications of the study

The importance of Mathematics on the social, economic, political and educational life of Nigerians cannot be over emphasized with changing time and advancement in science and technology. Mathematics phobia if not curbed and overcome will become more sophisticated and eventually be accepted as a normal way of life among Nigerian students. Therefore, this study demands for an intensive experimental study to find ways on how this phobia could be reduced among the students. Towards this end, counselors and all other helping professionals must be alert and sensitive to effective techniques like those used on this study to help this emotional problem related to Mathematics. The implication of this is that all concerned: teachers, parents, counselling psychologists, school administrators, government etc should embark on intensive studies to identify the different types of Mathematics related problems and find solution to such.

It is also of importance to make a clear distinction between cognitive and emotional distortions resulting in Mathematics failure, which is limiting our students to offer courses related to Mathematics like Statistics in the future. That is why some students in Education and Social Sciences continue to run away from Statistics till today. The factors underlying these behaviours will not be the same in all students, and thus, interventions will be needed towards solving anxiety in Mathematics

The present study has proved that numerical cognition and emotional freedom techniques were very effective in reducing Mathematics anxiety and enhancing Mathematics achievement among the study participants. The study has exposed the participants to how to reduce their false belief in Mathematics disability caused by lack of, inconsistent, poor, or inappropriate systematic Mathematics instruction; inattention, fear, anxiety, or emotion thereby improving their academic self-efficacy to achieve in the subject. It is believed that these two techniques will help the students to have positive thought about Mathematics and learn how to adjust their negative thought and believe in their ability to excel in the subject. Students will know how to plan, control and direct their mental processes toward the achievement of Mathematics in other areas they find themselves. They will understand how to control the time and effort to be used on tasks, and how to create and structure favourable learning environments, such as finding a suitable place to study, and seeking help from teachers and classmates when they have difficulties in the subject.

5.4 Conclusion

Identifying and designing effective intervention strategies and practical ways to solve anxiety in Mathematics and enhance Mathematics achievement taking cognizance of efficacy in the subject has been suggested as an important and viable avenue of future research. This study, therefore, sought to investigate the effectiveness of two strategic techniques (Numerical Cognition and Emotional Freedom) in reducing Mathematics anxiety and enhancing Mathematics achievement of participants in Ibadan, Oyo State with moderating effect of Mathematics efficacy. Findings of this study has clearly shown that numerical cognition and emotional freedom have significant effect in reducing anxiety and enhancing achievement in the subject. The two treatments were superior to control group; and emotional freedom technique was superior to numerical cognition in reducing anxiety and enhancing achievement in Mathematics. The results clearly showed that Mathematics efficacy of adolescents moderated the relationship between the two treatments in their effect on anxiety and achievement in Mathematics. It could be averred that low Mathematics efficacy could increase anxiety in the subject and decrease their performance in the subject. Students with higher levels of Mathematics efficacy set higher goals, apply more effort, persist longer in the face of difficulty in the subject and are more likely to cope better.

It was observed from this study that Mathematics anxiety was an emotional, rather than intellectual problem because the problem emanates from inconsistent emotion and therefore interferes with a person's ability to learn Mathematics which later results in an intellectual problem. Therefore, competent functioning in Mathematics requires self-beliefs of efficacy to perform effectively.

5.5 Recommendations

Based on the findings of this study, the following recommendations were made:

1. The treatment strategies reviewed in this study are recommended for use by educational psychologists, guidance counsellors, teachers and principals of

secondary schools. The strategies will provide these personnel with requisite educational diagnosis aimed at improving the educational system in Nigeria.

2. The study is recommended for policy makers in education to serve as an input on educational issues relating to the improvement of learning.

3. The study has revealed that Mathematics is not only an intellectual problem but emanating from emotional problems. Rather than concentrate only on cognitive distortions in the subject, the researchers recommended that these techniques could resolve emotional crisis in Mathematics and improve the students' performance in the subject.

4. There is the need to re-orientate teachers with contents of the training packages to enable them impart same to their students on a regular basis. This would make students help themselves.

5. The training packages can be used by counsellors in schools to give students a new orientation to enhance positive thinking pattern and a new belief in their capability.

6. Counselling psychologists and teachers should help students in building their efficacy in Mathematics because Mathematics efficacy has found to moderate the techniques used to solve Mathematics anxiety.

5.6 Contribution to Knowledge

The study has added to the existing scanty literature on the effect of Numerical Cognition and Emotional Freedom on Mathematics anxiety and achievement. This study is novel in Nigeria and Africa in general because to the best of the researcher's knowledge, nothing of such has been done here in Nigeria. This makes the study very peculiar and a contribution to knowledge. So, this study has served as frontier of knowledge in reducing anxiety and enhancing achievement in Mathematics through these two techniques.

One major achievement of this study is that it has been able to demonstrate that students' anxiety and achievement in Mathematics as the core and significant subject when it comes to academic success can be improved upon. To this extent, the research has focused on low-achieving students in Mathematics by working on the need to improve their performance. Students with dyscalculia could be assisted using these two techniques in Nigeria and Africa.

The study is also unique in terms of the treatment strategies employed. The therapeutic techniques – Numerical Cognition and Emotional Freedom (to the best of the researcher's knowledge) - have not been used in Nigeria for the same purpose for which they have been used in this study. The treatment techniques have been effective in improving Mathematics anxiety and achievement of students with pseudo-dyscalculia. This makes the study peculiar and thus contributing significantly to knowledge. The study will most likely enable learners 'look inward' as well as make them come up with an academic plan for action to make them not to be locked up again in the old habit.

5.7 Suggestions for further studies

This study is recommended for replication because of the following reasons:

A limited number of students (120) were used for this study. It will be quite revealing if interventions established could actually reveal vivid information on findings relationship between anxiety in mathematics and factors that cause. So, survey studies could be carried out so as to further widen researchers' perspectives and increase the numbers of participants in order to solve the problem.

The study was carried out in Ibadan metropolis, which may affect the generalization of the findings. So similar researches could be expanded throughout Nigeria.

The researcher has used gender and Mathematics efficacy as the moderating variables in the study. Although, Mathematics efficacy had significant interactive effect with the two therapeutic techniques; but this interactive effect was not significant when it comes to 3-way interaction with gender. Therefore, other researchers may look for other moderating variables apart from gender to complement Mathematics efficacy in solving the problem.

This research work carried out on public secondary school students in urban areas in Ibadan metropolis. So the study could not establish a comparative analysis between public and private schools, and between urban and rural secondary schools within the setting of the study. So, other researchers may expand their purpose by looking for comparative studies between urban and rural students, private and public schools. This will help to see how background of the students affect their anxiety in Mathematics and other related subjects.

The research could not get enough literature to back his findings on numerical cognition and emotional freedom in relation to the Mathematics anxiety and Mathematics achievement. So other researches should look for extensive literature to back their findings.

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UNIVERSITY OF IBADAN
FACULTY OF EDUCATION
DEPARTMENT OF GUIDANCE AND COUNSELLING

Dear Respondent,

This questionnaire is designed basically for a research purpose. It seeks to know how you would react to these statements. All information provided would be treated confidentially. Please be honest as much as possible.

SECTION A
Background Information.

INSTRUCTION: Below are some statements that relate to you. Put a tick on the statement that relate to you.

1) Age: ……………………...
2) Gender: Male ( ) Female ( )
3) Religion: Christian ( ) Muslim ( ) Others (specify)…………………..
4) Class in school……………

SECTION B
PSEUDO-DYSCALCULIA SCALE

Kindly respond by marking the response as it occurs to you using the format below:
Strongly Agree = SA, Agree = A, Disagree = D and Strongly Disagree = SD

No	ITEMS	SA	A	U	D	SD
1.	I find Mathematics interesting.					
2.	Mind goes blank and I am unable to think clearly when doing my Mathematics test.					
3.	I worry about my ability to solve Mathematics problems.					
4.	I become physically agitated when I have to go to Mathematics class.					
5.	I am always worried about being called on in Mathematics class.					
6.	Mathematics makes me feel confused					
7.	I find Mathematics challenging					

8.	I enjoy learning with Mathematics					
9.	I would like to take more Mathematics classes					
10.	It's clear to me in Mathematics class, but when I go home it's like I was never there.					
11.	Mathematics makes me feel nervous					
12.	I worry about my ability to solve Mathematics problem					
13.	I worry that I will get poor marks in mathematics					
14.	I tend to lose my concentration in Mathematics class.					
15.	I don't know how to study for Mathematics tests.					
16.	I am always worried about being called on in Mathematics class.					
17.	I'm afraid I won't be able to keep up with the rest of the class					
18	I often worry that it will be difficult for me in Mathematics classes.					

SECTION C

MATHEMATICS EFFICACY SCALE

Kindly respond by marking the response as it occurs to you using the format below:
Strongly Agree = SA, Agree = A, Disagree = D and Strongly Disagree = SD

No	ITEMS	SA	A	U	D	SD
1.	When Mathematics exercises are hard I don't give up or study only the easy parts.					
2.	I work on Mathematics exercises even when I don't have to do so.					
3.	I work hard to earn a good grade in Mathematics even when I do not like the subject.					
4.	I can plan my Mathematics school work.					
5.	I finish Mathematics assignments by deadlines.					
6.	I can study Mathematics when there are other interesting things to do.					

7.	I can organize my school work.					
8.	I would feel confident to solve Mathematics problems.					
9.	I can boldly discuss Mathematics problem with teacher					
10.	I can willingly come out of the class to express myself on Mathematics matters					
11.	I am confident enough to talk on Mathematics issue					
12.	I think I can still compete with my mates on Mathematics					
13.	If I am called many times, I will be willing to solve Mathematics problems even if I did not get the right answer.					
14.	Even though I had Mathematics problem, I am not ready to submit to fate					
15.	I won't be part of the students who always say Mathematics is difficult					

SECTION D

MATHEMATICS ANXIETY SCALE

Kindly respond by marking the response as it occurs to you using the format below:
Strongly Agree = SA, Agree = A, Disagree = D and Strongly Disagree = SD

No	ITEMS	SA	A	U	D	SD
1.	I cannot explain what actually accounts for my difficulty in Mathematics					
2.	I don't believe in my ability to do well in Mathematics					
3.	I only try to manage myself with somebody who knows better in class to pass Mathematics					
4.	I hate to see Mathematics teacher in my class.					
5.	I don't know how to follow Mathematics syllabus					
6.	I lose concentration in Mathematics class					
7.	I don't know how to focus on Mathematics problems					
8.	I am always overwhelmed with fear when asked to solve					

	Mathematics					
9.	I feel jittery in Mathematics tests or exams.					
10.	My mind is not compatible with anything called Mathematics					
11.	I feel emotionally down when it comes to solving of Mathematical problems					
12.	I avoid Mathematics and any other subject related to it					
13.	I always feel like skipping Mathematics classes.					
14.	I don't know how to follow laid down rules in Mathematics					
15.	I don't usually understand Mathematics instruction					
16.	I am not capable of solving Mathematics					
17.	I feel inferior finding myself among students who understand Mathematics better than me.					
18.	I feel inferior with other subjects related to Mathematics.					

SECTION E
MATHEMATICS ACHIEVEMENT SCALE

1. Simplify 10^2 X 10^3
   (a) 20^2
   (b) 100^5
   (c) 10^5
   (d) 10^2
   (e) 10^3

2. Simplify $22n^7$ / $2n^3$
   (a) $11n^4$
   (b) $24n^4$
   (c) $11n^4$
   (d) $11n^{10}$
   (e) $24n^{10}$
3. Simplify 19^0

(a) 19
(b) 0
(c) 1
(d) 9
(e) 19^0

4. Solve 5^{-2}
   (a) 10
   (b) -10
   (c) 1/25
   (d) 10^2
   (e) 25

5. Solve 2^3 X $(1/6)^{-1}$
   (a) 48
   (b) 2^2
   (c) 12^{3-1}
   (d) $8^{1/6}$
   (e) 8^2

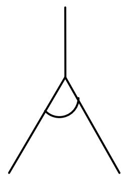
6. r X r^0 X r^{-5}
   (a) $1/r^4$
   (b) $1/r^5$
   (c) r^4
   (d) r^5
   (e) $1/r^{-4}$

7. Approximate 0.0567 to 2 decimal places
   (a) 0.05
   (b) 0.057
   (c) 0.06
   (d) 0.5
   (e) 0.0567

8. Find the difference between LCM and HCF of 18 and 30
   (a) 84
   (b) 90
   (c) 6
   (d) 80
   (e) 18

9. Find he sum o 1101_2 and 111_2
   (a) 1100_2
   (b) 10000_2
   (c) 10010_2
   (d) 10100_2
   (e) 10110_2

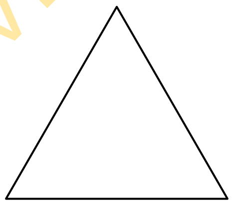
10. Find the value of angle x



   (a) 205^0
   (b) 195^0
   (c) 175^0
   (d) 172^0
   (e) 160^0

11. Find the simple interest on N36,000 for 2 years
   (a) 3% per annum
   (b) N7200
   (c) N216
   (d) N3600
   (e) N2160

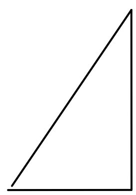
12. Determine angle m



   (a) 65^0
   (b) 130^0
   (c) 50^0

(d) 25^0
(e) 30^0

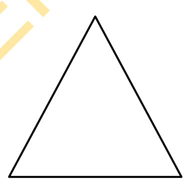
13. Solve the simultaneous equations: 5x – 2y = 14; 2x + 2y = 14
    (a) x = 4, y = 3
    (b) x = 3, y = 6
    (c) x = 2, y = 5
    (d) x = 4, y = 6
    (e) x = 4, y = 28
14. Using the diagram below, find the value of Sin θ



    (a) 5/2
    (b) 5/13
    (c) 12/13
    (d) 13/12
    (e) 12/5

15. A triangle in which only two angles are equal is said to be ____________
    (a) Equilateral
    (b) Equiangular
    (c) Isosceles
    (d) Scalene
    (e) Right-angled

16. Calculate the area of the shape



    (a) $28m^2$
    (b) $15m^2$
    (c) $35m^2$
    (d) $21m^2$
    (e) $10m^2$

17. Convert 37_{ten} to binary number
   (a) 101001_2
   (b) 101100_2
   (c) 100110_2
   (d) 100101_2
   (e) 10011_2

18. Ade, Bola and Jide share N400 in the ratio 4:7:9 respectively. How much did Bola receive?
   (a) N200
   (b) N180
   (c) N140
   (d) N120
   (e) N80

19. What is the square root of 144
   (a) 15
   (b) 14
   (c) 10
   (d) 11
   (e) 12

20. Solve 4x – 30 = 2x + 52
   (a) 38
   (b) 41
   (c) 39
   (d) 42
   (e) 49

21. Express 2.0495 correct to 4 significant figure.
   (a) 2.102
   (b) 2.045
   (c) 2.050
   (d) 2.06
   (e) 2.10

22. What is the one-twentieth of N10,000?
   (a) N1,000
   (b) N5,000

(c) N500
(d) N100
(e) N1,500

23. Calculate the circumference of a circle of diameter14m (take $\pi = 22/7$)
(a) $22cm^2$
(b) $44cm^2$
(c) $140cm^2$
(d) $154cm^2$
(e) $20cm^2$

24. Which of these marked angles are alternate angles?

(a) s and m
(b) r and s
(c) b and m
(d) b and p
(e) b, r and s

25. What is the mean score of the following 21, 40, 32
(a) 33
(b) 31
(c) 93
(d) 61
(e) 3

26. The sum of ages of two persons is 98, and the difference of their ages is 16. How old is each person?
(a) 41, 57
(b) 32, 66
(c) 42, 56
(d) 28, 70
(e) 45, 56

27. Fig. 1 is a pie chart showing the distribution of types of secondary schools in a country

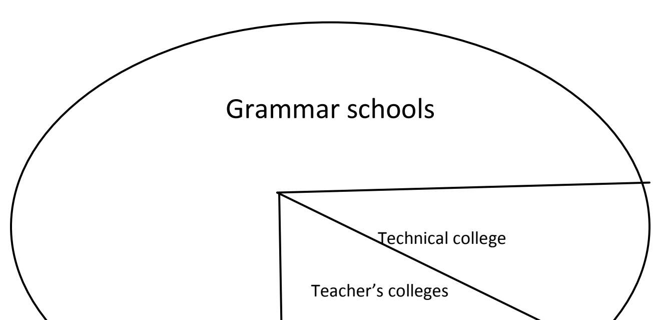


Fig. 1

What is the ratio of Teachers' Colleges to Grammar Schools?
(a) 1:5
(b) 1:6
(c) 3:8
(d) 2:9
(e) 3:10

28. Table 1 shows the shoe sizes of 20 children

Shoe size	36	37	38	39	40
Number of children	1	3	8	5	3

Table 1

Which size is the mode?
(a) 36
(b) 37
(c) 38
(d) 39
(e) 40

29. In table 1, which is the median shoe size?
(a) 36
(b) 37
(c) 38
(d) 39
(e) 40

30. The average speed, in km/h, of a car which travels 72 km in 45 mins is
    (a) 45
    (b) 54
    (c) 64
    (d) 88
    (e) 96

31. The height of a closed cylinder is equal to its radius r. Express the total surface area of the cylinder in terms of π and r.
    (a) Πr^2
    (b) $2 \Pi r^2$
    (c) $3 \Pi r^2$
    (d) $4 \Pi r^2$
    (e) $6 \Pi r^2$

32. A conical cup of base radius r and height h is filled with sand. How many cups of sand will be needed to fill a cylindrical container of base radius r and height 2h?
    (a) 2
    (b) 3
    (c) 4
    (d) 6
    (e) 9

33. A cone and a cylinder have equal heights and volumes, r is the radius of the cylinder. What the radius of the cone in terms of r?
    (a) $r \sqrt{3}$
    (b) 3r
    (c) r
    (d) 1/3r
    (e) $1/\sqrt{3}$

34. XYZ is a straight line such that XY = YZ = 3cm. A point P moves in the place of XYZ so that $PY \leq XY$. Which of the following describes the locus of P?
    (a) Line through X perpendicular to XZ
    (b) Line through Y perpendicular to XZ
    (c) Line through Z perpendicular to XZ
    (d) Circular disc, centre Y, radius 3cm
    (e) Circular disc, centre X, radius 3cm

35. If $0 \leq \theta \leq 180^0$ and $\sin \theta = 0.225$, then $\theta =$
(a) 13^0 only
(b) 13^0 or 167^0
(c) 77^0 only
(d) 77^0 or 103^0
(e) 103^0

36. The slant height of a cone is twice its base radius r. express the total surface area of the cone in terms of π and r
(a) $2/3\pi\ r^2$
(b) $\pi\ r^2$
(c) $1\ 1/3\ \pi\ r^2$
(d) $2\pi\ r^2$
(e) $3\pi\ r^2$

37. A circle, centre 0, radius 5cm is drawn on a sheet of paper. A point P moves on the paper so that it is always 2cm from the circle. The locus of P is
(a) A circle, centre 0, radius 3cm
(b) Two circles, centre 0, radius 6cm
(c) Two circles, centre 0, radii 3cm and 7cm
(d) Two circles, centre 0, radii 4cm and 6cm
(e) A circle, centre 0, radius 3.5cm

38. Express 468^0 as an angle between 0 and 360^0
(a) 72^0
(b) 108^0
(c) 234^0
(d) 252^0
(e) 288^0

39. If A = {3, 5, 6, 8, 9} and B = {2, 3, 4, 5} write down the sets A ∪ B and A∩ B. show A and b on a Venn diagram
(a) A ∪ B = {2, 3, 4, 5, 6, 8, 9}, A∩ B = {3, 5}
(b) A ∪ B = {2, 4, 5, 6, 8, 9}, A∩ B = {3, 5, 6}
(c) A ∪ B = {2, 3, 4, 8, 9}, A∩ B = {3, 5}
(d) A ∪ B = {2, 3, 4, 5, 6,}, A∩ B = {3, 5}
(e) A ∪ B = {2, 3, 4, 5, 6, 9}, A∩ B = {3, 5}

40. If C = {grapefruit, orange, pear} and D = {grapefruit, pear, apple, pawpaw} write the sets $C \cup D$ and $C \cap D$
   (a) $C \cup D$ {grapefruit, orange, pear, apple, pawpaw}, $C \cap D$ = {grapefruit, pear}
   (b) $C \cup D$ { orange, pear, apple, pawpaw}, $C \cap D$ = {grapefruit, pear}
   (c) $C \cup D$ {grapefruit, pear, apple, pawpaw}, $C \cap D$ = {grapefruit, pear}
   (d) $C \cup D$ {grapefruit, orange, pear, pawpaw}, $C \cap D$ = {grapefruit, pear}
   (e) $C \cup D$ {grapefruit, orange, pear, apple}, $C \cap D$ = {grapefruit, pear}

41. Evaluate $2a^2bc/2b - c$ when a = 3, b = - 4, c = - 5
   (a) -120
   (b) 120
   (c) -110
   (d) 110
   (e) -122

42. In a class of p students, the average mark is x and in another class of n students the average mark is y. what is the average mark for both classes?
   (a) Px + ny / p + n
   (b) Px + ny / pn
   (c) Px + ny / p – n
   (d) Px + py / p + n
   (e) nx + py / p + n

43. A car travels d km at an average speed of u km/h. How long does it take?
   (a) d/u hr
   (b) u/d hr
   (c) u hr
   (d) d hr
   (e) d/du hr

44. Solve 4 – 4x = 9 – 12x
   (a) x = 8/5
   (b) x = 5/8
   (c) x = 5
   (d) x = 8
   (e) x = 2

45. Solve 3(4c – 7) – 4(4c – 1) = 0

(a) -4 ¼
(b) -2 ½
(c) -4 ½
(d) 4 ¼
(e) 2 ¼

46. Solve the equation 3x + 2 / 6 – 2x – 7 / 9 = 0

(a) x – 4
(b) x = - 4
(c) x = 4
(d) x = -4x
(e) x = 4x

47. If 3 is a root of the equation x^2 – kx +42 = 0, find the value of k and the other root of the equation.

(a) K = 17
(b) K = 16
(c) K = 7
(d) K = 12
(e) K = -17

48. If 5 is one of the roots of the quadratic equation x^2 + 4x – 45 = 0, what is the other root?

(a) x = -9
(b) x = 9
(c) x = -3
(d) x = 3
(e) x = -9x

49. A ladder 20m long rests against a vertical wall so that the foot of the ladder is 9m from the wall. Find, correct to the nearest degree, the angel that the ladder makes with the wall

(a) 27^0
(b) 32^0
(c) 24^0
(d) 28^0
(e) 30^0

50. A point T is on the same horizontal level as the foot of a tower. If the distance of T from the foot of the tower is 80m and the height of the tower is 60m, find the angle of depression of T from the top of the tower. Give your answer to the nearest degree

(a) 37^0
(b) 45^0
(c) 36^0
(d) 40^0
(e) 32^0