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Differences Among Non -Handicapped Students, Students With Mathematics Learning Disabilities, And Students With Mild Mental Retardation, In Elementary School In The Cognitive Components For The Addition Operation

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3.Melissa Nail, Fawzi Al-Doukhi, Ammar Al-Ajmi, & Fahad Al-Shammari, 2006, "*Exploring the Impact of Interactive PowerPoint Presentations on Time-On-Task Behaviours' of Fifth Grade Students,* World conference on educational multimedia, hypermedia & telecommunications.

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DIFFERENCES AMONG NON-HANDICAPPED STUDENTS, STUDENTS WITH MATHEMATICS LEARNING DISABILITIES, AND STUDENTS WITH MILD MENTAL RETARDATION, IN ELEMENTARY SCHOOL IN THE COGNITIVE COMPONENTS FOR THE ADDITION OPERATION

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by

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CERTIFICATE OF APPROVAL

DOCTORAL DISSERTATION

This is to certify that the Doctoral Dissertation of

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ABSTRACT

This study is aimed at specifying the cognitive components for addition operations (encoding, speed of executing the operation, operation selection, and strategy choice) to determine if they are responsible for the difficulties that students with learning disabilities and mild mental retardation face in the elementary school in solving simple addition problems.

The researcher selected 240 male and female pupils as a random sample from third and fifth grades from the state schools in the State of Kuwait. The sample was selected based on the characteristics of gender, type of handicap, and grade.
The study employed two measurements. First, the addition operations pre-skills test. Second, the cognitive components for the addition operation test. To investigate the study hypotheses the following statistical tests were used: MANOVA and ANOVA tests followed by post hoc comparisons using Tukey's HSD, chi-square for independent samples, independent samples t-test and multiple regression.

The study results pointed out that three of the cognitive components for addition operations which are encoding, speed of executing the operation and strategy choice were responsible for the difficulties that learning disabilities and mild mental retardation students face it when solving simple addition problems in the elementary school.

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INTRODUCTION

Statement of the Problem

Math curriculum in the elementary school is based on many basic skills. Problem solving is one of the most important, if not the most, of these basic skills. Problem solving usually involves the four operations: addition, subtraction, multiplication and division. Mathematically, multiplication, subtraction and division operations are all conceptually based on the addition operation. In other words, subtraction is an opposite operation to addition. Multiplication is a sort of repeated addition and related to it is division which is the opposite of multiplication (which is a repeated addition, as has been mentioned). Thus, the three operations: multiplication, subtraction and division are based on addition. Consequently, a poor understanding of addition or a failure in solving addition problems may well lead to failure in solving the other three mathematical operations. Based on that, most of the problems that elementary students have with mathematical problems are due to the difficulties they face in addition operations.

Automatic production of the basic arithmetic facts (i.e., adding or subtracting two single-digit numbers) has assumed an important position in arithmetic teaching. In the past, proficiency of computation was considered fundamental to further arithmetic study (Ashlock & Washbon, 1978; Riptoes, 1995; Suydam & Dessart, 1976).

At present, it is generally accepted that even if students are not automatic with basic facts, they should be engaged in activities that promote the development of number sense and mathematical reasoning (Gersten & Chard, 1999). Still, much time and energy are spent in classrooms trying to attain basic arithmetic facts. The argument guiding such efforts is that automatic production is useful both in and out of the classroom (Isaacs & Carroll, 1999). Typically, students are taught how to become automatic either through the provision of drill and practice or through the direct teaching of a strategy (Tournaki, 2003). Kirby and Becker (1988) assumed that simple addition operations go on in the student's mind according to certain procedures that start with number encoding, and then selecting the operation type; these are followed by the operation execution, and last getting the result. These procedures are called cognitive components for the addition operation.

In their studies, Geary and Widaman (1987), and Kirby and Becker (1988) mention that studying the cognitive components in the student's mind, when giving a simple addition problem, may lead to identification of the basic elements for addition that perhaps are behind the difficulties that students face in solving simple addition problems. These cognitive components involve the following four elements:

1. Encoding: this refers to the student's ability to read the number and understanding its meaning.
2. Speed of executing the operations: this refers to the time used, starting at the beginning of doing the problem and ending with getting the result.

3. Operation selection: This refers to the ability of selecting the type of mathematical operation (whether addition, subtraction, multiplication, or division) on which the student depends in his or her solving of the problems (i.e. the student's ability to relate the mathematical sign he or she sees to its concept.)
4. Choosing the solving strategy: In their solving of the mathematical problems, students use either recall from their long term memory (automatic production) or use one of the counting strategies (which will all involve the student's use of his fingers or other manipulation.) These strategies are:
   - 4-1. Simple counting strategy, in which both additions are sequentially enumerated, and the answer is the resultant end tally. Thus, for each unit in the sum, an internal counter has been incremented one unit; for instance, in 3 + 5 =__, the student starts from 1 and goes up 8 units one by one.
   - 4-2. Addition of one number to the other strategy, in which the student starts with the cardinal value of the first addition and "counts on" the number of units specified by the second. For instance, in 3 + 5 =__, the student starts from 3 and adds 5 more units, or the student starts with the cardinal value of the second addition and "counts on" the number of units specified by the first. For instance, in 3 + 5 =__, the student starts from 5 and adds 3 more units.
   - 4-3. Addition to the smaller number strategy, in which the student selects the smaller addition and counts on from that cardinal value the

number of units specified by the larger addition. For instance, in 3 + 5 =__, the student starts from 3 and adds 5 more units.

4-4. Addition to the larger number strategy, in which the student selects the larger addition and counts on from that cardinal value the number units specified by the smaller addition. For instance, in 3 + 5 = __, the student starts from 5 and adds 3 more units.

Purpose of the Study

This study is aimed at specifying the cognitive components for addition operations (encoding, speed of executing the operation, operation selection, and strategy choice) to determine if they are responsible for the difficulties that students with learning disabilities and mild mental retardation face in the elementary school in solving simple addition problems.

Research Questions

To achieve this purpose, the study answers the following questions:

1. Which of the cognitive component elements for addition operations (i.e. encoding, speed of executing the operation, operation selection and strategy choice) may be responsible for the difficulties that students with learning disabilities and mild mental retardation face in the elementary school in solving simple addition problems?
2. Do the strategies that non-handicapped students, in elementary school, use to solve simple addition problems differ from those used by the students with learning disabilities and those with mild mental retardation?

3. Based on students' performance in a test for cognitive components for simple addition operations, can a mathematical equation that may predict students with learning disabilities and mild mental retardation in the elementary school be made?

Hypotheses

To answer these questions, the researcher depended on counting the time that the students use in their responses in each of the cognitive components for simple addition problems, then investigations of the following hypotheses made.

1. There are statistically significant differences in the response time for each of the cognitive component elements for the simple addition operation between:
   - 1-1. The boy and girl students in third and fifth grades who are non-handicapped students, and the students with learning disabilities.
   - 1-2. The boy and girl students in third and fifth grades who are non-handicapped students, and those with mild mental retardation.
   - 1-3. The boy and girl students in third and fifth grades who are learning disabilities students and those with mild mental retardation.
2. There are statistically significant differences between the strategies that the non-handicapped students use for solving addition problems and:
   - 2-1. Those used by the learning disabilities students.
   - 2-2. Those used by the students with mental retardation.
3. Based on the students' performance in a test for cognitive components for simple addition operations -the encoding, speed of executing the operations, operation selection and choosing the solving strategy:

3-1. Can predict students with learning disabilities in the elementary school.

3-2. Can predict students with mild mental retardation in the elementary school.

Significance of the Study

The Ministry of Education in Kuwait began to integrate students with learning disabilities and mild mental retardation with non-handicapped students in general education classes. These students demonstrated major difficulties in solving mathematical addition operation problems in general education classes because their abilities are limited. These difficulties became a root cause for these students' difficulties in all other mathematics operations and mathematics in general. This study is very important for three reasons. First, mathematically, multiplication, subtraction and division operations are all conceptually based on the addition operation. If the study determines the components that lead students to have difficulties in solving the addition operation, then it will be easy to treat and that should mitigate the difficulties in other mathematical operations and mathematics in general. Second, by identifying significant cognitive components, the results of this study will guide educators in the special education field as they re-evaluate the mathematics curriculum and integrate new strategies to help students master mathematics operation. Finally, there are no such studies done in this field in Kuwait, so this study will provide a foundation for future studies in the field.

Definitions of Terms

The following definitions are provided to facilitate a better understanding of the terms used in the study.

Learning Disabilities: The National Joint Committee on Learning Disabilities (1989) defines learning disabilities as:

> a generic term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual, presumed to be due to central nervous system dysfunction, and may occur across the life span. Problems in self-regulatory behaviors, social perception, and social interaction may exist with learning disabilities but do not by themselves constitute a learning disability. Although a learning disability may occur concomitantly with other handicapping conditions (for example, sensory impairment, mental retardation, serious emotional disturbance) or with extrinsic factors (such as cultural differences, insufficient or inappropriate instruction), they are not the result of those conditions or influences. (Kavanagh & Truss, 1988, p. 57)

Mental Retardation: The American Association on Mental Retardation (2002) defines mental retardation in their website as:

> A disability characterized by significant limitations both in intellectual functioning and in adaptive behaviour as expressed in conceptual, social, and practical adaptive skills. This disability originates before age 18.
>
> There are five assumptions essential to the application of the definition:
>
> 1. Limitations in present functioning must be considered within the context of community environments typical of the individual's age peers and culture.

2. Valid assessment considers cultural and linguistic diversity as well as differences in communication, sensory, motor, and behavioural factors.
3. Within an individual, limitations often coexist with strengths.
4. An important purpose of describing limitations is to develop a profile of needed supports.
5. With appropriate personalized supports over a sustained period, the life functioning of the person with mental retardation generally will improve.

Student with mild mental retardation: Is a student who is mentally retarded and whose IQ is between 55-70.

Cognitive components for simple addition operation: The cognitive components for simple addition operation involve the following four elements:

1. *Encoding:* The student's ability to read a number and understand its meaning.
2. *Speed of executing the operations:* The time used starting at the beginning of doing the problem and ending with getting the result.
3. *Operation selection:* The ability to select the type of mathematical operation (whether addition, subtraction, multiplication, or division) on which student depends in his/her solving of the problem. In other words, the student's ability to relate the mathematical sign he/she sees to its concept.
4. *Choosing the solving strategy:* In their solving of the mathematical problems, students use either recalling from their long term memory or use one of the counting strategies.

De-limitations of the Study

The study used male and female non-handicapped students and students with mathematics learning disabilities aged 6-12 years old, and students with mild mental retardation aged 8-15, the difference in ages between the groups relates to the Ministry of Education rules. The rules state that non-handicapped students and students with learning disabilities can attend elementary school if their ages are 6 or greater, but students with mild mental retardation can attend elementary school if their ages are 8 or greater. All the groups of students participating in the study were selected from regular classes in the third and fifth grades in the elementary schools in the State of Kuwait.

Chapter 2

REVIEW OF RELATED LITERATURE

Introduction

Calculation is a branch of mathematics that deals with numbers and symbols. Yet, calculation is less abstract than mathematics as it represents a language form that conveys concepts through symbols. These concepts include: quantity, size, order, relationships, forms, distance and time.

Piaget, as cited in Kaplan, Yamamoto and Ginsburg (1989), believed that children form their knowledge of calculation through observations and reactions with the environments around them. Through the daily reaction of the child with the environment, he or she forms the basic calculation concepts and this represents the base for the official learning at school where the child deals with specific curriculum for mathematical concepts. The mathematic concepts include: the place value of the number and the basic concepts for calculation such as addition, subtraction, multiplication and division.

Addition is one of the basic skills in calculation upon which other calculation operations are based. Many pupils are struggling with this skill (i.e., calculation) especially those with special needs like pupils with mental retardation or pupils with learning disabilities. Failing in calculation is described as having an inability to reach a certain level of knowledge and skill in solving problems (Schoenfeld, 1989).

Pressley (1986) believes that pupils who face difficulties in calculation learning at elementary school are facing difficulties in dealing with the environment right around them. For example, they have difficulties in focusing on one stimulant in the environment around them and ignoring the others. These difficulties hinder the development of their abstractive thinking. For these pupils, making benefit of new situations is very limited (Sutaria, 1985).

Performance in simple addition problems may offer very valuable information about the factors that lead to difficulties in solving calculation problems. This can be represented in two aspects: the first aspect is "Strategy Development." Pupils may use various strategies, such as counting or recalling facts from long term memory in solving calculation problems. However, comparison between pupils who have problems in calculations and those who do not, may present information about the types of strategies used by individuals in each of the two groups.

The second aspect is "Information Process Speed." Time spent on solving problems can be a proof for the existence or non-existence of calculation problems that pupils face (Siegler & Jenkins, 1989). Information processing as a method to study human abilities may offer a more subtle explanation for the factors that participate in calculation learning difficulties (Ashcraft, 1990).

Mental Retardation

Mental retardation is a condition that has different aspects and dimensions. This variety of aspects and dimensions led to the fact that different scholars address mental retardation differently and come out with various definitions for mental retardation. These definitions are based on intelligence (IQ), social adaptation, learning ability, and medical diagnosis. Diagnosing pupils with mental retardation can be based on one or more of these aspects (Jameel, 2002).

In addition to the variety of definitions and concepts, specialists in the field face the problem of perception of one term or idiom in one language having too many different meanings in another (Mursee, 2001). For example an English speaking specialist in the field of learning disabilities may use a term in English that can be perceived in many different meanings by Arab specialists. For example, the term "Learning disabilities" and the term "Learning difficulties" are the same, but in Arabic translation, each one has a different definition.

Nearly all scientific and working sectors are interested in studying mental retardation. Professionals in each of these sectors use a different paradigm to explore various facets of mental retardation. For instance, medical doctors address it according to their medical knowledge; sociologists explain it and mostly ascribe it to the cultural and social changes in the family and the environment around. In the same way, psychologists and educationalists look at it from their own academic and work backgrounds and have presented many explanations that are based on different educational and psychological theories (Alkaryooti, 2003).

There are several definitions for mental retardation. For example, Gold as cited in Bayari (1997) defines mental retardation as uncompleted, in degree and type, mental growth that makes the individual unable to adapt with the environment around him so that he can survive without a need for external help. Although Gold's perspective in his definition of mental retardation that is based on social adaptation is very important, depending only on this perspective is not enough. It does not contain an accurate description of mental retardation, because there are many pupils not adapted but also they are not mentally retarded. In addition, Gold's definition is so broad with no specific standards to measure this adaptation (Bayari, 1997).

Doll as cited in Alrayhani (1999) addresses the definition of mental retardation from a psychological and social perspective in an attempt to overcome the shortcomings of Gold. Doll makes clear what is meant by social adaptation and provides a definition for mental retardation based on it. According to Doll, an individual with mental retardation is a person who is:

1. Unable to adapt socially, is unable to perform at a job, and is unable to manage his own personal life.
2. Mentally, less than the normal.
3. With mental retardation that he or she has since his/her birth or early years in his or her life.
4. Still suffering the retardation even in his/her maturity period.
5. Someone whose mental retardation is caused by either heredity or sickness factors, and
6. Someone whose mental retardation is incurable.

One of the most recent and very important definitions is one that was given by the American Association on Mental Retardation in (2002). This definition states that retardation is a disability that is characterized with clear shortcomings in mental functioning performance and adaptive behaviour. These shortcomings may appear on the practical conceptual, social, and adapting skills. This disability exhibits before 18 years of age (Luckasson, et al., 2002).

Classification of mental retardation takes two main directions. First, the medical classification which describes mentally retarded individuals according to causal factors, that is, according to the existence of one or more anatomical, physical, or illness feature in combination with a lack of intelligence. Second, the behavioural classification which describes the mentally retarded according to their present behaviour features. Followers of this direction are divided in the way they deal with mental retardation. Some of them use level of intelligence as the basis of classification whereas others consider learning ability and some take social adaptation. Some scientists may consider using more than one of these dimensions in their classification (Mursee, 2001).

It is important to explain that classification is the process of dividing a larger group of individuals or things into subgroups according to their similarities or differences using a specific feature. Neiswarth and Smith, as cited in Bayari (1997), state that a classification system is a systemic plan or a group of procedures that are used to specify who, in a group of individuals, can be put within a group that has already been specified.

Classification used by the American Association of Mental Retardation is one of the most acceptable classifications among specialists in this field because the terms used in its classification do not contain a high level of negativity. This was especially true in the case of the other classifications, especially the old classifications that use terms like stupid, idiot or psycho. Table1 shows these classifications with the IQ for each group (Mursee, 2001).

Table 1

Classification of Mental Retardation Groups According to IQ

IQ Score	Classification
55-69	Mild mental retardation
40-54	Moderate mental retardation
25-39	Severe mental retardation
Less than 25	Very severe mental retardation

The main purpose behind the different classifications of individuals with mental retardation is to develop a sort of homogeneity among the individuals in one group so that a researcher can deal with them as one unit or group. This is especially important as the definition of mental retardation can be used with a large number of individuals that are not homogeneous in their psychological and physical features. Dividing individuals with mental retardation into groups that are more homogeneous is helpful with the identification of needs and the methods that can be utilized to improve social, psychological, health, educational and functional outcomes (Jameel, 2002).

Characteristics of Children with Mental Retardation

Knowing the characteristics of one group, whether classified according to age, social features, sickness, or disability helps to identify the needs of the individuals within that group. This will facilitate the preparation of efficient programs designed to assist these individuals in meeting their needs. Children with mental retardation are characterized by broad individual differences and the lack of homogeneity in their features and abilities. Yet, there are still many characteristics that must be taken in consideration when trying to learn about these individuals, or prepare educational and training programs for them (Alqureeti, 2004).

Alshaikh and Abdulghafar (1998) maintain that it is hard to develop general characteristics for a group when there is not enough homogeneity among the individuals of that group. When describing a group of non-handicapped children, one may generalize that there is homogeneity among the individuals of the group (i.e. one can anticipate which strategy(ies) that they may use in their solving of the problems). However, this becomes more difficult when dealing with a group of children with mental retardation due to the broad differences among these children (i.e., level of retardation, or cause of retardation). Alshaikh and Abdulghafar also believe that studying the characteristics of individuals with mental retardation helps to design and create educational curricula and programs that are necessary to prepare these individuals for adult life. Some of the most important of these characteristics are cognitive characteristics, physical characteristics, and social-emotional characteristics.

When examining the social characteristics of individuals with mental retardation, we are, in fact, looking for answers that are related to these individuals' behaviour towards their society, social relationships, and family relationships. Researchers believe that these individuals' social ability is less than their ordinary peers in two ways. First, social ability in individuals with mental retardation develops slower. For example, as far as performing acts independently is concerned, an ordinary child usually walks on her or his own at the age of one year, while a child with mental retardation may start walking on his or her own at a later age depending on the degree of retardation. Second, social ability for an adult with mental retardation does not reach full and complete maturity. In other words, independence in his or her social works, which is reached by the ordinary person, is not reached by the adult with mental retardation (Sadeq, 1996). A study conducted by Fischer (1980) shows that individuals with mental retardation who can be classified under mild mental retardation are gloomy, unsocial, very sensitive and not settled emotionally.

Haroun (2001) indicates that individuals with mental retardation often see themselves as failing and useless, and as having less ability than others. He believes that this feeling could be due to the fact that they are insecure or that they have faced many disappointments. Sadeq (1996) adds that individuals with mild mental retardation can achieve some success in adapting to their jobs and the society around them by being trained and appointed to work in places that are suitable for their level of ability.

On the other hand, Pressley (1986) believes that low levels of cognitive performance for individuals with mental retardation are not due only to their low mental ability. Rather, there are other factors, the most important of which are low levels of motivation and expectancy of failure. As for social psychological characteristics, children with mental retardation often tend to play and be involved in groups that are younger chronologically. This behaviour is expected as these children may feel that they are unable to compete with normally developing same age peers.

Learning Disabilities

Previous studies in special education describe learning disabilities as an imprecise disability and that children who have learning disabilities have other skills that may mask the weaker aspects in their performance. For example, children with learning disabilities may tell wonderful stories verbally, whereas they can not write them; or they can perform high-level and complex tasks while they fail in following simple instructions. These children have normal physical features. Thus, nothing in their appearance indicates that they are different from other children (Alkhateeb & Alhadeedi, 2000).

Although these children may seem like other children, they face many difficulties at school. Some do not learn to read, others do not learn to write, make the same errors repeatedly, and others have serious problems learning mathematics. Teachers describe these pupils as being very difficult to teach and as having special needs which make it difficult if not impossible to pass their classes like other children (Ysseldyke & Algozzine, 1990).

According to the definitions, many of which are stated below, it is assumed that these difficulties do not result from mental retardation, emotional disturbance, movement disability, or a defect in vision or hearing. It is also assumed that individuals who have learning disabilities have been given sufficient opportunities to learn but, but due to their disability, they have not been successful. Thus, any possibility of educational or economical deprivation as the main cause for learning disabilities is not considered (Sisalem, 1998).

Going through the most common definitions for learning disabilities, one can find the following common aspects. The clearest effect of special learning disabilities can be seen in the individual's performance in one or more of the basic academic skills (reading, writing or calculation). Learning disabilities are not a result of mental retardation, sensory disability, behavioural disorders, or a result of educational deprivation or shortage in the educational services. Learning disabilities are mostly related to a functional defect in the central neurological system. This defect may be a result of brain damage or neurological defect. Children with learning disabilities are not homogeneous either from the kind of disability on one hand or from its symptoms on the other. For instance, a disability in reading for two children might be the result of a hearing perception problem in one and visual perception in the other. Children with learning disabilities are in need of educational programs that are designed specifically to suit them; i.e., they should be modified in many aspects. For example, methodology, styles, curricula, or tools are appropriate modifications (Alkaryooti, 2003). Learning disabilities take the form of weakness in performance in one or more of the following: basic reading skills, reading understanding, hearing understanding, oral expression, writing expression, mathematic calculation or mathematic inference (Hargroof & Boteet, 1988)

Dyscalculia

For children, calculation can be one of the most difficult subjects, whether in its teaching or in its learning. The reason behind this difficulty is that calculation is abstractive in its concepts and relationships. Logical sequence adds to the difficulty of calculation. That is, teaching secondary concepts should have been preceded by teaching elementary concepts on which current and later teaching is based.

What increases the difficulty level of teaching and learning calculation is the differences in learners' abilities and levels of understanding. Further, children, even those without learning disabilities, differ in the speed at which they learn and understand the same topic. Some pupils may need only one lesson to fully grasp the concept whereas others may need repeated presentations of the same lesson (Alsharef, 2001). In most calculation classes of 20 or more pupils, it is expected to find at least one pupil who has a serious problem in learning calculation as well as many others that have continuous secondary problems (Fredrick, 1989).

Thornton and Toohey (1985) mention that pupils who have learning problems in calculation can not successfully complete homework as they do not have sufficient knowledge of the basic calculation facts. This leads to avoidance of completing homework in timely manner. Additionally, many pupils use alternative ways to solve calculations, such as counting using fingers, or guessing. In addition, these children often cannot understand the mathematical problems and often need the help of others. That means having difficulties in basic calculation facts leads to having difficulties in the other mathematics concepts.

Hargroof and Boteet (1988) state that pupils with learning disabilities in calculation are often or usually unable to improve their skills in corresponding objects, understanding the meaning of numbers (not just memorizing them), relating between visual and audio symbols, performing calculation operations, and following logical and successive steps in their solutions of various problems.

Alkhateeb and Alhadeedi (2003) also indicated that pupils with learning disabilities in calculation may show disability in one or more of the following aspects: matching numbers and symbols, recalling calculation rules, confusing columns and spaces, understanding calculation concepts, and solving mathematical narrated problems. Although some pupils may be able to obtain the right answer for some problems that are presented to them in writing, they often have difficulty obtaining the correct answer for the same problems when presented orally (Sharp, 1971).

Alkhateeb and Alhadeedi (2003) stated that pupils who have learning problems in calculation have difficulties classifying objects according to their sizes, matching them, or understanding calculation language and mathematical logic. Due to the use of wrong operations, difficulty in recalling basic facts, or giving random answers, problems in basic calculation operations may take place. Mann, Suiter, and McMlung (1979) mention that pupils who have difficulty with language, also have difficulty in reading and understanding terminology used in calculation problems, although they can comprehend the concepts presented to them through numbers.

Reasons behind the Difficulty of Mathematics

Following are some of the most important reasons for the perceived difficulty of mathematics:

1. Ability:
    - 1-1. Limited mental ability.
    - 1-2. Slow response speed.
2. Neurological aspects:
    - 2-1. A functional defect in the central neurological system.
    - 2-2. Damage in the occipital region.
    - 2-3. Physical problems.
    - 2-4. Sensational problems.
3. Perceptual Aspects:
    - 3-1. Problems in the visual memory.
    - 3-2. Difficulties in the space and place relationships.

4. Psychological Aspects:

    4-1. Emotional problems.

    4-2. Social problems.

5. Memory:

    5-1. Inability to remember the operations.

    5-2. Problems in the auditory memory.

6. Cognitive aspects:

    6-1. Quantitative thinking difficulties.

    6-2. Learning disabilities.

7. Learning:

    7-1. Language development disorder.

    7-2. Reading difficulties.

    7-3. Writing difficulties.

    7-4. Defect in these skills.

    7-5. Lack of these skills.

    7-6. Lack of the basic skills.

    7-7. Insufficient understanding of the meaning of numbers.

    7-8. Insufficient understanding of the correct procedure that should be used in solving a problem. (Hargroof & Boteet, 1988)

Cognitive Psychology and Calculation Disability

Cognitive psychology focuses on the scientific study of the ways individuals acquire information from the world around them, assimilate this information, transform this information into knowledge, and use it to evoke attention and behaviour. Cognitive psychology covers psychological aspects like: sensation, comprehension, neural functioning, pattern recognition, attention, learning, recalling, forming concepts, thinking, mind visualization, imagination and language, intelligence, emotions, and it also studies various behaviour aspects (Alsabwa, 2002).

Cognitive psychology also tries to understand the mechanism that controls human thinking. Due to the importance of these mechanisms in understanding the human behaviour patterns, it was highly important for the researcher in education in general, and special education in particular, to follow up with any scientific improvement in this field. New information has been developed in cognitive psychology recently. Researchers are learning more about systems that control mental operations such as: comprehension, recall, attention, and emotional and social patterns. The aim of cognitive psychology is to arrive at a very clear and accurate description for the internal mental processes so that one can understand, give explanation and anticipate pupils' behaviour. For example, psychological processes that will help solve mathematics problems are studied so that we can understand why some pupils succeed while others fail in learning simple mathematics (Lerner, 1993).

Cognitive theories suggest that learning problems take place due to weaknesses in problem solving methods and the way pupils with special needs process information. That is, these pupils are usually unable to determine a course of action to correctly solve a computation. Pupils with learning disabilities also find difficulty in recalling information and connecting that information with previous experiences (Almustafa, 1999).

As far as mathematic skills are concerned, experience is defined on the basis of the individual's knowledge of information, activities, skills used, and his or her performance. Thus, to study the way the individual treats the information about the basic facts for any mathematical skill, a focus should be placed on the cognitive process used in that skill (Pellegrino & Goldman, 1987).

Geary and Widaman (1987) believe that studying the cognitive processes that take place in the pupil's mind when he or she is given mathematical problems may help identify the basic processes that could be responsible for the difficulties that face pupils in mathematics. Cognitive psychologists try to identify the cognitive processes that go on in the pupil's mind during the solution of simple mathematics problems. Cognitive psychologists make some assumptions, called structures and forms, to explain the processes in the pupil's mind when solving mathematic problems.

Cognitive Processes

The past three decades witnessed increasing interest in the study of cognitive processes. This was accompanied with much focus on concepts like: thoughts, symbols, knowledge, inference, problem solving, and information preparation. The aim behind this transformation was to arrive at an explanation for the way mind works and how knowledge, used in the mental processing of information, is acquired (Alzayat, 2000).

Cognitive processes involve sensation, attention, remembering and thinking. All these processes involve the styles used by the individual to obtain knowledge or information from the environment wherein he or she lives. In addition, these processes involve obtaining information through the individual's interaction with that environment and all stimulation that it contains (Altayeb & Mansee, 1997).

Many cognitive psychologists look at the cognitive processes as a comprehensive treatment for information. In the same way, Neisser, as cited in Sisalem (1998), that the term "cognitive" is a comprehensive term that includes all the processes through which the sensory input is transformed, condensed, stored, recalled and used, are treated. Cognitive mental activity, which is also a thorough treatment for information, involves many of the processes that begin with the reception process and end with the final response based on several specifications that affect these processes.

Some psychologists prefer to look at cognitive processes as a mental treatment for the symbols. A symbol represents anything that can be imagined. Without symbolizing the daily events and happenings, it will be impossible for us to perform any treatment for the past, present or future. These psychologists also believe that the cognitive mental activity used in problem solving is the basis of the individual's cognitive mental structure as this structure represents the base through which information is gathered and used and solutions for problems are created (Alzayat, 2000).

Special interest is paid to thinking by cognitive psychologists. They state that thinking is one of the cognitive processes, and that, alternately, cognitive processes can be considered types of thinking as thinking covers a wide range of events, processes, and cognitive structures that are interacting dynamically. This dynamic interaction affects the individual's cognitive structure which then generally affects the individual's thinking and its limitations (Kutami, 1995).

Lastly, mental cognitive activity is looked at as a series of cognitive processes which include processes of reception, recognition, intention, perception, remembering, thinking, judging, inference, learning and problem solving. This perspective is an attempt for integration between cognitive mental activity and its types to take place (Alzayat, 2000).

From what has been mentioned above, one can see that cognitive activity can be looked at from different perspectives. This variety involves the following processes:

1. Thorough preparation and process of the information.
2. Mental process of the symbols.
3. Problem solving.
4. Dynamic interaction between thinking and cognitive processes.
5. Series of reception, encoding, remembering, recognition, retaining and recalling processes.

One of the difficulties that researchers and those interested in cognitive psychology face is that all the cognitive processes are invisible. This urged them to try to uncover and understand these very complicated processes. Thus, they tried to create models to explain the way these processes work and the relationship between each process. These models help researchers visualize the way human beings receive pieces of information, comprehend, treat, store and transform, and recall them.

Information Processing Models for the Mathematics Operations

Initial experimental studies to measure the ability to solve mathematical problems depended on measuring response time (time between seeing the problem and giving the answer). These experimental studies helped connect information treatment models in solving mathematics problems (Ashcraft, 1982, Widaman, Geary, & Cormier, 1986). Information treatment models involve counting (Groen & Resnick, 1977), and memory retrieval models (Ashcraft & Battaglia, 1978, Geary, Widaman, & Little, 1986). As pupils begin acquiring mathematics skills, they seem to use counting models in their solving of mathematics problems (Groen & Parkman, 1972; Groen & Resnick) and, as their cognitive development increases, they become more dependent on memory retrieval models in solving mathematics problems (Ashcraft & Battaglia; Geary, Widaman, Little, & Cormier, 1987). Thus, the process of solving mathematic problems is connected with counting and memory retrieval models.

Looking at addition problems, one can find that mostly they are solved in one of five main ways. The first way is counting using fingers. In this strategy, pupils use their fingers to represent the numbers in the problem, and then they count their fingers to find the total. This is often used by pupils in the first years of elementary schools. The second way is fingers. In this strategy, pupils use their fingers to represent the numbers too, but they count their fingers only after they present the answer. In other words, they use this procedure to make sure that they got the right answer. The third way is verbal counting. In this strategy, pupils count in an audible voice or they only whisper to themselves to get the answer for the problem. The fourth way is analysis of the problem. Here pupils divide the problem into several easier problems. For example, for 9+8, a pupil may subtract (1) from the (8) to add it to (9) and then he or she will add up (7) to (10) to get the right answer (17). The final way is memory retrieval. In this strategy, pupils recall the result of the addition problem directly from their long term memory. Looking at the development of the addition skill, one may find out that memory retrieval is the best choice among other methods as the pupil using it needs only a very short time to solve the problem, as well as a little space in the memory.

Counting models. Groen and Parkman (1972) present five basic models for counting used by pupils in solving mathematic problems. All these models are based on the treatment of the increase an increment of one at each time in the pupil's mind. However, they differ in aspects like the value of the number and the number position that pupils start the solution with. These models are explained in the following:

1. Addition to the larger numbers. In this model, the pupil puts the larger number in his mind and adds the smaller number to it.
2. Addition to the smaller number. In this model, the pupil puts the smaller number in his mind and adds the larger number to it.
3. Addition to the first number. In this model, the pupil puts the first number in his mind and adds the second number to it, no matter what the value of the first number is (smaller or larger).
4. Addition to the second number. In this model, the pupil puts the second number in his mind and adds the first number to it, no matter what the value of the second number is (smaller or larger).
5. Counting starting at the zero. Here, the pupil starts at the zero and he or she adds up units of the first addition to units of the second addition.

Using the first counting model (addition to the larger number) is the best indication of response time as the pupils who use this model will use shorter time than other pupils who use other models. On the other hand, using counting starting at the zero strategy is the worst indication of response time as the pupils who use this model will use longer time than other pupils who use other models.

Memory retrieval models. Memory retrieval models networks represent the alternative to counting models in solving mathematics problems. These models show a direct search for the numbers representing the solution for the problem, in the storage of that network. In this study, two of the memory retrieval models will be discussed.

In the first model, Ashcraft and Battaglia (1978) believe that the time needed to retrieve the result of the addition depends on how large the value of the added number. They also believe that memory retrieval processes take longer in problems that have large addition results, because that requires more direct search into the memory network. For example, when retrieving the result for 7+9, one will need more time than that needed for 2+3.

Ashcraft and Battaglia's (1978) concept of the memory network is represented with a square matrix that has columns and rows that cross each other at intersecting points with values between 0 and 9 that show the process of adding two numbers. The result of the addition for a simple addition problem is located in the intersection point (see Figure 1). From the figure, one can see that whenever the two numbers' values are small, the distance was smaller. On the other hand, whenever, the values are larger, the distance gets larger too. The distance shows the response time.

For instance, the distance for the problem (1+2=3) in the figure is small when compared to the distance for the (2+6=8) problem. Then, the response time in the second problem is larger than that of the first problem. It is also obvious from the figure that the distance for 9+4=13 and 7+8=15 is larger than the distance for the two previous problems. Thus, the larger the value of the two numbers added to each other, the larger the distance that represents the response time.

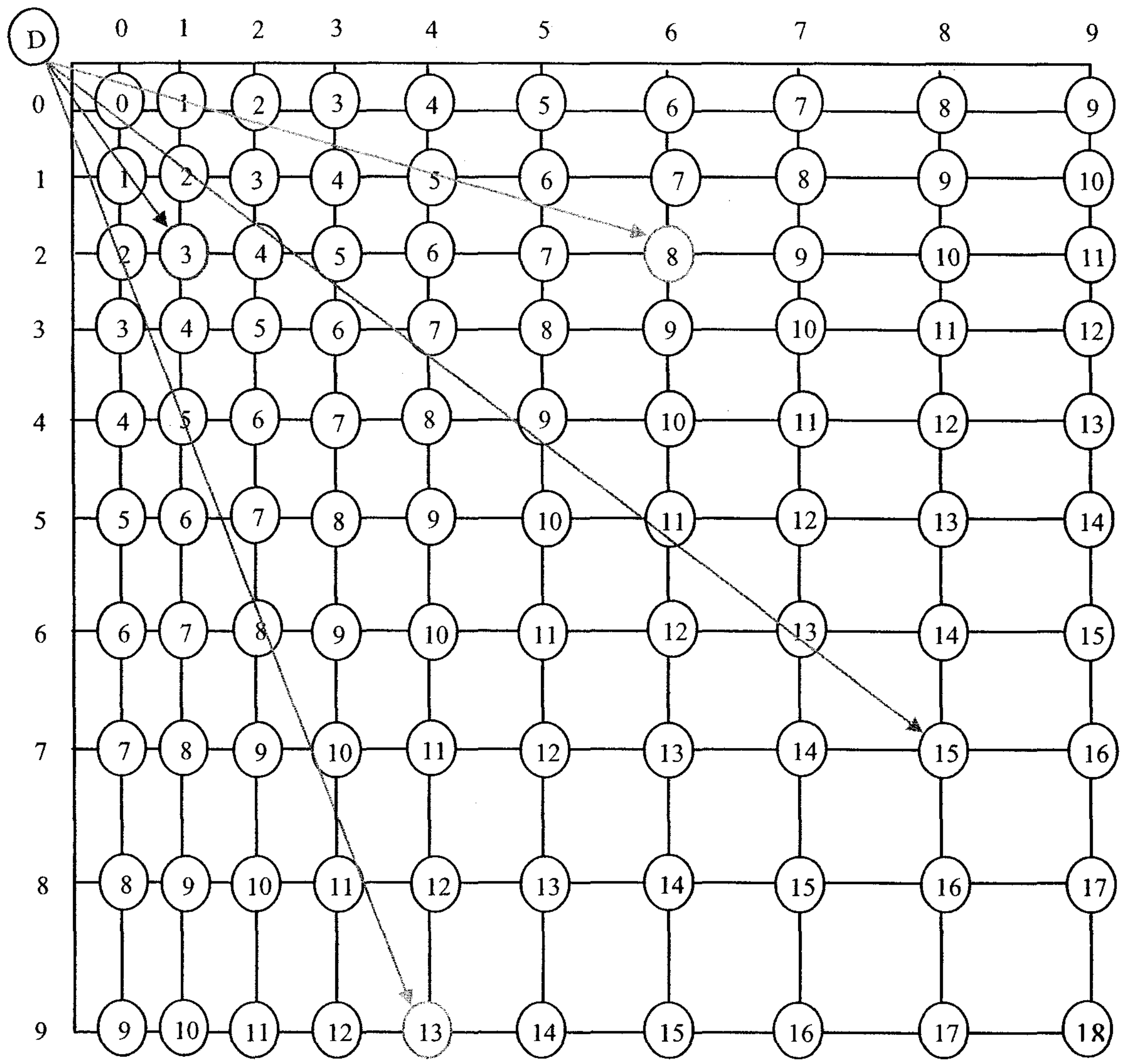

Figure 1. Illustration of Ashcraft and Battaglias' Memory Nnetwork Concept

In addition to what has been indicated before, increase in the response time is not fixed. In other words, the difference between the increase of response time in addition problems of which the result is 5 to those of which the result is 6 is different than the increase of response time in addition problems of which the result is 10 to 11. The more the results values are, the larger the differences become.

Ashcraft and Battaglia (1978) found out that time response increases with the increase of the addition result. For instance, if the response time for a problem with the result 3 is 2 seconds, the response time for a problem with the result 4 is 2 to the second power, and for a problem with the result 5 the response time is 2 to the third power and so on. This can be explained as follows: In the case of large added numbers, search in the matrix takes place in the spots where there are large addition results which results in long distances, and this means long response time for these results.

The second memory retrieval model is explained through the result of a simple addition problem. There are two memory retrieval sub models which can go under this concept. The first sub model is represented by a symmetrical matrix with orthogonal axes of which the intersecting points show the number to be added. The distance between the values at the intersecting points are fixed and not increasing ones like they were in Ashcraft and Battaglia's model (see Figure 2) (Geary, Widaman, Little, & Cormier, 1987).

Response time in simple addition problems is the time taken to activate the region where the intersecting point that contains the right answer is. The larger the result of the addition is, the longer the time taken to activate the spot. Thus, the response time to answer a given addition problem is increased. This means there is a relation between the result value and the retrieval time (Geary et al., 1987).

Looking at Figure 2, one can see that the smaller the result value, the shorter the distance between the region to be activated and the response taking place, while this distance become longer when the result value is bigger. The distance represents the response time.

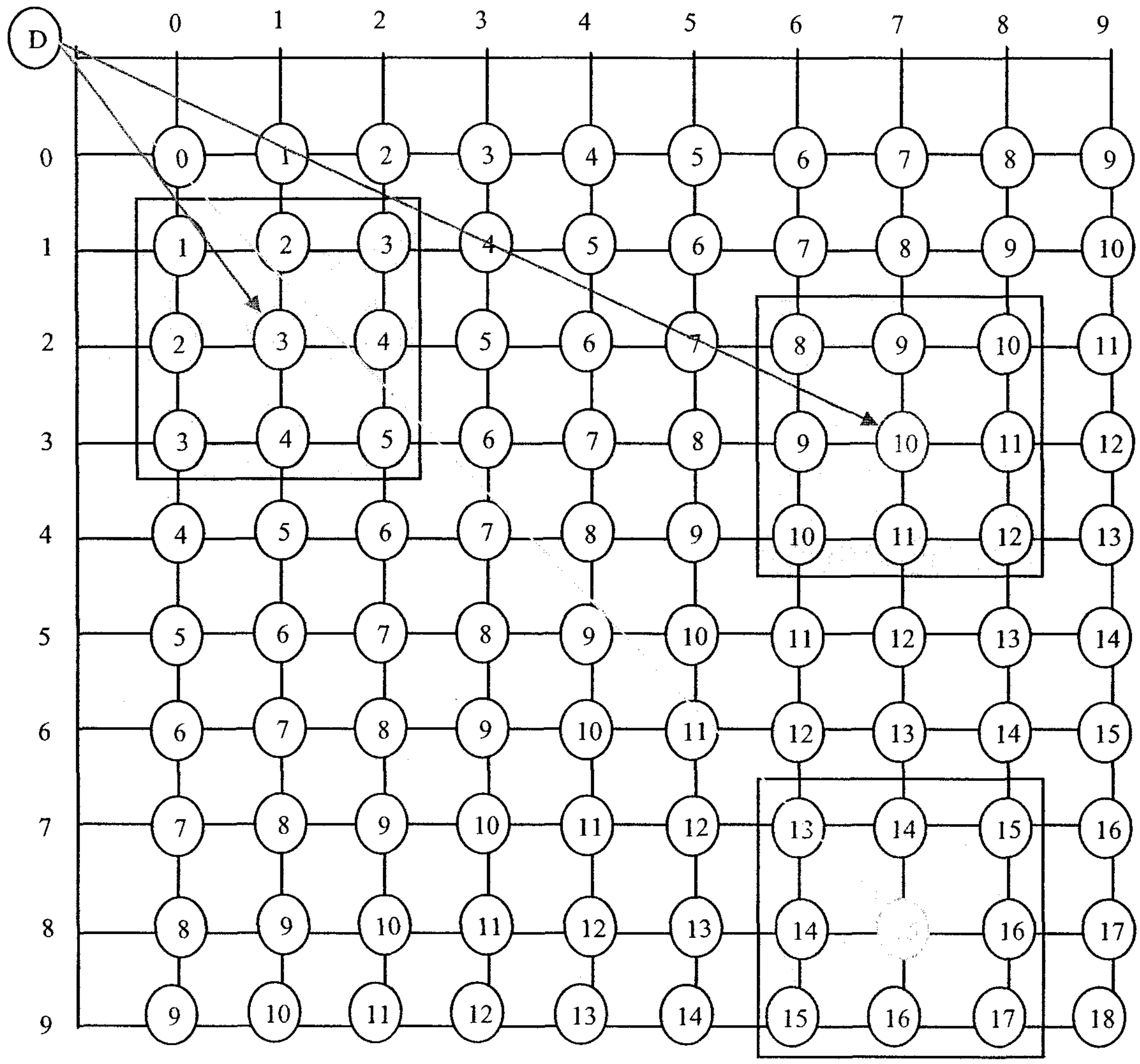

Figure 2. Illustration of Symmetrical Matrix Modal, Memory Retrieval Network.

It is also noted that the region to be activated is fixed, meaning it does not get larger when the result gets larger (see Figure 2). This means that that the response time gets longer when the result's value is larger in the region to be activated. In the problem 2+1=3, it is noticed that the distance between the region to be activated and the assurance response is small when compared to 3+7=10 and 8+7=15. In addition to that, the results in the active region for the first problem are smaller in value than the results in the active region for the second problem. On the other hand, results in the active region for the third problem are larger in value than the results in two active regions for the two previous problems. This is why the response time for the third problem is longer than that of the other two problems; the response time for the second problem is longer than the first problem.

The second sub model which was suggested by Siegler and Shrager (1984) and Siegler and Taraban (1986) is relations distribution. They applied that model on a sample of pupils who had disabilities in mathematics. They found out that there is a relationship between the size of the problem and the range of the alternative possible answers. In problems with small added numbers, the range of the alternative possible answers is limited to few answers or only one right answer for the addition. This is why the relation strength between the right result and possible right answer is very strong and clear which then will require only a short time and little effort to confirm the right answer. On the other hand, in problems with answers that are large in value, the range of the alternative possible answers is large and this means that the relation strength between the right result and the possible right answer is less clear which then will require more time and effort to confirm the most accurate answer among the alternative answers.

In other words, if the two added numbers in the problem are small, the number of possible answers is small which means that the pupil will need a short time to know the right answer. In the same way, the larger the value of the added numbers, the more the number of the possible answers which means that pupils need a longer time to know the right answer. For example, a student will need shorter time to calculate 2+3 than that time he/she will need to calculate 7+9.

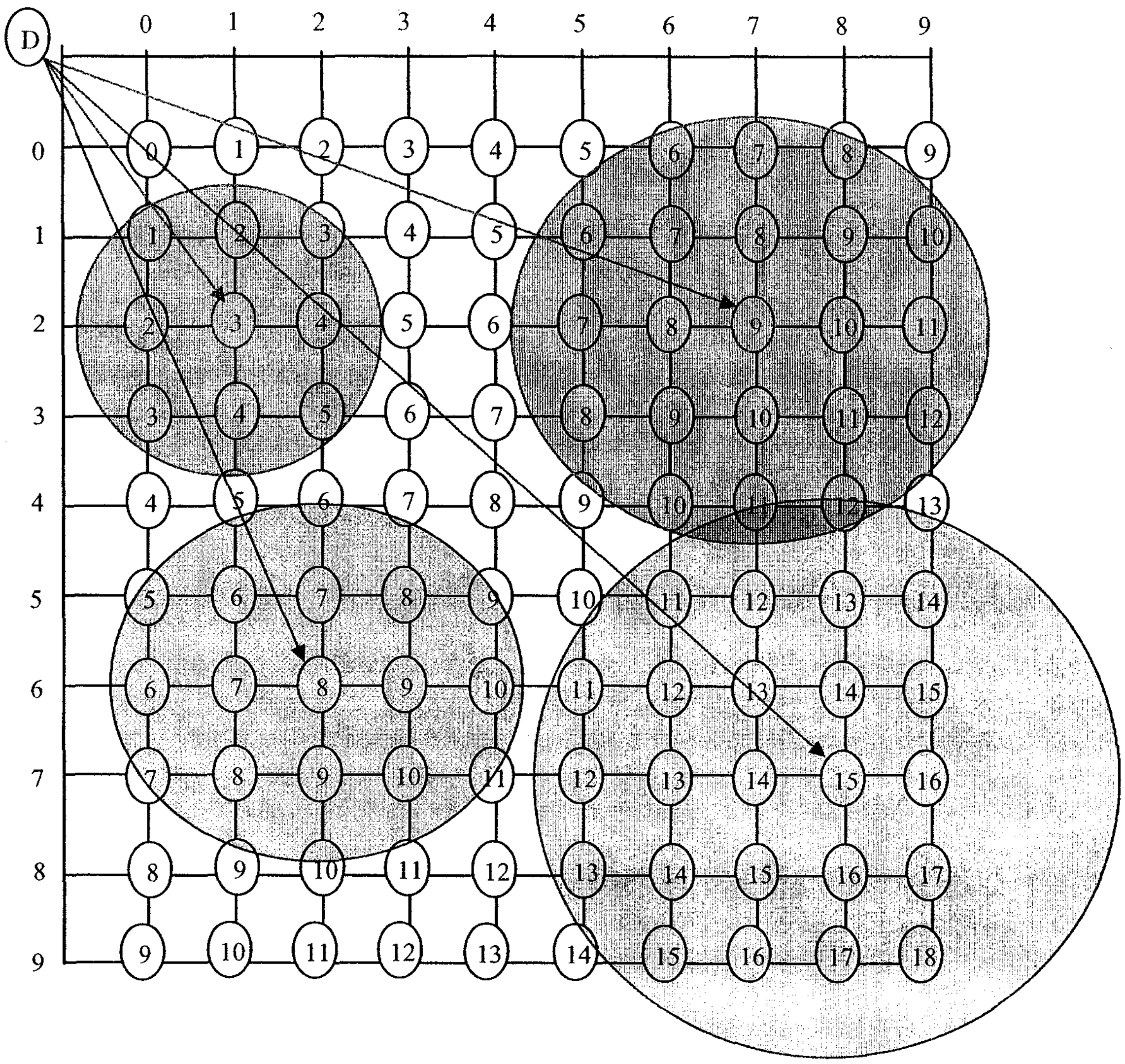

Figure 3. Illustration Showing the Relation Distribution

Figure 3 shows that the smaller the result value, the smaller the number of the results that are connected with it. In the same way, the larger the number of results related to the problem, the larger the problem results. The distance represents the time required to pick the right answer among other possible answers. The longer the distance is, the longer the time required to pick the right answer. In the problem 2+1=3, there were three related numbers (4, 3, and 2). Thus, the response time is the time taken to pick the right answer from the three answers. In the problem 6+2=8, there are five related numbers (10, 9, 8, 7 and 6). Again, response time is the time taken to pick the right answer from the five possible answers. It is important to notice that the number of answers related to the result in the problem 2+7=9 is more than that of the two previous problems and the number of related results in the problem 7+8=15 is very large when compared to the first problem.

Information Processing in Students Who Have Mathematics Learning Disabilities

Svenson and Broquist (1975) compared processing strategies that are used in solving simple addition problems used by third grade pupils who have no mathematics learning problems and those who have mathematics learning problems. Results showed that pupils who have learning problems needed more time than other pupils in finding the right answer. In addition, results showed that response time for simple addition problems for pupils who have mathematics learning problems was different among the pupils in the group, which means the time that pupils needed to solve each problem was different from pupil to other. This difference reflects the different strategies a pupil tries to get to the right answer.

Svenson and Broquist (1975) noticed that the average of the response time that pupils need to solve a simple addition problem become so long when the difference between the two added numbers is equal to 1 than when difference between the two added numbers is greater than 1. For example, the average response time for pupils who have mathematics learning problems, for the problems: 3+5, 5+3, 3+6, 6+3, was about two minutes and the average response time for problems like 3+4, 4+3 was almost three seconds. The length of response time was very obvious especially when the number was

3 or the smaller added number is in the first position. They got to the result that giving the answer for 3+4 and 4+3 at almost the same time means that pupils started counting using 3 instead of 4 (i.e., using the smaller value rather than the larger value).

Hamann and Ashcraft (1985) considered response time for simple addition problems as a significant variable for the pupils' mathematical ability. Fourth grade pupils who have very high abilities in mathematics answered addition problems in a shorter time than pupils with low and medium abilities. Thus, according to the results of both Svenson and Broquist (1975) and Hamann and Ashcraft, mental processing of mathematics problems in pupils with learning problems in mathematics is slower than that of pupils who have no learning problems in mathematics.

One of the best models in this respect is Kirby and Becker's model (1988) which shows the cognitive processes in the pupil's mind when he/she is solving a mathematical problem, is one of the best cognitive models in this respect (see Figure 4). This model is consisted of three numbers (3E), which represents (A) Encode the first number, (B) Encode the second number, and (C) Encode the given answer. That is in addition to (S) Select operation, (O) Execute operation and (C) Compare the results.

According to this model, response time for a problem A @ B = C (where @ is the type of operation and A, B and C are numbers), is the total of three units: encoding, selecting the operation and the execution of the operation. In other words response time = (3E+S+O).

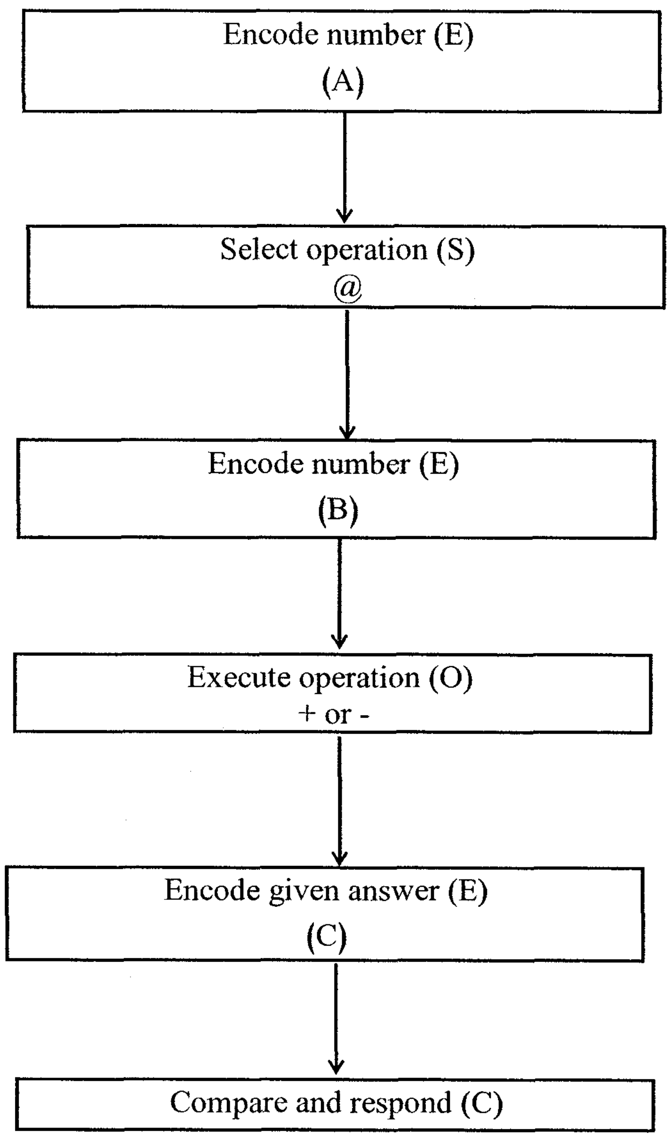

Figure 4. Model for Mathematical Processes Sequence.

Cognitive Components of Addition

Based on the studies done by Svenson and Broquist (1975), Geary and Widaman (1987), and Kirby and Becker (1988) in the field of mathematics difficulties, four cognitive components, which are suggested to be responsible for the difficulties that pupils face in solving addition operation, were specified. These difficulties were: encoding, speed of executing operation, selecting operation, and choosing strategy.

Encoding is the operation in which information that is received through the senses is analyzed and new information is matched with the old information in the long term memory (Alkinani & Alkandri, 2001). What happens in encoding is that we look at a stimulant and memorize a number of features that characterize it (we can not retain an exact copy of the things that we see). Encoding the stimulant takes different patterns. For example, individual's focus can be placed on the stimulant's color or shape, size, form, name or any other features that characterize it (Alzayat, 2000). It is important to indicate that many studies show that there is a relationship between encoding variable and the problems that pupils face in the mathematics operations they work on.

The speed of executing an operation is the time taken from the beginning of executing the operation until getting the result. Hamann and Ashcraft (1985) used the speed of executing mathematic operations as a significant variable for mathematic ability. Results of studies done by both Svenson and Broquist (1975) and Hamann and Ashcraft show that mental processing of mathematics problems in pupils with learning problems in mathematics is slower than that of pupils who have no learning problems in mathematics.

Studies that were looking for common mistakes in mathematics show that many mistakes can be ascribed to choosing a wrong operation (Kirby & Becker, 1988) or a problem in selecting operation. For instance, when given mathematics problems, some pupils rush to use an operation like addition or subtraction without looking at the operation symbols in the problem. This leads to mistakes. Many of these pupils discover their mistake while working on or when they are done with the problem. Then they work on the problem again using the right operation.

Pupils use one of many alternative strategies for solving any addition problems (strategy selection). These strategies range between using one of many counting models to recalling the answer from the long term memory (Geary & Brown, 1991a).

Geary and Widaman (1987) stated that pupils use a variety of strategies in solving mathematical problems. Sometimes, pupils may use two different strategies in answering the same problem in two different situations. In the first grade for example, pupils usually use the simplest counting models (i.e., using fingers and counting starting at the zero) in solving addition problems. In a simple procedure, like solving a problem (6+9), they start with the larger number which is (9) and then they start counting a number of units equal to the smaller number (each unit is 1) to get the total. Although there are many alternatives to this strategy, there is not much development in the strategy used. This is obvious when pupils with problems in mathematics use the strategy of starting counting at zero and then adding number of units, which is equal to the number of both numbers (9) and (6).

Selecting the strategy for one problem usually depends on the relations distribution between the problem and all the possible answers for it (Relation Distribution is a conceptual modal suggested by Siegler and Shrager [1984] to select the strategy). A strategy selected for solving a problem shows the associative relationship between the problem and its right answer. In other words, the selected strategy shows to what extent the right answer can be retained in the confidence criterion which is an internal standard through which pupils establish their confidence of retaining the right answer. When solving a problem, pupils start by measuring: (a) confidence criterion and (b) length of search time, which shows the maximum number of retrievals attempts that have been made by pupils before choosing an alternative strategy. When a confidence criterion value exceeds the associative relationship for all possible answers and has been placed on only one answer, and this does not exceed the proposed search time, pupils will use memory retrieval. On the other hand, if the answer does not exceed confidence criterion value and the proposed search time, pupils will guess on one of the retrieved answered or they are going to use one of the overt strategies or they will develop their own internal strategies. For example, in the overt strategy, pupils demonstrate with their fingers to show addition problems. This way increases the associative relationship between the problem and the right answer. When the associative relationship does not exceed confidence criterion, pupils will give an answer. However, if it exceeds it, pupils will use retrieving styles like counting on fingers, or verbal counting to solve the problem (Geary & Brown, 1991b).

Previous research in the field of mathematics problems suggests that pupils who have learning problems in mathematics are different from pupils who do not have such problems in the following ways. First, pupils who have learning disabilities get confused and mix up the strategies for solving addition problems. This shows that these pupils use more general strategies than those that are used by pupils who have no learning disabilities. Second, is the random use of strategies. This could be related to an improper development in the envisioning of long term memory for basic mathematics facts (Geary & Brown,1991b). In other words, some pupils with learning disabilities can not retain many of the basic facts like 3+4=7 from the long term memory even by the end of their elementary school. These pupils use counting in solving many of the simple addition problems.

Summary

Through the use of cognitive theory and experimental methods, we now have a reasonable understanding of the number, counting, and arithmetic competencies and deficits of children with mental retardation or learning disability (Geary & Brown, 1991b; Goldman, Mertz, & Pellegrino, 1989). Most of these children appear to have nearly average number processing skills, at least for the processing of simple numbers (e.g., 3, 6), but they show persistent deficits in some areas of arithmetic and counting knowledge. Many of these children have an immature understanding of certain counting principles and, with respect to arithmetic, use problem-solving procedures that are more commonly used by younger, typically achieving children. They also frequently commit procedural errors. For some of these children procedural skills, at least as related to simple arithmetic, improve over the course of the elementary school years, and thus, the early deficit may not be due to a permanent cognitive disability. At the same time, many children with mental retardation or learning disability also have difficulties retrieving basic arithmetic facts from long-term memory, a deficit that often does not improve.

Chapter 3

METHODOLOGY

The Study Sample

The researcher selected 240 pupil boys and girls as a random sample from the third and fifth grades from the state schools in the State of Kuwait. The sample selected was based on the characteristics of gender, type of handicap, grade as shown in the following table.

Table 2

The Distribution of the Study Sample According to their Characteristics

Grade	Group	Boys	Girls	Total
Third Grade	Non Handicapped	20	20	40
	Learning Disabilities	20	20	40
	Mental Retardation	20	20	40
Fifth Grade	Non Handicapped	20	20	40
	Learning Disabilities	20	20	40
	Mental Retardation	20	20	40

Sample Choice Criteria

The participants in the study were selected according to the following criteria:

1. All selected pupils passed successfully the addition operations pre skills test before they were accepted to be in the study sample.
2. Learning disabilities sample were selected from the students who were classified as mathematics learning disabled and had case diagnosis files in the school archive.
3. Mental retardation sample were selected from the students who were classified as students with mild mental retardation and had case diagnosis files in the school archive.

The Study Instruments

To investigate the hypotheses and reach the goals of this study, the researcher used several instruments, which are described below.

The Addition Operations Pre-Skills Test

This test was prepared by the researcher to test the mastery of the study sample for the addition operations pre-skills. The design of this study requires the complete mastery of the addition operations pre-skills for all study groups (non handicapped, learning disabilities, and mild mental retardation). Therefore, it is impossible to any student to be in the study sample without getting a full score in this test. This test included the following skills (number recognition, writing numbers, numbers concept, the relation between the numbers, and order of numbers) (See Appendix A). The results of testing the reliability and validity for this instrument were shown in the pilot study part.

The Cognitive Components for the Addition Operation Test

This test was prepared by the researcher to measure the cognitive components for the simple addition operation which are:

1. Encoding.
2. Speed of executing the operation.
3. Operation selection (Addition - Subtraction).
4. Strategy choice (Counting – Recalling).

This test consists of four subsidiary tests, each subsidiary test measures one of the cognitive components for the addition operation. These tests have been designed so that the pupils respond with either true or false. The analysis of tests results depend on the time spent on solving the problem. The right or wrong answers do not affect the results because all the wrong answers are excluded from the test.

Each test of the four subsidiary tests consist of 20 items, 10 of them are right and 10 are wrong. These items are preceded by four training items for the test takers to understand the test lay out. There are several regulations that were taken in consideration when choosing the test items to guarantee efficiency. These regulations are:

1. The added numbers in all the test items ranged between 0 - 9.
2. The number of the items with the right products was equal to the number of the items with wrong products in each subsidiary test.
3. In the tests that contained items with addition and subtraction operations, the number of the items with addition operations was equal to the number of the items with subtraction operations. In addition, the right and wrong products were equal in each of them.

4. The addition and subtraction product value for the items with the wrong answers was limited to no less or more than 2 than the correct answer.
5. It was not allowed to repeat any of the two added numbers or their products in two consequent items.
6. It was not allowed to repeat more than three right or wrong answers in three successive items.
7. In each subsidiary test, number of repetitions for each of the added numbers was equal to the number of repetitions for other added numbers.
8. This test was conducted using a computer supplied with a stop watch that is designed to calculate 0.01 parts of the second.

The Test Tasks

The test of the cognitive components for the addition operation is a battery that includes six subsidiary tests. Each of these tests is designed to measure specific different task. In general the focus of all these tasks is to measure the time that the students spent in each of these tasks. The following is a description of each of these subsidiary tests.

The measurement of the successive encoding. The purpose of this test was to measure the time that the pupil takes for encoding one number. Each item in this test was showing a number and equal sign in the computer (an example: 3 =) for 5 seconds, then the second number was appearing (an example: 3= 3) then the pupil had to decide if the relationship is right or wrong. The purpose behind showing only a number and the equal sign at the beginning is for the pupil to encode the first number before the stop watch automatically starts with the appearance of the second number until the pupil gives the answer. This test consists of 20 right and wrong items organized randomly (See Appendix B.1).

The measurement of the simultaneous encoding. The purpose of this test was to measure the time that the pupil takes for encoding two numbers. In each item in this test, two numbers were appearing with an equal sign between them (an example: 5 = 5 or 7 = 6) then the pupil had to decide whether this relationship is right or wrong. There are two differences between this test and the previous one. The first difference is that in this test the relationship were appearing completely in one time. The second is that the stop watch was automatically start at the appearance of the relationship. This test consists of 20 right and wrong items organized randomly (See Appendix B.2).

Measure the speed of execution of the addition operations. The aim of this test was to measure the pupils' speed in executing the addition operations. This test consists of 20 addition operations items. Organized randomly, the products of 10 of the items are right while they are wrong for the other 10 of these operations. The operations were appearing vertically in the computer. The pupil had to decide whether the product of the operation is right or wrong. In this test, the tester or the researcher informed the pupils that all these items are addition operations and he/she had to remind them of that with each item. This was to exclude the effect of operation selection. The response time of this test is the extended time from the appearance of the operation in the computer until the pupil response (See Appendix B.3).

Measure the ability of select the operation type. The aim of this test was to measure the pupils' ability to select the operation type (addition, subtraction) for the given operation. This test consists of 10 addition operations items and 10 subtraction operations items. The addition and subtraction operations have been divided into two halves with each consisting of five right and five wrong products. All the items are ordered randomly. The operations were appearing vertically in the computer. The pupil had to decide whether the product of the operation is right or wrong. The response time of this test is the time taken from the appearance of the operation in the computer until the pupil responds (See Appendix B.4).

The cognitive model (strategy) used in the solving the addition problem. The aim of this test was to determine the cognitive model or the strategy that the pupils used in solving the addition operations (counting – recalling), and if they used the counting models, what is the counting strategy that they mostly followed when they start the counting (i.e. whether they start with the first number, the second number; the smallest number, the greatest number, or start from the zero). The test consists of 10 pairs of addition operations (20 items) (an example of the pair: 3 + 5 = 8, 5 + 3 = 8) five were with right products and five were with wrong products. The two items in each pair do not follow each other throughout the test. The operations appeared vertically in the computer. The pupil had to decide whether the product of the operation is right or wrong. The response time of this test is the time taken from the appearance of the operation in the computer until the pupil responds (See Appendix B.5).

Applying and grading the test. The cognitive components for the addition operation test were used with small groups of no more than three pupils in order for the tester or researcher to be able to observe them easily. As for the grading of the first, second, and the third subsidiary tests, items that are answered wrongly were excluded from the tests, and then the responding times for all items with right answers were collected. The averages for each subsidiary test collected and the outcomes prepared for the analysis. As for the fourth subsidiary test, a pair was accepted if only both items are correct. Otherwise the pair was excluded even if one item in the pair is answered correctly. Then the researcher compared the response times for each of the two items in all pairs as the following:

1. If the responding times of the two items in the pair were equal and they increase with the increase of the product value. The pupil used either recalling model or counting from the zero model, and we can decide on which one of the two was used by reviewing the response times of the pair (responding time with average of about 3 seconds means the pupil used the recalling model, whereas, responding time with average of about 10 seconds means that he or she used the counting from the zero model).
2. If the responding times of the two items in the pair were equal but there was no relationship between the responding time and product value. The pupil used either starting with the greatest number model or starting with the smallest number model, and we can decide on which one of them by comparing the items that have the same greatest added number, and comparing the items that have the same smallest added number.
3. If the responding times of the two items in the pair were not equal and there was no relationship between the responding time and product value. The pupil used either starting with the first number model or starting with the second number model, and we can decide on which one of them by comparing the items that have the same first and second added number.

The researcher used Excel software to execute all the comparisons abovementioned. Table 3 provides a summarizing for the relationship between the times that pupils spent in solving the addition problems and models that they used.

Table 3

Relationship between Responding Time and Model

Relationship between responding times in pairs	Relationship between responding times and product	Comparing according to	Model used
The responding times were equal in pair items.	There was a positive relationship between responding times and product.	The average of responding time was about 3 seconds.	Recalling model.
		The average of responding time was about 10 seconds.	Start from the zero model.
	There was no relationship between responding times and product.	The items that have the same smallest added number had equal response time.	Adding to the greatest number.
		The items that have the same greatest added number had equal response time.	Adding to the smallest number.
The responding times were not equal in pair items.	There was no relationship between responding times and product.	The items that have the same first added number had equal response time.	Adding to the second number.
		The items that have the same second added number had equal response time.	Adding to the first number.

Study Design

This study used the descriptive design by applying a group of tests on three groups of students (non-handicapped, learning disabilities, and mild mental retardation) that were chosen randomly by using the clustered sample procedure. Two of the six provinces in the State of Kuwait were chosen randomly. Two schools (one boys' and one girls' school from each province) were randomly selected. In the selected schools, students who meet the study criteria were identified and a sample of students was selected randomly to be used in any of the three study groups.

Hypotheses

1. There are statistically significantly differences in the response time for each of the cognitive component elements for the simple addition operation between:

   1-1. The boy and girl students in third and fifth grades who are non-handicapped students, and the students with learning disabilities.

   1-2. The boy and girl students in third and fifth grades who are non-handicapped students, and those with mild mental retardation.

   1-3. The boy and girl students in third and fifth grades who are learning disabilities students and those with mild mental retardation.

2. There are statistically significant differences between the strategies that the non-handicapped students use for solving addition problems and:

   2-1. Those used by the learning disabilities students.

   2-2. Those used by the students with mental retardation.

3. Based on the students' performance in a test for cognitive components for simple addition operations -the encoding, speed of executing the operations, operation selection and choosing the solving strategy:

   3-1. Can predict students with learning disabilities in the elementary school.

   3-2. Can predict students with mild mental retardation in the elementary school.

The Field Test of the Instruments

The researcher conducted a field test of the study's instruments on a sample of 40 pupils from third and fifth grades. The aim of this field test was to determine the reliability and the validity of the study instruments. It also helped identify any problems could have arisen when the researcher applied the instruments in the main study. In addition to that, it helped the researcher to have an idea about the pupils' readiness to use the testing software, and if there is any difficulty in the understanding of the instructions that they will receive before they start using the software.

The field test of the instruments' results showed that non handicapped and the learning disabilities pupils appeared to understand the instructions for the tests and using the software, while the mild mental retardation pupils needed repeated the instructions for them to understand it. The Addition Operations Pre-Skills Test required 10 – 20 minutes to apply. The Cognitive Components for the Addition Operation Test required 15 – 30 minutes to apply.

The researcher found the students tired when all tests were applied, so he divided the tests into two parts. The first part included the Addition Operations Pre-Skills Test and the first two subtests of the Cognitive Components for the Addition Operation Test, while the second part was included the last three subtests of cognitive components for the addition operation test. Each part was applied in separate day.

Validity

The researcher used the internal consistency to test the validity for the Addition Operations Pre-Skills Test and all Cognitive Components for the Addition Operation Subsidiary Test. All tests demonstrated good internal consistency (See Table 4).

Table 4

The Internal Consistency for the Study Instruments

	Internal Consistency			
	Non Handicaps	Learning Disabilities	Mental Retardation	All Groups
Tests	N= 16	N= 16	N= 16	N = 48
Pre-Skills Test	.84	.79	.76	.88
Successive encoding	.63	.70	.81	.78
Simultaneous encoding	.62	.77	.58	.70
Speed of execution of the addition operations	.88	.70	.79	.83
Select the operation type	.88	.65	.81	.86
Cognitive model (Strategy)	.89	.76	.82	.87

Reliability

The researcher used the Test-Re-Test to test the reliability for the Addition Operations Pre-Skills Test and all Cognitive Components for the Addition Operation Subsidiary Test. The students were tested two times with a one-week interval between the two tests. All tests demonstrated good reliability (See Table 5).

Table 5

The Reliability for the Study Instruments

	Reliability (Test-Re-Test)			
	Non Handicaps	Learning Disabilities	Mental Retardation	All Groups
Tests	N= 16	N= 16	N= 16	N = 48
Pre-Skills Test	.98	.93	.89	.90
Successive encoding	.84	.73	.80	.77
Simultaneous encoding	.81	.75	.73	.74
Speed of execution of the addition operations	.91	.82	.64	.79
Select the operation type	.79	.74	.67	.71
Cognitive model (Strategy)	.83	.69	.58	.67

The Application Procedures

The following are the guide procedures that the researcher followed during his study:

1. Obtained approval of the Ministry of Education in State of Kuwait to apply the study instruments on some of its schools, and the random selection of those schools.
2. Met the principals of schools that were selected to secure their approval to apply the study instruments on the selected pupils in their schools. It is also

important to schedule for the dates and times for applying the study instruments.

3. Randomly selected the study sample for the three groups (non-handicapped learning disabilities and pupils with mild mental retardation). All the individuals in the sample meet the study sample criteria.
4. Applied the addition operations pre-skills test for all the three study groups to exclude all pupils who did not master these skills at 100 % accuracy.
5. Applied the cognitive components for the addition operation test for all the three study groups (non-handicapped learning disabilities and mild mental retardation) in the selected schools. This test was conducted by using three computers.

The Statistical Tests

To achieve the goals of the study, three hypotheses were investigated. For the first hypotheses, the MANOVA test was conducted to analyze the data for this hypothesis. There were four dependent variables: encoding, speed of executing the operations, operation selection, and choosing the solving strategy. There were three independent variables: students' groups (non-handicapped, learning disabilities, and mild mental retardation), gender (male, female), and the grade (third grade, fifth grade). This test was followed by one way ANOVA in all the cases when there was significant interaction between the independent variables. The one way ANOVA was also followed by Scheffe test, one of the post hoc comparison tests, in all the cases when there were significant differences between the students' groups in any of the dependent variables. Post hoc tests are tests that are used when the independent variable has three or more levels. It is important to mention that the higher scores in all the dependent variables refer to more difficulties in the variable as the test is based on the time spent on solution. The more the time that is spent, the higher the difficulty. The less time are indicators of less difficulty (or no difficulties).

As for the second hypothesis, a Chi-square for independent samples was conducted to investigate the differences among the three students' groups (non-handicapped, learning disabilities, and mild mental retardation) in the strategies used in solving the addition operations. The frequency of using each strategy (simple counting strategy "counting from zero," addition of the first number to the second number strategy, addition of the second number to the first number strategy, addition of bigger number to the smaller number strategy, addition of smaller number to the bigger number strategy and recalling from the memory strategy) in solving the addition problems were counted. Then a comparison among the three groups was conducted.

As for the third hypothesis, a multiple regression test was conducted to investigate if the cognitive components of addition operation (encoding, speed of executing the operations, operation selection, and choosing the solving strategy) predict the type of student (non-handicapped, learning disabilities, and mild mental retardation). Then if this test was significant, the slope equation was created for these variables.

Summary

This chapter addressed the population and the sample study, the method, and the criteria followed in extracting the sample out of the population. This chapter also included the research design followed in the study. A large part of this chapter discussed the tools used in the study in terms of their description, criteria of their design and the objective of using them in this study. The field test of the study's instruments was also addressed, it was used to investigate the suitability of the tools. In addition, the chapter included the method of collecting the data and the procedures for conducting the research of the study. Statistical tests used for investigating the hypothesis of the study were also discussed.

Chapter 4

PRESENTATION OF RESULTS AND ANALYSIS OF DATA

Overview

The primary purpose of this study was to attempt to determine which of the cognitive components for addition operations (encoding, speed of executing the operation, operation selection, and strategy choice) are responsible for the difficulties that students with learning disabilities and mild mental retardation face in the elementary school in solving simple addition problems. In addition the purpose was to determine if these cognitive components can predict students with learning disabilities and mild mental retardation in the elementary school. This chapter contains a description of the analysis and summary statements with regard to the three study hypotheses.

Results - First Hypothesis

According to Geary and Widaman (1987), and Kirby and Becker (1988), there are four components for the addition operation which are encoding, speed of executing the operations, operation selection, and choosing the solving strategy. They argued that studying these cognitive components may lead to identification of the basic elements for addition that perhaps are behind the difficulties that students face in solving simple addition problems. Based on what Geary and Widaman, and Kirby and Becker thought, the first hypothesis was stated that "There are statistically significantly differences in the response time for each of the cognitive component elements for the simple addition operation between:

1. The boy and girl students in third and fifth grades who are non-handicapped students, and the students with learning disabilities.
2. The boy and girl students in third and fifth grades who are non-handicapped students, and those with mild mental retardation.
3. The boy and girl students in third and fifth grades who are learning disabilities students and those with mild mental retardation.

To investigate this hypothesis a multivariate ANOVA was conducted with student type, grade and gender as independent variables and encoding, speed of executing the operation, operation selection, and strategy choice as dependents variables. This analysis test was created four interactions and three main effects which are:

1. The interaction between student type, grade, and sex.
2. The interaction between student type and grade.
3. The interaction between student type and sex.
4. The interaction between grade and sex.
5. The main effect of student type.
6. The main effect of grade.
7. The main effect of sex.

The Interaction Between Student Type, Grade, and Sex

There was no statistically significant interaction between student type, grade and sex in all the cognitive components for addition operation (encoding, $F(2,228)= 1.79$,

p=.231, speed of executing the operation, $F(2,228)$= 2.64, p=.074, operation selection, $F(2,228)$= 2.71, p=.065, strategy choice, $F(2,228)$= 2.01, p=.137) (See Table 20). That means, any of the study independent variables (student type, grade, and sex) did not affect the interaction for the other two independent variables. Therefore, no additional analyses for this stage were needed.

The Interaction Between Student Type and Grade

There was a statistically significant interaction between student type and grade in encoding, $F(2,228)$= 61.05, p<.001, (ω^2=.35), (See Table 20). To test the interaction between student type and grade in encoding, tests of simple main effects were conducted in order to examine differences between third grade and fifth grade students within each student type. Fifth grade students in all groups (non-handicapped learning disabilities, and mild mental retardation) had significantly less time in encoding than third grade students, when each group of them compared with their partners in the third grade (See Tables 6 and 21).

Table 6

T-Test for the Differences in Encoding Between Third and Fifth Grades

Group	*t*	*df*	*Sig*
Non-Handicapped	20.23	78	.001
Learning Disabilities	5.59	78	.001
Mild Mental Retardation	2.35	78	.021

Tests of simple effects, followed by post hoc comparisons using Tukey's HSD, were also conducted to examine differences in encoding among student type for each grade. For third and fifth grades, the students in the non-handicapped group spent significantly less time than the students in learning disabilities and mild mental retardation groups. On the other hand, the students in learning disabilities group spent significantly less time than the students in mild mental retardation group (See Tables 7 and 21).

Table 7

ANOVA for the Differences in Encoding Among Student Type

Grade	Source	*SS*	*df*	*MS*	*F*	*Sig*
Third grade	Student type	23.05	2	11.53	62.95	.001
	Error	21.42	117	.18		
	Total	720.78	120			
Fifth grade	Student type	71.66	2	35.83	216.80	.001
	Error	19.33	117	.17		
	Total	699.54	120			

There was a statistically significant interaction also between student type and grade in speed of executing the operation, $F(2,228)= 9.01, p<.001$, ($\omega^2=.07$), (See Table 20). To test the interaction between student type and grade in speed of executing the operation, tests of simple main effects were conducted in order to examine differences between third grade and fifth grade students within each student type. Fifth grade student in non-handicapped and mild mental retardation groups spent significantly less time in executing the operation than third grade students, when each group of them compared with their partners in the third grade, while there was no statistically significant differences in speed of executing the operation between third and fifth grades students in learning disabilities groups (See Tables 8 and 21).

Table 8

T-Test for the Differences in Speed of Executing the Operation Between Third and Fifth Grades

Group	*t*	*df*	*Sig*
Non-Handicapped	27.52	78	.001
Learning Disabilities	.02	78	.99
Mild Mental Retardation	4.43	78	.001

Tests of simple effects, followed by post hoc comparisons using Tukey's HSD, were also conducted to examine differences in speed of executing the operation among student type for each grade. For third grade, the students in the non-handicapped group spent significantly spent less time in executing the operation than the students in learning disabilities and mild mental retardation groups. On the other hand, the students in learning disabilities group spent significantly less time in executing the operation than the students in mild mental retardation group. For fifth grade, the students in the non-handicapped group spent significantly spent less time in executing the operation than the students in learning disabilities and mild mental retardation groups. There was no statistically significant difference in speed of executing the operation between the students in learning disabilities and the students in mild mental retardation group (See Tables 9 and 21).

Table 9

ANOVA for the Differences in Speed of Executing the Operation Among Student Type

Grade	Source	*SS*	*df*	*MS*	*F*	*Sig*
Third	Student type	131.98	2	65.99	140.44	.001
	Error	54.98	117	.47		
	Total	1834.92	120			
Fifth	Student type	243.77	2	121.88	88.17	.001
	Error	161.75	117	1.38		
	Total	1476.10	120			

There was a statistically significant interaction also between student type and grade in operation selection, $F(2,228)= 5.05, p=.007$, ($\omega^2=.04$), (See Table 20). To test the interaction between student type and grade in operation selection, tests of simple main effects were conducted in order to examine differences between third grade and fifth grade students within each student type. Fifth grade student in non-handicapped and mild mental retardation groups spent significantly less time in operation selection than third grade students when each group of them compared with their partners in the third grade, while there was no statistically significant differences in operation selection between third and fifth grades students in learning disabilities groups (See Tables 10 and 21).

Tests of simple effects, followed by post hoc comparisons using Tukey's HSD, were also conducted to examine differences in operation selection among student type for each grade. For third grade, the students in the non-handicapped and learning disabilities groups spent significantly less time in operation selection than the students in the mild mental retardation group. There was no statistically significant difference in operation selection between the students in the non-handicapped group and learning disabilities group. For fifth grade, the students in the non-handicapped group spent significantly spent less time in operation selection than the students in learning disabilities and mild mental retardation groups. There were no significant differences in operation selection between learning disabilities and mild mental retardation students (See Tables 11 and 21).

Table 10

T-Test for the Differences in Operation Selection Between Third and Fifth Grades

Group	*t*	*df*	*Sig*
Non-Handicapped	2.79	78	.001
Learning Disabilities	.16	78	.870
Mild Mental Retardation	2.40	78	.019

Table 11

ANOVA for the Differences in Operation Selection Among Student Type

Grade	Source	*SS*	*df*	*MS*	*F*	*Sig*
Third	Student type	24.64	2	12.32	8.27	.001
	Error	174.27	117	1.49		
	Total	1057.11	120			
Fifth	Student type	37.64	2	18.82	9.19	.001
	Error	239.58	117	2.05		
	Total	1298.89	120			

There was a statistically significant interaction also between student type and grade in strategy choice, $F(2,228) = 19.05$, $p < .001$, ($\omega^2 = .14$), (See Table 20). To test the interaction between student type and grade in strategy choice, tests of simple main effects were conducted in order to examine differences between third grade and fifth grade students within each student type. Fifth grade students in the non-handicapped group significantly used strategies that allowed them to spend less time in solving the operation than third grade students, while there was no statistically significant differences in strategy choice between third and fifth grades students in learning disabilities groups, and between third and fifth grades students in mild mental retardation groups (See Tables 12 and 21).

Table 12

T-Test for the Differences in Strategy Choice Between Third and Fifth Grades

Group	*t*	*df*	*Sig*
Non-Handicapped	21.50	78	.001
Learning Disabilities	1.75	78	.084
Mild Mental Retardation	1.58	78	.119

Tests of simple effects, followed by post hoc comparisons using Tukey's HSD, were also conducted to examine differences in strategy choice among student type for each grade. For third and fifth grades, the students in the non-handicapped group were significantly using strategies that allowed them to spend less time in solving the operation than the time that the students in learning disabilities and mild mental retardation groups spend in solving the operation. On the other hand, the students in the learning disabilities group significantly used strategies that allowed them to spend less time in solving the operation than the time that the students in the mild mental retardation group spend it in solving the operation (See Tables13 and 21).

Table 13

ANOVA for the Differences in Strategy Choice Among Student Type

Grade	Source	*SS*	*df*	*MS*	*F*	*Sig*
Third	Student type	61.45	2	30.73	187.30	.001
	Error	19.19	117	.16		
	Total	2303.75	120			
Fifth	Student type	115.00	2	57.50	451.72	.001
	Error	14.89	117	.13		
	Total	2757.25	120			

The Interaction Between Student Type and Sex

There was a statistically significant interaction between student type and sex on strategy choice, $F(2,228)= 6.15, p=.003$, ($\omega^2=.05$), (See Table 20). To test the interaction between student type and sex in strategy choice, tests of simple main effects were conducted in order to examine differences between male students and female students within each student type. For non handicapped and mild mental retardation groups, there were no significant differences in strategy choice between male and female students. While the male learning disabilities students significantly used strategies that allowed them to spend less time in solving the operation than the time that the female learning disabilities students spent in solving the operation (See Table 14 and 21).

Table 14

T-Test for the Differences in Strategy Choice Between Male and Female

Group	t	df	Sig
Non-Handicapped	.39	78	.698
Learning Disabilities	2.50	78	.015
Mild Mental Retardation	1.31	78	.195

Tests of simple effects, followed by post hoc comparisons using Tukey's HSD, were also conducted to examine differences in strategy choice among student type for each sex. For male and female, the students in the non-handicapped group were significantly used strategies that allowed them to spend less time in solving the operation than the time that the students in learning disabilities and mild mental retardation groups spent in solving the operation. On the other hand, the students in the learning disabilities group significantly used strategies that allowed them to spend less time in solving the operation than the time that the students in the mild mental retardation group spent in solving the operation (See Tables 15 and 21).

All the other interactions between student type and sex were not significant; encoding $F(2,228)= .07, p=.937$, speed of executing the operation $F(2,228)= .25, p=.778$, and operation selection $F(2,228)= 1.97, p=.143$ (See Table 20).

Table 15

ANOVA for the Differences in Strategy Choice Among Student Type in Each Sex

Grade	Source	*SS*	*df*	*MS*	*F*	*Sig*
Male	Student type	89.63	2	44.82	225.40	.001
	Error	23.26	117	.20		
	Total	2551.90	120			
Female	Student type	83.36	2	41.68	215.19	.001
	Error	22.66	117	.19		
	Total	2509.10	120			

The Interaction Between Grade and Sex

There was a statistically significant interaction between grades and gender on encoding, $F(1,228)= 52.72$, $p<.001$, ($\omega^2=.19$), (See Table 20). To test the interaction between grade and gender on encoding, tests of simple main effects were conducted in order to examine differences between male students and female students within each grade. For third grade students, female students spent significantly less times in encoding, than male students, while there was not a significant difference in encoding reaction time between male and female students in fifth grade (See Tables 16 and 21).

Tests of simple main effects were also conducted in order to examine differences between third grade and fifth grade students within each gender. For male students, there was not a significant difference in encoding reaction time between third and fifth grades. For female students, fifth grade students spent significantly less time in encoding, than third grade students (See Tables 17 and 21).

Table 16

T-Test for the Differences in Encoding Between Male and Female in Each Grade

Group	*t*	*df*	*Sig*
Third Grade	3.88	118	.001
Fifth Grade	1.80	118	.074

Table 17

T-Test for the Differences in Encoding Between Third and Fifth Grade in Each Sex

Group	*t*	*df*	*Sig*
Male	1.66	118	.099
Female	3.51	118	.001

There was a statistically significant interaction also between grades and sex on strategy choice, $F(1,228)= 8.97$, $p=.003$, ($\omega^2=.04$), (See Table 20). To test the interaction between grade and gender on strategy choice, tests of simple main effects were conducted in order to examine differences between male and female students within each grade. For third and fifth grades, there were no significant differences in strategy choice between male and female students (See Tables 18 and 21).

Tests of simple main effects were also conducted in order to examine differences in strategy choice between third and fifth grades students within each sex. For male students, fifth grade students significantly used strategies that allowed them to spend less time in solving the operation than the time that third grade students spend in solving the operation. For female students, there was no significant difference in strategy choice between third and fifth grades (See Tables 19 and 21).

Table 18

T-Test for the Differences in Strategy Choice Between Male and Female in Each Grade

Group	*t*	*df*	*Sig*
Third Grade	.72	118	.473
Fifth Grade	.92	118	.361

Table 19

T-Test for the Differences in Strategy Choice Between Third and Fifth Grade in Each Sex

Group	*t*	*df*	*Sig*
Male	3.00	118	.003
Female	1.36	118	.177

The other two interactions between grade and sex were not significant; speed of executing the operation $F(1,228)= .01, p=.909$, and operation selection $F(1,228)= 1.10$, $p=.296$ (Table 20).

The Main Effect of Student Type

The main effect of student type was statistically significant on encoding, $F(2, 228) =284.14, p<.001$ ($\omega^2=.71$), (See Table 20). Post hoc comparisons using Tukey's HSD were conducted. The students in the non-handicapped group spent significantly less time in encoding than the students in either the learning disabilities or mental retardation groups. On the other hand, the students in the learning disabilities group spent significantly less time in encoding than the students in the mild mental retardation group (See Table 21).

The main effect of student type was also statistically significant on speed of executing the operation, $F(2, 228) = 193.76, p < .001$ ($\omega^2 = .63$), (See Table 20). Post hoc comparisons using Tukey's HSD were conducted. The students in the non-handicapped group spent significantly less time in executing the operation than the students in either the learning disabilities or mental retardation groups. The speed of executing the operation reaction time of students in the learning disabilities group and mental retardation group did not differ significantly (See Table 21).

The main effect of student type was also statistically significant on operation selection, $F(2, 228) = 13.40, p < .001$ ($\omega^2 = .11$), (See Table 20). Post hoc comparisons using Tukey's HSD were conducted. The students in the non-handicapped group spent significantly less time in operation selection than the students in either the learning disabilities or mental retardation groups. The operation selection reaction time of students in the learning disabilities group and mental retardation group did not differ significantly (See Table 21).

The main effect of student type was also statistically significant on strategy choice, $F(2, 228) = 637.80, p < .001$ ($\omega^2 = .85$), (See Table 20). Post hoc comparisons using Tukey's HSD were conducted. The students in the non-handicapped group significantly used strategies that allowed them to spend less time in executing the operation than the strategies used by students in either the learning disabilities or mental retardation groups. Also the students in the learning disabilities group significantly used strategies that allowed them to spend less time in executing the operation than the strategies used by students in the mental retardation group (See Table 21).

The Main Effect of Grade

The main effect of grade was statistically significant on encoding, $F(1, 228) = 6.52$, $p = .011$ ($\omega^2 = .28$) (See Table 20). The students in fifth grade significantly spent less time in encoding than the students in third grade. The main effect of grade was statistically significant on speed of executing the operation, $F(1, 228) = 33.47$, $p < .001$ ($\omega^2 = .13$) (See Table 20). The students in fifth grade significantly spent less time in executing the operation than the students in third grade. The main effect of grade was also statistically significant on strategy choice, $F(1, 228) = 62.82$, $p < .001$ ($\omega^2 = .22$) (See Table 20). The main effect of grade was not statistically significant on operation selection, $F(1, 36) = .333$, $p = .567$ (See Tables 20 and 21).

The Main Effect of Sex

The main effect of sex was statistically significant on operation selection, $F(1, 228) = 4.58$, $p = .033$ ($\omega^2 = .20$) (See Table 21). The female students significantly spent less time in operation selection than the male students (See Table 20). The main effect of gender was not statistically significant on encoding, $F(1,228) = 1.71$, $p = .192$, speed of executing the operation, $F(1,228) = .12$, $p = .725$, and strategy choice, $F(1,228) = .50$, $p.482$ (Table 21).

Table 20

Multivariate ANOVA Summary Table

Source	*DV*	*SS*	*df*	*MS*	*F*	*Sig*	ω^2
Type	encode	77.96	2	38.98	284.14	.001	.71
	speed	359.05	2	179.53	193.76	.001	.63
	operation	45.22	2	22.61	13.40	.001	.11
	strategy	171.34	2	85.67	637.80	.001	.85
grade	encode	.89	1	.89	6.52	.011	.03
	speed	31.01	1	31.01	33.47	.001	.13
	operation	3.56	1	3.56	2.11	.148	
	strategy	8.44	1	8.44	62.82	.001	.22
sex	encode	.23	1	.23	1.71	.192	
	speed	.12	1	.12	.12	.725	
	operation	7.74	1	7.74	4.58	.033	.02
	strategy	.07	1	.07	.50	.482	
type * grade	encode	16.75	2	8.37	61.05	.001	.35
	speed	16.69	2	8.35	9.01	.001	.07
	operation	17.06	2	8.53	5.05	.007	.04
	strategy	5.12	2	2.56	19.05	.001	.14
type * sex	encode	.02	2	.01	.07	.937	

Table 20

Multivariate ANOVA Summary Table (continued)

Source	*DV.*	*SS*	*df*	*MS*	*F*	*Sig*	ω^2
type * sex	speed	.47	2	.23	.25	.778	
	operation	6.63	2	3.32	1.97	.143	
	strategy	1.65	2	.83	6.15	.003	.05
grade * sex	encode	7.23	1	7.23	52.72	.001	.19
	speed	.01	1	.01	.01	.909	
	operation	1.85	1	1.85	1.10	.296	
	strategy	1.20	1	1.20	8.97	.003	.04
type * grade *	encode	1.99	2	1.00	1.79	.152	
sex	speed	4.88	2	2.44	2.64	.074	
	operation	12.85	2	6.42	2.71	.069	
	strategy	.54	2	.27	2.01	.137	
Error	encode	31.28	228	.14			
	speed	211.25	228	.93			
	operation	384.79	228	1.69			
	strategy	30.63	228	.13			
Total	encode	1420.32	240				
	speed	3311.02	240				
	operation	2356.01	240				
	strategy	5061.00	240				

Table 21

Descriptive Statistics

DV	Gender		Non-Handicap		Learning Disabilities		Mental Retardation	
			3rd G	*5th G*	*3rd G*	*5th G*	*3rd G*	*5th G*
			N = 40	*N* = 40	*N* = 40	*N* = 40	*N* = 40	*N* = 40
Encode	Male	*M*	1.77	1.19	2.50	2.14	2.63	2.85
	N= 120	*SD*	.20	.06	.35	.59	.16	.37
	Female	*M*	1.93	1.16	2.59	2.33	3.21	2.73
	N=120	*SD*	.17	.08	.38	.27	.67	.52
Speed	Male	*M*	2.15	.95	3.99	3.31	4.89	3.65
	N= 120	*SD*	.22	.05	.39	1.17	.44	1.04
	Female	*M*	2.35	1.02	4.40	4.05	4.46	4.22
	N=120	*SD*	.31	.07	.62	1.60	1.35	.21
Operation	Male	*M*	2.36	2.02	3.64	3.42	3.30	3.51
	N= 120	*SD*	.62	.07	1.02	2.27	1.30	1.93
	Female	*M*	2.32	2.24	2.99	3.11	3.43	3.65
	N=120	*SD*	.21	.98	.86	.30	1.24	.89
Strategy	Male	*M*	5.10	5.95	4.45	4.73	3.20	3.63
	N= 120	*SD*	.19	.05	.46	.44	.50	.85
	Female	*M*	5.20	5.92	4.28	4.38	3.60	3.48
	N=120	*SD*	.25	.04	.54	.40	.22	.58

Results - Second Hypothesis

According to Geary and Widaman (1987) and Kirby and Becker (1988), in terms of solving the mathematical problems, students usually use either recall from their long term memory strategy (automatic production) or use one of the counting strategies (which might involve the student's use of his fingers or other manipulative). These counting strategies are: simple counting strategy, addition to the first number strategy, addition to the second number strategy, addition to the smaller number strategy, and addition to the larger number strategy.

Based on the above addition solving strategies, the second hypothesis stated that "There are statistically significantly differences between the strategies that the non-handicapped students use for solving addition problems and:

1. Those used by the learning disabilities students.

2. Those used by the students with mental retardation."

To investigate this hypothesis a Chi-Square test for independence was conducted to examine if there were differences among the three types of students in strategies that were used to solve addition problems in third and fifth grades.

In recalling strategy, there were statistically significant differences among the three types of students (Non Handicapped, Learning Disabilities, and Mild Mental Retardations) in third grade. $X^2(8, n = 120) = 163.57, p < .001$. Also, there were statistically significant differences among the three types of students (Non Handicapped, Learning Disabilities, and Mild Mental Retardations) in fifth grade. $X^2(10, n = 120) = 240.00, p < .001$ (See Table 22).

Table 22

Chi-Square Test for Recalling Strategy

		Frequencies		
	Times	Non Handicap	Learning Disability	Mental Retardation
	using the	$N = 40$	$N = 40$	$N = 40$
Grade	strategy	(for each grade)	(for each grade)	(for each grade)
Third	2 times	1	7	40
	6 times	17	15	0
	8 times	7	18	0
	10 times	11	0	0
	12 times	4	0	0
Fifth	2 times	0	3	40
	6 times	0	12	0
	8 times	0	14	0
	10 times	0	11	0
	18 times	23	0	0
	20 times	17	0	0

In adding to the larger number strategy, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in third grade, $X^2(10, n = 120) = 124.00, p < .001$. Also, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in fifth grade, $X^2(8, n = 120) = 53.86, p < .001$ (See Table 23).

Table 23

Chi-Square Test for Adding to the Larger Number Strategy

		Frequencies		
Grade	Times using the strategy	Non Handicap $N = 40$ (for each grade)	Learning Disability $N = 40$ (for each grade)	Mental Retardation $N = 40$ (for each grade)
Third	0 times	0	10	8
	2 times	1	6	20
	4 times	1	9	7
	6 times	3	13	5
	8 times	31	2	0
	10 times	4	0	0
Fifth	0 times	14	13	3
	2 times	23	10	17
	4 times	2	6	16
	6 times	0	6	4
	8 times	0	5	0

In adding to the first number strategy, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in third grade, $X^2(10, n = 120) = 89.04, p < .001$. Also, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in fifth grade, $X^2(12, n = 120) = 165.14, p < .001$ (Table 24).

Table 24

Chi-Square Test for Adding to the First Number Strategy

Grade	Times using the strategy	Frequencies Non Handicap $N = 40$ (each grade)	Learning Disability $N = 40$ (each grade)	Mental Retardation $N = 40$ (each grade)
Third	0 times	9	5	0
	2 times	8	13	1
	4 times	3	11	4
	6 times	19	6	8
	8 times	1	0	19
	10 times	0	5	8
Fifth	0 times	39	0	1
	2 times	1	11	4
	4 times	0	9	5
	6 times	0	6	5
	8 times	0	1	18
	10 times	0	9	7
	12 times	0	4	0

In adding to the second number strategy, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in third grade, $X^2(6, n = 120) = 77.14, p < .001$. Also, there were statistically significant differences among the three types of students (Non Handicaps, Learning Disabilities, and Mild Mental Retardations) in fifth grade, $X^2(4, n = 120) = 45.18, p < .001$ (See Table 25).

Table 25

Chi-Square Test for Adding to the Second Number Strategy

		Frequencies		
Grade	Times using the strategy	Non Handicap $N = 40$ (for each grade)	Learning Disability $N = 40$ (for each grade)	Mental Retardation $N = 40$ (for each grade)
Third	0 times	40	19	7
	2 times	0	8	26
	4 times	0	9	1
	6 times	0	4	6
Fifth	0 times	40	27	13
	2 times	0	10	16
	4 times	0	3	11

In adding to the minimum number strategy, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in third grade, $X^2(4, n = 120) = 22.39, p < .001$. Also, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations) in fifth grade, $X^2(4, n = 120) = 78.46, p < .001$ (See Table 26).

Table 26

Chi-Square Test for Adding to the Minimum Number Strategy

		Frequencies		
Grade	Times using the strategy	Non Handicap $N = 8$ (for each grade)	Learning Disability $N = 8$ (for each grade)	Mental Retardation $N = 8$ (for each grade)
Third	0 times	29	14	19
	2 times	10	23	15
	4 times	1	3	6
Fifth	0 times	38	19	4
	2 times	2	18	22
	4 times	0	3	14

In adding to the Zero strategy, there were statistically significant differences among the three types of students (non-handicapped, learning disabilities, and mild mental retardations)in third grade, $X^2(10, n = 120) = 111.01, p < .001$. Also, there were statistically significant differences among the three types of (non-handicapped, learning disabilities, and mild mental retardations) in fifth grade, $X^2(6, n = 120) = 71.50, p < .001$ (See Table 27).

Table 27

Chi-Square Test for Adding to the Zero Strategy

		Frequencies		
Grade	Times using the strategy	Non Handicap $N = 8$ (for each grade)	Learning Disability $N = 8$ (for each grade)	Mental Retardation $N = 8$ (for each grade)
Third	0 times	38	10	0
	2 times	1	13	9
	4 times	1	11	8
	6 times	0	2	9
	8 times	0	4	8
	10 times	0	0	6
Fifth	0 times	40	13	5
	2 times	0	17	14
	4 times	0	7	13
	12 times	0	3	8

Results - Third Hypothesis

The third hypotheses stated that "Based on the students' performance in a test for cognitive components for simple addition operations, the encoding, speed of executing the operations, operation selection and choosing the solving strategy:

1. Can predict students with learning disabilities in the elementary school.
2. Can predict students with mild mental retardation in the elementary school."

To investigate this hypothesis a multiple linear regression was conducted to examine if the cognitive components of addition operation (encoding, speed of executing the operation, operation selection, and strategy choice), grades and gender predicted students type. Table 28 shows the correlation between students' type and each of the cognitive components of addition operation. It also shows the correlation among the cognitive components of addition operation. In addition to that the table also shows the descriptive statistics for the students' type and the cognitive components of addition operation. The model was statistically significant, *r-square* = .831, $F(6,233) = 191.53$, $p<.001$. Speed of executing the operation, strategy choice and grade were statistically significant in predicting student type (See Table 29).

Table 28

Correlation and Descriptive Statistics (N = 240)

	M	*SD*	Encode	Speed	Operation	Strategy	Grade	Gender
Student type	2.00	.82	.69*	.66*	.18*	-.88*	.00	.00
Encode	2.31	.76		.72*	.12*	-.69*	-.08	.04
Speed	3.35	1.62			.01	-.66*	-.22*	.01
Operation	2.80	1.42				-.16*	.09	-.13*
Strategy	4.49	.96					.20*	-.02
Grade	.50	.50						.00
Gender	.50	.50						

$*p < .05$.

Table 29

Multiple Linear Regression

Variable	*b*	*Sb*	*t*	*P*
Encoding	.058	.047	1.24	.217
Speed of executing	.076	.021	3.57	.001
Operation selection	.016	.016	1.01	.316
Strategy choice	-.667	.035	-19.30	.001
Grade	.308	.046	6.70	.001
Gender	-.023	.044	-.53	.599
Constant	4.422	.245	18.21	.001

Chapter 5

THE RESULTS, DISCUSSION, AND CONCLUSION

This chapter contains discussion of the study results. In addition to the study conclusion, the educational applications for the study results and suggested research are addressed.

Discussion of the Study Results

The Differences According to the Student Type

The study results showed that the non-handicapped students were spending less time in proceeding through each of the cognitive components of addition operation (encoding, speed of executing the operation, operation selection, and strategy choice) than the learning disabilities and mild mental retardation students. In addition, non-handicapped were using the solving strategies that led them to spend a shorter time in finding the product of the addition operation than the time that the learning disabilities and mild mental retardation students spend to find the product of the addition operation. Moreover, the results showed that the time students with learning disabilities were spending in encoding was less than the time that the mild mental retardation pupils were spending in the same component. The students with learning disabilities were also using the solving strategies that lead them to spend a shorter time in finding the product of the addition operation than the time that the mild mental retardation students spent to find the product of the addition operation. No differences appeared between them in the speed of executing the operation and operation selection.

By taking into consideration that the study sample, which were the non-handicapped, learning disabilities, and mild mental retardation students have mastered all the previous skills for addition operation, the differences between the non-handicapped, learning disabilities, and mild mental retardation in the cognitive components of the addition operation could be attributed to a disorder in the cognitive or the meta-cognitive operations that the students used when they solved the operation.

Moreover, the mental ability limitations and the weaknesses in the numbers recognition skill for the pupils with learning disabilities and mild mental retardation could negatively affect the cognitive components of the addition operation. Usually that weakness arises during the first years of the school, where the disorder is in factors like realization, attention, the audio and optic memory, mental ability and other factors that usually accompanying the learning disabilities and mild mental retardation pupils which can lead to the weakness in the skill of recognition on the numbers (Frederick, 1989). As a result of non-treatment of this weakness in the first years, this problem starts to present more and more through the advancing academic years. Therefore, the non-handicapped pupils develop their skill in recognizing numbers without any problems, due to the absence of those factors which hinder the cognitive growth development of that skill. This helps them increase their encoding ability as they advance through their academic years. Conversely, the skill of recognizing numbers for the pupils with learning disabilities and mild mental retardation remains at the same level, due to those factors that hinder the development of the recognizing numbers skill, which leads to their weakness in the ability of encoding the numbers. These factors contribute to the problem appearance as these students advance though their academic years.

These results have agreed with the results of other studies where their results revealed that the pupils who suffer from difficulties in the mathematics have a weak ability in cognitive components of the addition operation (Carpenter & Moser, 1984; Fuson 1988; Kirby & Becker, 1988; Svenson & Broquist, 1975).

The Differences Between the Students in the Third and Fifth Grades

The study results showed that male and female students in the fifth grade were spending less time in processing each of the cognitive components of addition operation (encoding, speed of executing the operation, operation selection, and strategy choice) than the male and female students in the third grade. In addition, the male and female fifth grade students were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the male and female students in the third grade spent to find the product of the addition operation.

When the third grade pupils are separated from the fifth grade pupils, and the comparison of the reaction times among the three study groups (the non-handicapped, learning disabilities, and mild mental retardation) in each grade is taken separately, the results showed that the non-handicapped pupils in the third grade were spending less time in processing each of the cognitive components of the addition operation (encoding, speed of executing the operation, operation selection, and strategy choice) than mild mental retardation pupils. In addition, the non-handicapped pupils in the third grade were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the mild mental retardation pupils spent to find the product of the addition operation. On the other hand, the non-handicapped pupils were spending less time in processing two of the cognitive components of the addition operation which were (encoding and speed of executing the operation) than the learning disabilities pupils, and they were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the learning disabilities pupils spent to find the product of the addition operation. There were no differences between them in choice of the type of the mathematical operation. The comparison between the learning disabilities and the mild mental retardation pupils in the third grade showed that the learning disabilities pupils were spending less time in processing each of the cognitive components of the addition operation (encoding, speed of executing the operation, operation selection, and strategy choice) than the mild mental retardation pupils. In addition, they were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the mild mental retardation pupils spent to find the product of the addition operation.

For the fifth grade pupils, the results showed that the non-handicapped students were spending less time in processing each of the cognitive components of the addition operations (encoding, speed of executing the operation, operation selection, and strategy choice) than the time spent by the learning disabilities and mild mental retardation students. In addition, they were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the learning disabilities and mild mental retardation students spent to find the product of the addition operation. On the other hand, the comparison between the learning disabilities and the mild mental retardation pupils in the fifth grade showed that the learning disabilities pupils were spending less time in proceeding the encoding numbers than the mild mental retardation pupils. They were also using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the learning disabilities pupils spent it to find the product of the addition operation. There were no differences between them in speed of executing the operation and choice of the type of the mathematical operation.

All the results, indicate that the ability of the non-handicapped pupils in the cognitive components of addition operation (encoding, speed of executing the operation, operation selection, and strategy choice) is increasing as they move toward the higher academic grades, while this ability usually remains as it is with the learning disabilities and mild mental retardation pupils as they move toward higher academic grades. If there is any improvement, this improvement will be very small when comparing it with the improvement of the non-handicapped pupils.

The non development or improvement of the learning disabilities and mild mental retardation pupils' abilities in the cognitive components of the addition operation through the academic stages may be attributed to what Carpenter and Moser (1984) reported about the features of pupils that suffer from difficulties in mathematics. They mentioned that such pupils usually try to repeat the solution operation more than once to insure that they got the right answer. They do not have enough confidence with their knowledge and skills to ensure that they get the right answer the first time, so they try to resolve the operation for a second and third time until they have enough confidence that the answer that they got is the right answer. Moreover, when they count the two additions, they may forget the ordinal count (count by one, 1, 2, 3, ...) which leads them to spend a longer time in the ordinal count attempts. The ordinal count is related to the long-term memory and recalling ability, and the learning disabilities and the mild mental retardation pupils suffer in general of weakness in a long-term memory and recalling ability (Hargroof & Boteet, 1988).

This result agrees with the results that earlier studies reached (Geary, 1990; Geary & Brown, 1991a; Geary & Widaman, 1987; Kirby & Becker, 1988) where it was found that the pupils who suffer from difficulties in mathematics were taking a longer time executing the mathematical operations as compared with the non-handicapped pupils.

The Differences Between the Male and Female Pupils

As for the differences between the males and the females, the results showed that there were no differences between them in all the cognitive components of addition operations except for the operation selection component in which the female students were spending less time in processing mathematical operation selection than the time spent by the male students. When the students were separated according to their non-handicapped and handicapped types, and the comparison of the reaction times between the male and the female students in each type were taken separately, the results showed that the there were no differences between the males and the females in all the cognitive components of addition operations at the non-handicapped and the mild mental retardation groups. In the learning disabilities group, the female students were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the male students spent it to find the product of the addition operation. In addition to that, when the third grade pupils were separated from the fifth grade pupils, and the comparison of the reaction times between the male and the female students in each grade took place separately, the results showed that the male students in the third grade were spending less time in encoding the numbers, and were using the solving strategies that led them to spend less time in finding the product of the addition operation than the time that the female students spent. No difference appeared between the male and female students in the fifth grade in any of the cognitive components of addition operation.

It can be noted that the differences between the male and the female students were not greatly clear. Therefore, these differences could be attributed to the individual differences of the participants in the study or to the nature of the gender differences in the Middle Eastern countries. For example, life practices for females are different from that of males. Moreover, the literature review (guiding their study) did not include any study results that indicated differences between the male and the female students in any of the cognitive components of addition operation.

The Differences in the Solution Strategies

The study results showed that the non-handicapped pupils in the third and fifth grades were depending on advanced strategies in order to solve the mathematical operations. The third grade pupils were using each of the adding to the greatest number strategies, which is considered the most advanced of the counting strategies, in addition to the recall strategy. The non-handicapped pupils in the fifth grade were depending completely on recall as a strategy to solve the mathematical operations. As for learning disabilities pupils in the third and fifth grades, they were rarely using the recall strategy. In addition, they did not use a clear or stable strategy to solve the mathematical operations. The mild mental retardation pupils were dependent completely on the simplest model of counting, which is; starting from zero, in order to solve the mathematical operations.

This result may be attributable to slowed cognitive development and the difficulties in acquiring the mathematical operations skills that are common to students with learning disabilities and mild mental retardation. Pupils in the first grades usually use the primitive counting models such as the counting from zero strategy in order to solve the addition operation. With the development of their cognitive abilities, they increase their acquisition of mathematical operations skills. Consequently, they start to depend on the count models that are more advanced such as the addition on the first and the addition on the greatest strategies until they come to use with use the recall strategy at the end (Geary, 1990). Slowness in the cognitive development of the learning disabilities and the mild mental retardation pupils inhabits their development of advanced strategies for solving mathematical operations. Consequently, they do not develop their skills in choosing the most efficient models for solving the addition operation. These students experience confusion when they try to choose the model that they will use to find the answer of the operation. Moreover, they sometimes use two different models to solve the same operation in two different settings (Goldman, Mertz, & Pellegrino, 1989). Consequently, the natural cognitive growth of non-handicapped pupils enhances their development of skills. For example, they learn to choose the most efficient models for solving the addition operations.

These results agreed with the results reached by Svenson and Broquist (1975) which illustrated that the mathematics difficulties that learning disabilities and the mild mental retardation pupils face in solving addition operations are consistent with their disability to select suitable strategies. These results also agreed with the study results of Fuson (1988) which illustrated that first grade pupils used different counting models in solving the addition operations, while the pupils in the higher grades sometimes used the counting models, while at other times used the recall strategy. These results also agreed with the study results of Geary and Brown (1991b) which showed that the learning disabilities and the mild mental retardation pupils were mostly using the counting models and rarely used the recall strategy, while the non-handicapped pupils were mostly using the recall strategy and rarely used the counting models in solving the addition operations.

The Ability of Prediction

Two of the cognitive components: the speed of executing the operation, and strategy choice, showed, in addition to the academic grade variable, their ability to predict the pupil type (the non-handicapped, learning disabilities, and mild mental retardation). However, the ability of the cognitive components to predict the pupil type is different from one component to another. While speed of executing the operation, strategy choice, and academic grade variables were highly predictive of pupil type, the ability of the other components and variables such as encoding, operation selection, and gender were rather low in predicting the pupil type.

Therefore, we can say that the components that best predict the pupil type were the speed of executing the operation and strategy choice in addition to the academic grade variable. The reason for the increase of the ability of these two components to predict the pupil type may by ascribed to the big differences between the non-handicapped pupils and each of the learning disabilities and the mild mental retardation in those two components. This conclusion agrees with the results of the first question in this study and the results of the previous studies.

The Conclusion

In review of the results of the study, it is asserted that the weakness in the cognitive components of the addition operation skills is the primary factor in the difficulties that the learning disabilities and the mild mental retardation pupils' experience in solving the mathematical operations. More specifically, the encoding and the speed of executing the operation components plays the largest role in the difficulties that those pupils face in solving the mathematical operation in the first grades, while the strategy choice, encoding and speed of executing the operation have the biggest share of the difficulties that those pupils face in solving the mathematical operation in the higher grades.

Therefore, in our school's curriculum, more attention must be given to encoding and the speed of executing the operation components in the first years, and to strategy choice, encoding and speed of executing the operation in the advanced years. Moreover, we should attempt to treat the difficulties that learning disabilities and the mild mental retardation pupils face in those components in order to solve the difficulties that those pupils in mathematical operation and in mathematics in general.

The Educational Applications

In light of what the results of the current study show, we can extract the following educational applications:

1. When designing therapeutic educational programs and creating the individual plans for the learning disabilities and the mild mental retardation pupils who

face difficulties in the mathematical operation, we should:

1-1. Use multiple channels and all or most of the students' senses in teaching encoding numbers.

1-2. Not go to the next steps until the teacher is sure that the student encodes all the numbers correctly in his/her memory.

1-3. Teach students how to use effective strategies (adding to the greatest number and recalling strategy) when solving addition operations.

2. Changing the mathematics textbooks in the elementary school include the skills that help in raising pupils' efficiency in encoding numbers, speed in executing the mathematical operations, and support the cognitive ability to choose suitable strategies for solving the mathematical operations by:

   2-1. Including in the mathematics textbooks all five counting strategies, and the recalling strategy for solving the addition operations.

   2-2. Including in the mathematics textbooks some exercises that depend on time to finish. This will help students use the recalling strategy.

   2-3. Re-organize all skills and concepts in the mathematics textbooks to build on perceivable – semi-abstract to abstract strategies.

3. Concentrate on teaching the pupils in the first grades the most efficient counting models, which is adding to the greatest number, to help the learning disabilities and the mild mental retardation pupils avoid confusion in choosing the suitable counting model for the given addition operation.

4. Consolidating and increasing the confidence of the learning disabilities and the mild mental retardation pupils with their ability to recall the addition facts

from memory by:

4-1. Encourage them to recall the simple addition facts such as (1 + 1) from their memory.

4-2. Give them some addition facts that you know that he/she is familiar with to recall answers from their memory.

4-3. Use with them a lot of exercises to recall the addition facts from their memory.

5. Using the cognitive components of the addition operation measurement used in this study as an initial diagnostic tool for learning disabilities and mild mental retardation pupils.

Suggested Research

According to the results reached in the current study, the researcher suggests the following studies:

1. Studying the differences in the cognitive components of the addition operation among the non-handicapped, learning disabilities and mild mental retardation pupils, including all the school grades in the elementary school.
2. Investigating the reasons that contribute to the weakness of the learning disabilities and the mild mental retardation pupils in the cognitive components of the addition operation.
3. Investigating the effect of interventions designed to increase the ability of the learning disabilities and the mild mental retardation pupils in the cognitive components of the addition operation in solving the mathematical operations.

4. Studying differences in the cognitive components of the other mathematical operations such as subtraction, multiplication and division among the non-handicapped, learning disabilities and mild mental retardation pupils, to find correlations that might lead to better interventions.

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APPENDIX A

The Addition Operations Pre-Skills Test

Name:______________________________

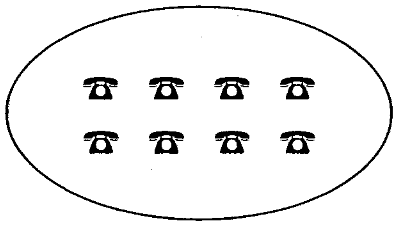
Grade:_____________________________

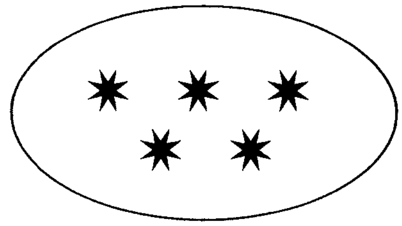
School:____________________________

The researcher
Fawzi Aldoukhi

First question:

Match between the figures and the numbers





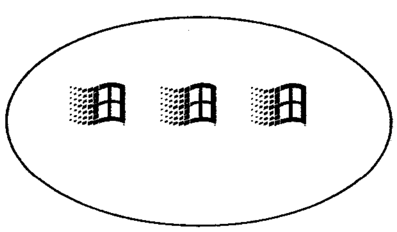
8	7	5	4

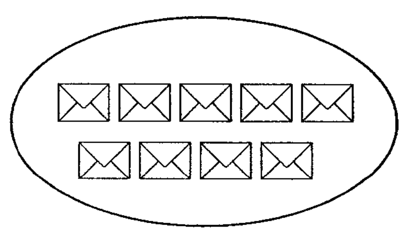
Second question:

Write the numbers will be dictated on you

Third question

Write the number:





Fourth question:

Put (< , > or =)

3		5
8		4
9		9

Fifth question:

Arrange the numbers in ascending order

7	9	0	3

Sixth question:

Arrange the numbers in descending order

4	1	8	5

APPENDIX B

Appendix B.1

The Cognitive Components for the Addition Operation Test

Prepared by the researcher

The first subsidiary test: the measurement of the encoding ability.

A- The measurement of the successive encoding:

1- The training tasks

1. 2 = then 1	2. 5 = then 5
3. 7 = then 7	4. 8 = then 9

2- The tasks

1. 8 = then 8	2. 3 = then 3
3. 4 = then 5	4. 7 = then 6
5. 3 = then 5	6. 2 = then 2
7. 0 = then 1	8. 5 = then 5
9. 0 = then 0	10. 3 = then 4
11. 8 = then 6	12. 9 = then 9
13. 7 = then 7	14. 1 = then 1
15. 9 = then 7	16. 4 = then 4
17. 8 = then 9	18. 2 = then 0
19. 6 = then 6	20. 1 = then 2

Appendix B.2

The Cognitive Components for the Addition Operation Test

Prepared by the researcher

The first subsidiary test: the measurement of the encoding ability.

B- The measurement of the simultaneous encoding:

1- The training tasks

1. 3 = 3	2. 9 = 9
3. 4 = 2	4. 5 = 6

2- The tasks

1. 2 = 2	2. 5 = 3
3. 6 = 6	4. 9 = 9
5. 6 = 5	6. 2 = 0
7. 8 = 9	8. 1 = 1
9. 4 = 3	10. 8 = 8
11. 0 = 0	12. 8 = 7
13. 5 = 5	14. 3 = 3
15. 2 = 1	16. 9 = 7
17. 4 = 4	18. 0 = 1
19. 6 = 4	20. 7 = 7

Appendix B.3

The Cognitive Components for the Addition Operation Test

Prepared by the researcher

The second subsidiary test: Measure the speed of execution of the addition operations.

1- The training tasks

Addition

1. 2 + 3 = 5	2. 1 + 8 = 7
3. 9 + 0 = 9	4. 7 + 4 = 12

2- The tasks

Addition

1. 1 + 2 = 3	2. 4 + 5 = 10
3. 7 + 8 = 17	4. 0 + 4 = 4
5. 9 + 7 = 16	6. 8 + 6 = 14
7. 3 + 9 = 13	8. 6 + 1 = 5
9. 5 + 3 = 8	10. 2 + 0 = 1
11. 9 + 4 = 11	12. 3 + 2 = 6
13. 7 + 6 = 13	14. 8 + 1 = 7
15. 0 + 9 = 9	16. 5 + 7 = 14
17. 1 + 3 = 4	18. 2 + 5 = 7
19. 6 + 0 = 5	20. 4 + 8 = 12

Appendix B.4

The Cognitive Components for the Addition Operation Test

Prepared by the researcher

The third subsidiary test: Measure the ability of select the operation type.

1- The training tasks

1. $6 - 3 = 4$	2. $8 + 4 = 12$
3. $9 - 2 = 7$	3. $5 + 1 = 8$

2- The tasks

1. $9 - 4 = 7$	2. $2 + 5 = 5$
3. $9 + 6 = 15$	4. $5 - 5 = 0$
5. $3 + 4 = 6$	6. $8 - 7 = 1$
7. $3 + 6 = 9$	8. $5 + 8 = 13$
9. $2 + 1 = 4$	10. $7 - 3 = 3$
11. $8 - 6 = 2$	12. $7 + 0 = 7$
13. $2 - 1 = 1$	14. $9 - 5 = 6$
15. $1 + 8 = 7$	16. $3 - 0 = 4$
17. $6 - 1 = 5$	18. $0 + 9 = 8$
19. $4 - 2 = 3$	20. $7 + 4 = 11$

Appendix B.5

The Cognitive Components for the Addition Operation Test

Prepared by the researcher

The fourth subsidiary test: the cognitive model (Strategy) used in the solving .

1- The training tasks

1. $3 + 6 = 9$	2. $1 + 5 = 7$
3. $2 + 8 = 11$	4. $6 + 6 = 12$

2- The tasks

1. $4 + 8 = 12$	2. $0 + 6 = 6$
3. $1 + 3 = 5$	4. $5 + 7 = 10$
5. $0 + 4 = 3$	6. $1 + 7 = 8$
7. $8 + 4 = 12$	8. $7 + 5 = 10$
9. $6 + 8 = 15$	10. $2 + 3 = 5$
11. $6 + 0 = 6$	12. $3 + 1 = 5$
13. $2 + 9 = 13$	14. $7 + 1 = 8$
15. $5 + 9 = 14$	16. $4 + 0 = 3$
17. $9 + 2 = 13$	18. $8 + 6 = 15$
19. $3 + 2 = 5$	20. $9 + 5 = 14$

APPENDIX C

Informed Consent Form (Parent's Permission)

Indiana State University

Indiana State University
Institutional Review Board
APPROVED
Date of IRB Approval: 10/30/2006
IRB Number: 6055
Project Expiration Date: 10/30/2007

October 1, 2006

Dear Parent or Guardian:

I am Fawzi Aldoukhi, a doctoral student in the CIMT (Curriculum, Instruction, and Media Technology) Department at Indiana State University. I request permission for your child to participate in a research study to be used for my doctoral dissertation. I am conducting a research project on (Differences among Non-handicapped Students, Students with Mathematics Learning Disabilities, and Students with Mild Mental Retardation, in Elementary School in the Cognitive Components for the Addition Operation.).

I hope to use what I learn from the study to make changes to the teaching of mathematics so it will help students with learning disabilities and mild mental retardation learn mathematics in a better way.

The study consists of the following activities:

1. I will ask your permission for your child to take part in 2 tests. The first one will take about ten minutes. Your child will take this test with the whole group of participants. For the second test, your child will take a test individually. This will take about 20 minutes.
2. These two tests may include: (1) answering some mathematical questions that he/she will do either by hand or using the computer.

Only the professor supervising my work and I will have access to information from your child. At the conclusion of the study, children's responses will be saved and secured in a personal computer file.

Participation in this study is voluntary. However you permission for the inclusion of your child in the study will be highly appreciated. Your permission will mean that you and your child are not waiving any legal claims, rights, or remedies because of your child's participation in this research study.

Should you have any questions or desire further information, please feel free to contact

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Keep this letter after completing and returning the signature page to me.

If you have any questions about your rights as a research subject, you may contact the Indiana State University Institutional Review Board (IRB) by mail at 114 Erickson Hall, Terre Haute, IN 47809, by phone at (812) 237-8217, or e-mail the IRB at irb@indstate.edu. You will be given the opportunity to discuss any questions about your rights as a research subject with a member of the IRB. The IRB is an independent committee composed of members of the University community, as well as lay members of the community not connected with ISU. The IRB has reviewed and approved this study.

Sincerely,

Fawzi Aldouhki

CIMT (Curriculum,
Instruction, and
Media Technology)

Indiana State University
Institutional Review Board
APPROVED
Date of IRB Approval: 10/30/2006
IRB Number: 6055
Project Expiration Date: 10/30/2007