WHAT KIND OF STRATEGIES CAN I USE TO HELP 4TH GRADE STUDENTS LEARN THEIR MULTIPLICATION FACTS?
ABSTRACT

The study investigates the value and rationale of using some multiplication learning strategies in the Mathematics classroom with special focus on their effectiveness in promoting problem solving skills in Mathematics. The work involves comparison with traditional teaching methods. The sample was composed of 4th grade students, separated into two groups, taught various strategies on how to master their multiplication facts. Pre- and post- mathematical proficiency tests were adopted to evaluate students’ performance in multiplication problem solving skills and achievement. This was done over a period of four weeks. After the study, an evaluation questionnaire was given to each of the participants at the end of the experiment.
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CHAPTER 1: INTRODUCTION

Background and Research Context

One of the basic aims mathematical educational research studies in the U.S.A. and even globally, is to improve the process of teaching and learning math. And such research has always been rooted in the Mathematics classroom (Nickson, 2000). Searching for the effects of various factors that influence the process of learning and teaching is still a subject of serious concern among researchers around the world. Social class, individual ability, cultural factors, gender, self-motivation, teacher’ ability to teach well, environmental factors, curriculum architecture, style of learning, teaching approaches, individual state of health, student’s approach way of approaching new situations, and several other factors all affect learning and teaching.

Instructional methodologies and strategies involved in the mathematical classrooms are basically one of the most fundamentally significant factors that might determine the learning process and have an effect on students' outcomes. Nevertheless, these strategies must constantly be aimed at improving the quality of students' learning and encourage an advanced and contemporary level of thinking process. Though there is an increasing amount of research that has been done in aspect of improving learning in mathematics education in the past few decades, there is need for more empirical studies-- such as this-- to either reinforce or disagree with some of those past studies. The search for the effectiveness of most of the classroom learning and teaching instructional strategies towards improving problem solving skills is particularly important. The quest for the rationality of adopting various mathematics problems solving strategies that result from most of these studies is equally important.
In America's modern-day academics setting, mathematics education is regarded as the practice of teaching and learning mathematics, in conjunction with the related scholarly research. Primarily in mathematics education, researchers are concerned with methods, tools and approaches that promote study of practice or practice itself. Today, mathematics education research has grown into a far-reaching field of study (Orton, 1992), having its own theories, concepts, methods, organizations –both at national and international levels, literature and conferences. This study especially focuses on multiplication problem solving skills as a way of contributing to the existing body of studies in the mathematics educational research field.

The contents of this chapter consist of many sections that provide answers to the following questions: Why is the study needed? What is researcher aiming at? What are the research questions? Moreover, what is the context of the study?

**Purpose of Study**

Generally as found in the review of literature in mathematics education and researcher’s observation based on personal experience in classroom teaching in America, this study is important and needed due to the concerns discussed below.

*Prospect of Improving Mathematical Problem Solving Skills via Multiplication*

Many researchers in various parts of the world have drawn attention to the benefits which mathematics learning strategies can have over the conventional and individualized forms of support that have been provided for students who find it learning difficult in the mathematics classroom. This study was specifically designed to look at the effects of various strategies of teaching and learning multiplication facts
at fourth grade level. This study agrees with instructional design features ranging from what has been illustrated by Hasselbring and his partners (Hasselbring et al., 1988; Hasselbring et al., 2005) to modern approaches to instruction in math facts (Garnett, 1992; Isaacs & Carroll, 1999; Ma, 1999; Sherin & Fuson, 2005; Thornton, 1990; Van de Walle, 2003) –these studies all suggest that strategy instruction also comprises an emphasis on the connection between facts and extended facts.

General Weakness and Difficulties in Mathematics Problem Solving

Orton (1992) argued that although mathematical education has grown to become an established subject from both perspectives of mathematics as a subject and education as a discipline, a need for specialized study on its own is still very important. Furthermore, it is generally strongly believed within the mathematics education setting that most students are unable to apply the mathematics they learn at school in situations beyond the classroom (Boaler, 1997). This insinuates that students are not capable of reconciling what they are being taught in mathematics classes with real life situations –meaning, there is a disjoint between theoretical knowledge and practical knowledge. Students cannot appreciate properly the theory, laws, symbols, formulas and algorithms to apply them in addressing real life problems (Tall and Razali, 1993). Wain and Woodrow (1980) also pointed the role of language in teaching mathematics as an important factor for students, particularly where mathematics language is a unique language which is not often so easily understood and handled appropriately. In the actual sense, United States students just like any other students, experience difficulties in learning mathematics. Often times, parents as well as teachers complain that mathematics is the weak point of students, especially when it comes to applying mathematics in the advanced thinking process.
Non-application of Rational Mathematics

Mathematics is used realistically and virtually as a subject in daily life endeavors. Everywhere and at all times, people either consciously or unconsciously apply mathematics. If not for any other thing, there is always a need to apply mathematics as we calculate, deal with time, work on other subjects, market, carryout professional and any other forms of jobs such engineering, medicine, industry, trading, economic analysis, education, physical sciences, nitration, enforcement of law, and several others. Consequently, effective utilization of mathematics is crucial to man’s everyday experience and existence. The basic goal of mathematics education is to provide students with the right background in mathematics to enable them fair well as they pursue their respective careers (Charles and Lester, 1984). According to findings by Cooper and Dune (2000), several research studies reveal that students more often than not fail to make relevant to their endeavors realistic mathematics or possibly they fail to demonstrate their knowledge and understanding of the mathematics they have gained from the various views in the classroom.

Other reasons for this study include need to improve the quality of the teaching and learning process in American Mathematics Classrooms, and negative attitudes towards the subject of mathematics.

The Academic Context and Key Academic Theory

Information-processing theory favors the standpoint that automaticity in mathematical facts (in the context of this study, multiplication facts) is essential to achievement in several areas of mathematical learning. Students are probably likely to battle with a high cognitive load if they lack the ability to retrieve facts unswervingly or
involuntarily. The additional processing demands ensuing from incompetent techniques for example counting (vs. direct retrieval) often bring about declarative and procedural inaccuracies (Cumming & Elkins, 1999). Probable difficulties extend well past whole numbers operations. Finding common multiples while factoring algebraic equations and / or adding fractions with contrasting denominators are but two instances from high grade mathematics where automaticity in multiplication / mathematics facts can enhance successful performance. Proponents of present-day approaches to mathematics, ones that have a tendency to emphasize more on problem solving and conceptual understanding than on computational skills, are able to spot an essential place for automaticity in mathematical / multiplication facts. For example, note that automaticity is important in estimation and mental computations (Isaacs and Carroll, 1999). These skills, especially the capability to carry out mental computations (for example, make approximations based on rounded numbers such as 100s and 1,000s), are key to the current improvement of number sense. Ball and colleagues (2005) in an attempt to reaching an accord on the current state of mathematics education, also confirm the importance of automaticity in mathematical / multiplication facts.

It is however regrettable that many decades of research have revealed that students still exhibit substantial troubles in developing automaticity in their facts. Delays and difficulties are evident even from start of elementary school. Some students, not necessarily with learning disabilities, fail to perform direct retrieval of facts when presented independently or when hidden in tasks such as computations involving multi-digit. Though research on primary grade students shows that students having difficulties with learning are more liable to depend on counting strategies than direct
retrieval whilst handling problems involving single-digit fact (Hanich, Jordan, Kaplan, & Dick, 2001). Furthermore, these students are likely to make more retrieval as well as counting mistakes on simple addition and multiplication problems. The outcome of Goldman and her partners’ research on second through sixth grade students with learning disabilities shows that these students tend to depend more profoundly on counting rather than direct retrieval methods (Goldman et al, 1988).

Also at fourth grade and even other grades, studies have revealed that two groups often emerge when facts retrieval challenges are given. The two groups are those who use suboptimal strategies and those who employ more sophisticated strategies –with the former group being largely dominated by students having learning challenges. As a result, Goldman et al. (1988) in their conclusion state that elementary students with learning challenges are belated in their capability to learn facts automatically, and propose that this delay can be tackled through systematic practice –a finding that is in agreement with the outcomes of other research (e.g., Geary, 1993) suggesting the necessity of interventions for students with learning disabilities in order to make certain that they are able to retrieve facts automatically upon completion of elementary school.

**Hypothesis and Research Questions**

This study is intended to scrutinize the impact of various strategies to teaching multiplication facts to groups of low level fourth grade students. My intervention intends to draw on the instructional design based on the fact that strategy instruction also comprises an emphasis on the association between facts and extended facts.
The research questions below guided this study:

1. Would any other specific approach to teaching multiplication facts result to greater automaticity in facts than just timed practice?
2. Would the specific approach above help the students master learning their multiplication facts better?
3. Utilizing a pre- and post- test, would extensive practice on multi-digit computational challenges in the comparison circumstance bring about any noteworthy differences?

**Key Assumptions**

Without doubt, any research methodology is bound to have both merits and demerits, and there is not likely to be one particular best system of approaching the task in question. As Silverman (1993) lays the point, methodologies are not like theories, which are either true or false; rather they are only more or less useful. Therefore, the following assumptions are proposed in order to boost the usefulness of the methodology adopted in this research:

1. The case study methodology applied is accurate.
2. The subject under investigation has been able to set a record that worthy of this kind of study.
3. Unbiased and uncomplicated analyses have been provided by researcher.
4. Researcher has maintained equilibrium between theoretical aspiration and what is practically obtainable in mainstream / conventional setting.
5. All that has been sketched out in the previous brief topics as well as problems above constitute the most noteworthy in mathematics teaching and have brought about a rethink of strategies for learning.
CHAPTER 2: LITERATURE REVIEW

Introduction to Chapter
A concrete understanding of the fundamentals of multiplication / mathematics is desirable in order to be able to appreciate the sufficiency of any multiplication method together with its application restrictions. This understanding will aid in analyzing how accurately the flow is mathematically described, which abridging assumptions were made, and how they influence the end result of the calculation. To help satisfy this requirement, literature facts will be discussed in detail in this chapter. Therefore, this chapter reviews literature on fundamentals of learning from the standpoint of elementary math / multiplication, and some teaching methodologies which help in improving learning multiplication facts at fourth grade. Then the significance of integrating these teaching strategies is also discussed.

Multiplication Facts Teaching Strategies
It has been asserted that quick recall of basic multiplication facts is crucial in the application of math to everyday / real-life circumstances and same may also enhance success with more complex problems in mathematics (Mercer & Miller, 1992). A survey in the United States however, found that quite a number of adults could not cope with simple, basic multiplication. Susan (2011), and Lombardo and Drabman (1985) suggested that failure to be able to master multiplication tables can drastically hinder a student’s progress in math / arithmetic, whereas Mercer and Miller (1992) maintained their point that the rate of learning in the subject of mathematics may be cut to half that of regular students due to difficulties with basic mathematics facts. These claims are also particularly correct when applied to the context of learning multiplication facts. It is very likely that, as such basic skills get more vastly
practiced, they turn out to be automatic, thereby requiring less cognitive processing faculty, which in turn creates more allowance for the capacity to understand and interrelate higher order concepts (Hasselbring et al 1987; 1988).

Students having learning difficulties in particular are more likely to have difficulties with immediate memory for multiplication / number facts (Miles & Miles, 1992). Extra practice may be required to help them learn these facts in addition to them requiring help in using the most helpful compensatory strategies to derive facts that are not automatically retrievable (Lloyd & Keller, 1989). This additional assistance however may go beyond the available resources of many schools; consequently, parental support may be next and only option to fall back on.

Although several unconventional strategies have been applied in teaching multiplication facts to students and people in general, each of these strategies works differently with different students in terms of efficiency. Rote memorization, otherwise known as drilling, was once a generally applied instructional strategy for teaching multiplication / mathematics facts. The New York Times Magazine reveals that studies suggest that this method is ineffective and can perhaps be harmful. That is, while some subjects discovered that the rules and strategies were too complicated (Chinn & Ashcroft, 1992), attaining an automatic level of response was simply impossible for others (Hasselbring et al., 1988). Consequently, new strategies have surfaced to assist students master their multiplication facts much better. Those strategies that offer promise are the basis of this study. They include: Count-By; Time Delay; and Strategy Instruction.
Count-By Strategy

Count-By method involves counting to arrive at the answer, and it entails the student saying or counting a “times table” loudly and clearly in order to get the answer to the specific multiplication problem. For instance, if the problem is "3 x 4," the learning student will shout, "Three, Six, Nine, 12" just to be able to determine that three multiplied by four gives twelve (12). They may as well say, "Four, Eight, 12" in order to have the same answer. For all intents and purposes, this strategy entails the student using their capacity to "count by" the number to in order to solve the multiplication problem. As revealed by the Mathematics Education Research Journal, this Count-By strategy has been shown to boost multiplication facts proficiency among fourth grade students, especially those with learning difficulties. A similar study by McIntyre, et al. (1991) specifically used the Count-By strategy to enhance multiplication-facts fluency for a fourth grade student having learning disabilities. In the research, positive results were achieved for aimed facts applying 10 to 15-minute instruction sessions each day, and after withdrawal of instruction, fluency was retained at points near the mastery standards of 80 digits per minute.

Time Delay Strategy

The Time Delay Method entails the teacher presenting the student with flash cards to represent equations involving multiplication. If student is hesitant to act in response or is uncertain, the teacher suggests assistance in “timed intervals” (Cybriwsky & Schuster, 1990). For instance, after the presentation of flash card, the teacher may observe two seconds waiting period before letting answer to student then gradually increase the waiting time to assist, hence affording the student more time to answer on their own. Multiplication flash cards are presented at random in order to lessen the
likelihood that the student will turn out memorizing correct responses. Actually, the
goal is utilize a repetitive method to assist student; that is, through repetition student
will in the long run be able to respond without delay and more accurately exclusive of
teacher’s assistance.

Time delay may be progressive or constant. Progressive Time Delay entails
progressively delaying the length of time between the request and the prompt—
meaning, the delay is made progressively longer. If student is unsure of the answer,
they are advised to wait for the prompt (the correct answer) from teacher before they
answer. This method has three major advantages: (a) students simply get ‘to see or
hear’ correct answer, not puzzled with listening to or seeing their incorrect guesses;
(b) students will probably concentrate more to enable them remember and listen to or
see teacher’s prompt as they already know the answer will be provided if they are
unsure; and (c) students’ self esteem gets boosted up as they hardly ever fail.

Constant Time Delay (CTD) however involves selecting a delay interval (for
example, 6 seconds) by teacher; same will be put to use during all teaching periods
after the completion of the zero-second delay opening session. The interval length is
determined by student’s ability, task in question, and what teacher expects of the
student. Hasselbring, et al. (1987; 1988) asserts that using Constant Time Delay may
be the most important step in developing the needed ‘automatization’ in basic
mathematics facts such as multiplication facts as a groundwork for further
mathematics study.

Historically, Time Delay was examined by Touchette (1971) who recorded success in
teaching three "seriously retarded" boys a straightforward form of discrimination of
the letter E reversals, with errorless results. Constant Time Delay was used by Cybriwsky and Schuster (1990); multiplication facts were taught to a student with behavioral disorders and learning difficulties – who learnt 15 math facts with an error rate of 2.8% in just about one hour of instruction. In a similar study, Mattingly and Bott (1990) got almost an error-free learning, 98.3%, for 30 multiplication facts involving a group of four students having learning difficulties in Grades 5 and 6.

The minimal preparation and training time needed for Constant Time Delay Strategy and Count-By Strategy makes them predominantly appropriate as means of teaching students quick recall of multiplication facts, whether they are experiencing difficulties or not. However, it must be noted at this point that investigative studies on their effectiveness are way too small in number.

**Strategy Instruction / Integrated Approach**

Strategy Instruction other hand affords teacher the opportunity to assist the student in developing strategies for solving multiplication problems correctly. Strategies like using a manipulative (e.g. chips to represent a mathematics problem) or drawing a picture assists students to visualize concept of mathematics and make it more material. For instance, in solving the multiplication problem "3 x 4", student is given liberty to draw a set of three eggs four times then count up the total number of eggs.

**Integrating the Strategies**

Research suggests that an equilibrium pose for teaching facts such as multiplication facts to both academically low-achieving students and those with learning difficulties involves an integration of strategy instruction with CTD (Cumming and Elkins,
According to their research, instruction in strategies alone may not essentially bring about automaticity. CTD is crucial. However, strategies assist in increasing a student’s ability to use numbers in a more flexible manner, and in view of that, Cumming and Elkins argue the adoption of strategy instruction for all students all the way through the end of elementary school. In fact, an international comparative math research shows that fact strategies are a regular feature of instruction for Asian students in their elementary grade (Ma, 1999; Fuson & Kwon, 1992). In line with the above arguments, strategy instruction can also be advantageous to the development of mental calculations and estimation. In this regard, strategy instruction assists the student in developing number sense, and this used to be topic of fanatical interest in the special education literature in the late 1990s (Gersten & Chard, 1999).

**Definitions**

Within the content of this study, below are the terms used and their definitions:

*Traditional teaching method*: the conventional teaching methods that teachers have long used in their mathematics classes where information is didactically presented by teachers.

*Teaching strategies*: refers to all teacher’s moves, objectives, procedures and apparatus used from commencing the lesson to finishing it, towards achieving the aims including the class organization and supervision, the learning ambiance plus students' response.

*Time Delay Method*: entails the teacher presenting the student with flash cards to represent equations involving multiplication.
*Count-By Method:* involves counting to arrive at the answer, and it entails the student saying or counting a “times table” loudly and clearly in order to get the answer to the specific multiplication problem.

*Integrated learning strategy:* refers to the model of implementation that parents / teachers were trained to use for the purpose of this experiment. It was actually a blend of other strategies generated from different learning methodologies towards achieving most of the basic components for an effective learning.
CHAPTER 3: METHOD (PROCEDURES FOR INVESTIGATING QUESTIONS)

Introduction to Chapter

This chapter discusses the motivation behind this study, preliminary steps taken to secure approval from the subjects’ school authority, the ground work done in order to facilitate the study, highlights of the study approach and techniques adopted (plus sources of primary data as well as sample size, the method data collection, and techniques used to analyze the data.

Participants and Setting

The experimental subjects involved 10 fourth grade-aged students with diverse socioeconomic backgrounds grouped into two – they were selected from a public school in Southgate, MI where learning of tables is a part of the usual school program. The selected students for the experimental group had not mastered their required grade knowledge as well as multiplication facts automaticity.

Materials and Data Collection Instruments

Pertinent data were collected from the subjects, their teachers, school authority and parents / guardians – through oral and semi-structured interviews. The method adopted was more of an inducting theory utilizing details akin to case studies rather than sticking to hypothesis testing alone. In this approach, theoretical models were applied all through the empirical study in a grounded approach instead of utilizing hypothesis testing. Therefore, in this approach a large number of cases towards achieving validity is not required, but rather the more profound study of a relatively small number of subjects to examine adequately what is happening (Remenyi et al., 1998; Burgoyne & Reynolds, 1998).
Integrated Strategy Group

Students in the respective intervention groups were taught multiplication facts strategies as reviewed in the literature on multiplication facts cited above. It has been noted that many of these strategies have been included in “Fact Fluency and More!” (Woodward and Stroh, 2004a) and “Transitional Mathematics, Level 1” (Woodward and Stroh, 2004b) curricular facilitating materials, which were applied as the basis for the daily instruction. Facts were divided into relatively less challenging ones and those that have in general been regarded as more challenging. A variety of descriptive and empirical literature was applied to support this distinction. Therefore, fact like 0s and 1s, doubles, and times 5s that are rule-based have appeared to be less challenging for students to learn at an automaticity level (Wood & Frank, 2000; Van de Walle, 2003; Sherin & Fuson, 2005).

As recommended by literature, more difficult facts are to be taught via derived fact or doubling and doubling-again strategies – e.g., multiplication facts like 6 x 7 and 7 x 8 that were contained in the study materials were taught via a derived strategy which is as follows: (6 x 7 = 6 x 6 + 6, 7 x 8 = 7 x 7 + 7)

The visual illustration of the derived fact strategy above may be found in Figure 1 below.

Facts such as 6 x 4 were taught to the students via a doubling and doubling-again strategy (for example, 6 x 4 is presented as 6 x 2 = 12; then 12 x 2 = 24). Number lines and a variety of blocks projected overhead – to enhance the students’ visual appreciation of multiplication facts strategies – were the materials used with the Integrated group.
The daily timed practice worksheets were organized using a controlled practice scheme identical to one adopted by Hasselbring et al. (2005). New facts were administered in small portions; that is, an average of 7 facts and no more than 10 facts per strategy. The timed practice worksheets were weaved round a specific strategy with each daily timed practice worksheet having 40 facts of which half of the facts were review facts and the remaining half were randomly presented new facts. The review facts was meant to serve as distributed practice.

Finally, the connection between the single-digit facts shown above and extended facts such as extending 4 x 2 to 40 x 2 and 400 x 2 were taught to the student with the aid of other materials. Instructional materials featured worksheets where students handled 20 randomly ordered single-digit facts as well as extended facts. This however was an untimed activity, meant to assist students towards generalizing their knowledge of facts. An array of block overhead transparencies and number lines like the one shown in Figure 2 below were applied when the parents and students discussed extended multiplication facts.

**Timed practice only group**

The methods adopted for students in this group were practically based almost entirely on the controlled practice technique found in the literature, especially the adoption of direct instruction for teaching multiplication / math facts and the traditional multiplication algorithm (Stein et al., 1997). This approach included many of the instructional principles explained in the Hasselbring et al. (2005) research. Sequentially (that is, starting with the 1s, then the 2s), new facts were taught while
previously taught facts were reviewed on each day and same were incorporated into the daily CTD.

The direct instruction strategy adopted for multi-digit multiplication worksheets emphasized an unambiguous presentation of the traditional algorithm. At the beginning of study, problems were 2 x 1 digit problems – progressed gradually up through 2 x 2 and 3 x 1 digit problems. The design of the material was such that it provided a systematic review of prior problem types as students ascended hierarchically from easier to more challenging problems.

**Procedure**

A letter was issued to school authority informing them to permit parents of 4th grade students who have not mastered their required grade knowledge and multiplication facts automaticity to participate. These parents and their children were trained to put into practice and complete a four week program – since all parents / guardians of children with difficulties were not available to participate; only 10 were selected. Some other parents who showed good measure of willingness could not be involved since their children have demonstrated passable fluency in multiplication facts. At random, these parents were separated into two groups – this division gave rise to 5 parents with 5 children to try out the Constant Time Delay (CTD) strategy only, and 5 parents with 5 children to try out the Integrated Strategy (CTD plus Instruction Strategy, IS). The children were divided into two groups in order to reach an accurate comparison between the usefulness of each type of strategy or intervention and the expected level of multiplication facts understanding in each group, with the believe
that grade 4 students generally have limited knowledge since they have all had less exposure to multiplication facts.

The subject students’ multiplication facts individual fluency level was tested prior to administration of intervention strategies – that is, a pre-test was applied to quantify their multiplication facts fluency. Parents were then encouraged and guided as to following up the intervention with their respective children at home. After undertaking the intervention programs, CTD and CTD + IS, another test (post-test) was administered to examine and determine which strategy works better. Subjects were distributed according to method of assistance; see Table 1.

Students were coordinated and assigned at random based on results of pretest measures – i.e., the Common Multiplication Facts Test. Scores were position ordered, and students’ names were placed at the top of each list and randomly attached to each condition. At the commencement of each instructional session, the students took the materials to their respective parents (i.e., whether Integrated or CTD). Parents in both groups were instructed to take their children for 25 minutes each day, five days in a week, and for four consecutive weeks. Every necessary effort was made by researcher to control the amount of instructional time for each group in order to maintain a fair balance between the groups each day. The teachers who participated in the study were guided such that they developed extensive knowledge with both the adopted materials in each condition and the instructional methods. The researcher met with the parents prior to the study and reviewed important teaching elements for their respective method (that is, the integrated and the CTD only). To guarantee dependability of implementation every week researcher met with students’ parents.
using a checklist that contained the major instructional techniques for each intervention. The observational notes and checklists were used as the basis for discussions with respective parents. This weekly discussion with parents helped in ensuring that each method was consistently and appropriately implemented. Finally, to control for parents effects, researcher organized two sessions with the students midway through the study.

*Integrated group*

The daily instruction for the integrated group was administered in three distinct phases—the first being either a review of the previously taught strategies or an introduction of new fact strategies. Parents devoted more time to this phase of the session on the days when their children were shown a new strategy (such as seen in the derived fact strategy for 6 x 7 in Figure 1 above where arrays or number lines on the overhead were used to visualize the strategy. Students were then cheered to discuss the strategy and compare it with earlier taught strategies. For example, 5 x 8 could be considered a “times 5” strategy, but it was a part of the “times 9 strategy”, too.

On other days, parents used the overhead to talk about facts that represented the hitherto taught strategies. Number lines or arrays were used in visualizing the strategy since it was not requisite for students to memorize the strategies and apply them in a rote mode on any of the worksheets employed during the intervention.

Phase two of daily instruction was a two-minute CTD – materials used have been described above. At the end of each two minutes, parent dictated answers to
multiplication facts, and student corrected his or her own work, circling any incorrect facts and writing correct answers after the parent finished dictating the answers. Researcher collected the daily worksheets to monitor the advancement of the students in each group as they drew nearer automaticity in a particular strategy. When a student got 90% correct on a particular strategy, parent moved a step further to next strategy in the instruction. Basically, automaticity was regarded as 36 correct problems within the time period of two minutes. The final stage of daily instruction varied. Once in a while, the relationship between facts and extended facts was taught to students. Parents used number lines and arrays as visual models to foster this connection (review Figure 2).

*Timed practice only group.*

The first phase here involved either a systematic review of already taught facts or the introduction of new multiplication facts. In each lesson, parents used a prepared set of facts. Upon being taught new facts, their parents introduced the fact including its answer, after which the students were asked the answer to the fact (for example, “7 x 3 is 21. What is 7 x 3?”). And in the case of the previously taught facts, the students were simply asked the answers to fact questions (for example, “What is 7 x 4?”). Oral responses were demanded in both instances. Stein et al (1997) considered these formats as key features of direct instruction.

In the second phase of instruction, a two-minute CTD was involved; materials for this have been described above. In the last part of the drill, parents dictated correct answers to the facts and students righted their own work by circling the incorrect facts and writing in correct responses. While shifting to instruction on new facts, parents
adopted the same procedures as those in the integrated situation. When students got 90% correct on a strategy, parent moved to the next set of facts.

In the third phase of instruction, worksheet practice on computational problems utilizing the conventional multiplication algorithm was involved. Parents modeled how to craft new types of problems as they advanced from 3 x 1 to 2 x 2 digit problems over the course of the study. Students were also reminded by their parents to use their knowledge of facts as they solved problem sets. Problems involving computation were limited to those involving facts that had been taught to the students up to this end in the study. As a result, students did not really work any computational problems that contained any facts that they had not been taught as a part of the study. The moment students had completed each stage of problems, the parents dictated answers and any errors were corrected by the students themselves.

To evaluate students’ understanding of multiplication facts as well as related skills, a range of measures were developed. The standardized measure of computational skills adopted was Iowa Test of Basic Skills, ITBS. And an independent group of five fourth grade students was used to calculate the reliability of test-retest for each measure for all other computational measures. Test-retest reliability above .90 was achieved in all of the measures. Students’ general disposition towards the subject of mathematics was also assessed. On the Math Computations subtest of the Iowa Test of Basic Skills (Hoover et al, 1996) for the 10 participants, mean grade equivalence was 3.6 (the 41st percentile), which indicated that on the average, subject students were obviously half to one year behind fourth grade level as at the time the study was conducted. Table 1 gives further demographic information on the participants.
CHAPTER 4: RESULTS (OUTCOMES)

Introduction to Chapter

Facts, computational abilities in multiplication, and attitudes in the direction of mathematics are the basis of grouping for analyses of the data in this study. Math Computations subtest score of the ITBS was employed as the covariate in all analyses of covariance (ANCOVA). To quantify effect size for all statistically significant between-group relationships, Cohen’s d was used. The sample size of students did not naturally call for the use of inferential statistics; however, comparative data to shed light on the efficacy of each of the respective instructional methods for all students were obtained.

Measures of Facts

Familiar Facts

A time by group i.e., 3 x 2 ANCOVA was carried out on the Common Multiplication Facts Test. Table 2 gives the statistical description for students by group and time. Wilks’ lambda criterion was used to analyze data, results of which suggested a considerable variation between condition groups \[ F(1, 55) = 6.38, p = .01, d = .68 \]. There was a noteworthy relation for time and group \[ F(2, 54) = 3.89, p = .02 \].

The array of t-tests carried out on the pretest, post-test, and maintenance tests showed no considerable differences between groups on the pre-test \[ t(56) = -.09 \], however there were sizeable differences between groups on the post-test \[ t(56) = 2.22, p = .02, d = .27 \]. Similarly, significant differences were seen on the maintenance test \[ t(56) = 2.20, p = .02, d = .27 \].
For both groups, mean percent correct on post-test and maintenance tests was comparatively high, especially when compared with the pre-test scores. The data imply that the Integrated group continued at a mastery level from post-test to maintenance test – at or exceeding 90%, but this was not the case for the CTD Only group. See Figure 3 for graphical representation. Performance however declined for both subgroups from the post-test to the maintenance test.

**Hard facts**

A time by group (3 x 2 ANCOVA) was carried out on the Hard Multiplication Facts Test. Table 3 presents the descriptive statistics for students by group and time. Wilks’ lambda criterion was also employed to analyze data on these repeated measures. Results however did not show significant differences between groups \( F(1, 55) = .13, p = .72 \) and close to significant differences within groups \( F(1, 55) = 3.83, p = .06 \). For time and group \( F(2, 54) = 4.61, p = .01 \), interaction was significant, with the source occurring between pre-test and post-test. Significant differences within groups \( F(1, 55) = 4.52, p < .05 \) were revealed by a 2 x 2 ANCOVA carried out on this phase of the repeated measures. Mean score changes help explain the significant interaction. For Integrated group, mean pre-test score was 11.97 (30% correct) – compared to 16.32 (41% correct) for CTD Only group. Post-test mean scores for both groups rose to virtually the same levels – at 25.76 and 25.46 (64% correct), respectively. A significant level \( F(1, 55) = 3.55, p = .07 \) was indicated by the differences between groups for this phase of the study.

Table 3 and Figure 7 show the comparison of students on the Hard Facts Test. A considerable gain from pre-test to post-test was reflected for students in both groups.
Though, no group of students attained mastery of these facts by the conclusion of the four-week intervention. Interestingly, decline from post-test to maintenance test on these facts was comparable, and marginal, across groups (that is, approximately 2% correct on the average).

*Extended facts*

Significant differences \(F_{(1,55)} = 16.38, p < .001, d = 1.08\) in favor Integrated group was shown by an ANCOVA done on the Extended Facts Test. Table 4 shows the means, standard deviations, and percent correct for this post-test. Percent correct showed that, generally, the Integrated students were at a mastery level of performance. This again, was different for the CTD Only students. Table 4 also explains mean performance differences between groups on extended facts, with only some of the students in the Integrated group having scores above mastery level criterion.

*Multiplication Measures – Computation and Approximation*

For Computation Test, an ANCOVA performed on post-test indicated no significant differences between groups \(F_{(1,55)} = 2.84, p = .10\) – though, percent correct (see Table 5) revealed significantly higher levels of performance on the part of CTD Only group. Generally, all subgroups had below what may be called mastery level performance on this measure (that is, 80 – 85% correct). Mean scores range also indicated the individual interventions, with students in the CTD Only group scoring near or above students in the Integrated group. Mean performance also showed that students in the Integrated group performed significantly below the other CTD Only.
In the approximations measure, a final ANCOVA was performed and results pointed significant differences in favor of the Integrated group \([F_{(1,55)} = 39.37, p < .001, d = 1.68]\). See Table 6 for descriptive statistics for this post-test measure.

Noticeable differences were seen between groups in mean percent correct, with 83% correct for the Integrated group in comparison to 51% correct for the CTD Only group. On this measure, mean performance also revealed the individual impact of the instructional techniques used in each condition. This means, more importance being placed on approximation skills in the Integrated group was evident in face of the fact that students’ mean scores in this group were higher than those of subjects in the CTD Only group.

**Attitudes Toward Mathematics Survey**

A time by group (2 x 2 ANCOVA) was carried out on the measures administered to Integrated and CTD Only students. Table 7 gives the descriptive statistics for students by group and aptitude for time (that is, pre-test to post-test). Using Wilks’ lambda criterion, data were analyzed and results suggested no significant difference between groups \([F_{(1,55)} = .43]\). Also, there was no significant interaction for time and group \([F_{(1,55)} = .02]\). But significant difference was discovered within groups \([F_{(1,55)}= 6.42, p = .01, d = .68]\). Table 7 shows descriptive statistics, which indicate a moderate increase in the bearing of a better attitude toward mathematics for the two groups.
CHAPTER 5: DISCUSSION

Discussion

Two approaches to teaching multiplication facts to academically low-achieving students at fourth grade level were juxtaposed in this study. Literally both methods proved effective in improving the mean performance level based on a blend of common math facts to mastery or near mastery levels; only slight decreases were seen in these levels during the maintenance phase of the study. According to Cohen’s $d$ analyses in which small effect sizes were indicated, the Integrated group generally on the expansion of automaticity in these math facts was favored. The two groups improved noticeably in their knowledge / understanding of the harder multiplication facts. But the limited time frame for the intervention period of four weeks prevented student in neither group from attaining mastery levels of performance. With mean success levels approximating 63%, post-test and maintenance test scores for both groups were virtually identical.

Generally, students improve in performance levels across groups but for some differences – with the most visible differences between groups appearing a propos the instructional activities that accompanied the daily facts instruction. Students in Integrated group got the opportunity to visually observe and discuss the factors connecting facts (basic and extended) and methods for approximating answers to multiplication problems. Consequently, their performance on the Approximation Tests and Extended Facts seemed appreciably higher than that of students in the CTD Only group.
Conversely, students in the CTD Only group were allowed many more practicing opportunities to learn 3 x 1 and 2 x 2 multiplication problems via the traditional algorithm. And of course, this extra practice engendered higher performance levels, albeit the differences between groups on the Computations post-test were not statistically significant.

On a final note, students in both groups appeared to be positive in terms of feelings about the subject of mathematics and the intervention in particular. This accounts for slight rise observed in mean scores on the Attitudes Toward Math Survey over the period of intervention.

**Limitations of Study**

No research is faultless, and many times, some limitations are outside the control of the purposes of research. So as to have a reasonable outcome, a researcher’s choice of a particular case study methodology must be kept germane to the mean between what is practically obtainable and what is theoretically understood —researcher must maintain equilibrium between theoretical aspiration and realistic limitations. Consequently, there is no best, specific methodology that has been scientifically designed for conducting such a case study—rather, the chosen technique must be suited to the circumstantial variables that are prevalent in the environment in which the research is being conducted (David, 2001).

However, in this case study, a pre-test method and a post-test method were used to source required information in order to shift away from a widely recognized fact that an observation is influenced by an observer’s background and past experiences, including previous technical training, cultural background as well as system of beliefs.
According to Stuart et al, the concern expressed above could lead to a biased sample, which usually affects the manner of interpretations of observations—this consequentially affects parameter estimation (2002).

The following are specific limitations of this study:

Group ordered timed evaluation such as employed in this study can be a professional approach of extracting data for consequential quantitative analysis. But, as argued by some researchers (Sherin & Fuson, 2005; Baroody, 1997), the border line between automaticity and the continuous application of multiplication strategies may not be as discrete as literature on automaticity often suggests. In a more specific argument, quite a few students who were proficient in answering math facts in the space of three seconds per fact standard may have sustained the use of a combination of direct retrieval and strategic methodologies to answer facts. This phenomenon is referred to as “hybrid” strategies by Sherin and Fuson in their taxonomic analysis of multiplication and its expansion in elementary-aged students (2005). The adoption of qualitative discussions and thorough observations could have exposed the degree to which even the most proficient students in this study continued to employ hybrid strategies, principally on some types of problems (such as 7 x 6, 4 x 8). As noted by Siegler (1996), even the most proficient elementary students differ in the way they respond to mathematical tasks, subject to the exact characteristics of problems they are required to solve.

Also, another limitation of this study concerns the limited time frame. It has been suggested that longitudinal study is required to ascertain how well academically
weak-performing students keep up with automaticity and the degree to which strategic instruction might be of benefit to them (Cumming and Elkins, 1999).

And on a final note, the choice to proceed on to new facts derived from the performance of at least 70% of the students in class caused a problem that has customarily destroyed instruction on topics in the vein of math facts in heterogeneous environments. To be precise, the lowest performing students did not get the supplementary practice at other times during the day that would have assisted them cope with the remainder of the class. It is therefore recommended that future studies should investigate the impact of controlled, supplementary practice for academically weak-performing students as well as the ones with learning disability.

**Importance of Findings**

Automaticity in facts was endorsed as essential in overall math proficiency in the k-12 education by recent national policy documents. That notwithstanding, this skillfulness is now entrenched in a more ambitious perspective than it has been some time ago (Kilpatrick et al., 2001; Ball et al., 2005). Whilst automaticity in facts is still germane to adeptness in traditional algorithms, automaticity has turned out to be essential in mental calculation, estimation, and approximation skills. Mental calculation and the other two latter skills are part of the improvement of what has time and again been regarded as “number sense” (see Kilpatrick et al., 2001; Sowder, 1992; Greeno, 1991). According to results from this study, an integrated approach and CTD can be compared in their usefulness at assisting students move in the direction of automaticity in basic facts. Either method would possibly suffice should there be any need for educators only considering facts as a basis for proficiency in traditional
algorithm. Thus far, the educationally noteworthy differences between groups found on the approximations tests as well as extended facts tests ought to encourage special educators to think about the way strategy instruction can be of advantage to students’ expansion of number sense.

**Summary / Conclusion**

The findings in this study are in fact in harmony with recommendations by Cumming and Elkins’ (1999) – that strategy instruction be put into practice through elementary school with all students. They are by the same token consistent with the thinking of mathematics educators who place significant importance on problem solving in addition to conceptual understanding (such as, Isaacs & Carroll, 1999). Moreover, some topical analyses of mental computational skills have pointed out that low-achieving students are more vulnerable to relying on tapered techniques – ones that mirror long established paper-and-pencil algorithms – than their more competent counterparts (Foxman & Beishuizen, 2002). A long-drawn-out spotlight on mental computations and approximations could deal with this difference more effectively. Recent emphasis on number sense related skills does not really reduce the significance of aptitude in traditional computational algorithms. Nevertheless, the degree to which facts are taught exclusively for this purpose should be reassessed.
REFERENCES


*Mathematical Cognition, 5*(2), 149-180.


Figure 1: Example of visual representation of derived fact strategy for 6 x 7
Figure 2: Connection between facts and extended facts using number lines and blocks
Figure 3: Extended Fact and Partial Product Algorithm

```
341
X 2
2  
80
+600
---
682
```

“Find 55 and round to the nearest 10.”

```
40  50  60  70
```

“Find 398 and round to nearest 100.”

```
200  300  400  500
```

Figure 4: Number Lines for Teaching Approximation
“Let us assume that you were traveling across America on an airplane. The plane departed from Ohio to California. The flight takes 6 hours. Early in the flight the pilot announces, "We are moving at the speed of 513 miles per hour, and we will land in California at 7:35 pm. Can you tell how far is it from Ohio to California?"

Figure 5: Sample Word Problems for Integrated Group

Figure 6: Graphical representation of pre-, post -tests & maintenance mean scores for common multiplication facts
Figure 7: Graphical representation of pre-, post-tests & maintenance mean scores for hard multiplication facts
LIST OF TABLES

<table>
<thead>
<tr>
<th>Information</th>
<th>Integrated Strategy</th>
<th>CTD Only</th>
</tr>
</thead>
<tbody>
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<td>Population</td>
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</tr>
<tr>
<td>Age (Years)</td>
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<td>9</td>
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<tr>
<td>ITBS Computation</td>
<td>23.92 [6.50] (^{SD})</td>
<td>25.54[5.60]</td>
</tr>
<tr>
<td>Common Facts Pretest</td>
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<td>27.18[7.14]</td>
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<tr>
<td>Gender Ratio</td>
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<td>2F /3M</td>
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</tbody>
</table>

SD: All enclosed scores represent standard deviation

Table 1: Participants' Demographic Information

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<td>Standard Deviation</td>
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<tr>
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<td>86</td>
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<td>Maintenance Test</td>
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<td>Standard Deviation</td>
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Table 2: Mean, Standard Deviation, Percent Correct for Common Multiplication Facts
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</tr>
</thead>
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<td><strong>Pre-Test</strong></td>
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<td>Mean</td>
<td>11.97</td>
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<td><strong>Post-Test</strong></td>
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<td>64</td>
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<tr>
<td><strong>Maintenance Test</strong></td>
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<td>Mean</td>
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<td>24.61</td>
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<td>Standard Deviation</td>
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<tr>
<td>Mean % Correct</td>
<td>63</td>
<td>62</td>
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</table>

Table 3: Mean, Standard Deviation, Percent Correct for Hard Multiplication Facts

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<td>10.78</td>
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<tr>
<td>Standard Deviation</td>
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<td>3.90</td>
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<tr>
<td>Mean % Correct</td>
<td>90</td>
<td>72</td>
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</table>

Table 4: Mean, Standard Deviation, Percent Correct for Extended Facts Tests
# Table 5: Mean, Standard Deviation, Percent Correct for Computation Tests

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<td>Mean</td>
<td>8.43</td>
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<tr>
<td>Standard Deviation</td>
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<td>3.05</td>
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<td>Mean % Correct</td>
<td>56</td>
<td>71</td>
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# Table 6: Mean, Standard Deviation, Percent Correct for Approximation Tests

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</tr>
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<td>Mean</td>
<td>12.40</td>
<td>7.57</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.58</td>
<td>4.46</td>
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<tr>
<td>Mean % Correct</td>
<td>83</td>
<td>51</td>
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# Table 7: Mean, Standard Deviation for Attitude towards Math

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<td><strong>Pre-Test</strong></td>
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<tr>
<td>Mean</td>
<td>47.93</td>
<td>49.79</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10.41</td>
<td>6.60</td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>51.90</td>
<td>53.54</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10.31</td>
<td>5.59</td>
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### LIST OF APPENDICES

#### WEEK  ACTIVITIES

<table>
<thead>
<tr>
<th>WEEK</th>
<th>ACTIVITIES</th>
</tr>
</thead>
</table>
| 1 | 1. Issuance of letter to school authority/parents to seek permission  
2. Conduction of training for parents  
3. Familiarize with teacher(s) |
| 2 | 1. Grouping of students  
2. Pre-test  
3. Commencement of instructional sessions  
4. Monitor adherence to research procedures |
| 3 | 1. Instructional sessions  
2. Monitor adherence  
3. Special session with students to control for parents effects |
| 4 | 1. Instructional sessions  
2. Monitor adherence |
| 5 | 1. Instructional sessions  
2. Monitor adherence  
3. Post-test |

**Appendix 1: Weekly Activity Chart**
Dear School Authority
The researcher is working on a study titled, "What Kind of Strategies can I use to Help 4th Grade Students Learn their Multiplication Facts?" to get the Masters degree in Mathematics Education.
The study is aimed at seeking ways by which 4th grade students can master their multiplication facts better and ultimately enhance their mathematical learning experience.
Researcher sincerely solicits your maximum cooperation towards making your students better and contributing immensely to the existing literature in Mathematics Education. Kindly sign below to enable researcher interact with both parents and teachers of 4th grade students in order proceed with this study.

Faithfully Yours
Researcher

Note of Authorization
Researcher is hereby authorized by the school authority to proceed with the said study.

________________________
Authorized Signatory

Appendix 2: Letter of Permission
Teaching Method: __________________
Sex: ________; Age: ________________

Dear Student,

The statements that are mentioned in the following pages aim to assess the effectiveness of teaching methods in multiplication in different strategies: its effect on the academic achievement in mathematics and the multiplication problem solving skills, outcomes other than the achievement, attitudes of the students toward mathematics, their perspectives toward the method applied in teaching mathematics and the search for other external factors may affect the students’ performance.

Each statement carries a specific idea which you may agree or disagree with and you are asked to respond to each statement in a way which describes your real opinion and your feelings and not in a way that you think you should feel. It is not an examination of your information or your ability, but it is to assess your response on the idea that the statement carries. Please, select the choice that best reflects your response towards the following statements by putting (x) in the space provided for each statement.

Key: SA (Strongly Agree)
A (Agree)
U (Uncertain)
D (Disagree)
SD (Strongly Disagree)

This is for the first four parts of the questionnaire. Please answer the last part by putting (x) in the in the space provided for each statement by selecting the choices Yes or No.

Be sure that your answers will be used for the scientific research objectives only.

Thank you very much for your help and cooperation.

The Researcher

Appendix 3a: Program Evaluation Letter to Students
<table>
<thead>
<tr>
<th>No</th>
<th>Statement</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Teaching method develops the mathematical knowledge for me.</td>
<td>SA A U D SD</td>
</tr>
<tr>
<td>2</td>
<td>Teaching method does not increase my understanding of the difficult concepts.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Teaching method helps my higher achievement in mathematics.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Teaching method encourages me to use the new mathematical vocabulary words properly.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Teaching method helps me to understand the mathematical rules.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Teaching method increases my ability to use the concepts and rules in solving mathematical problems.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Teaching method does not teach me how to transfer the concepts and the skills in new situations and problems</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Teaching method does not help me in doing mathematical roofs.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Teaching method introduces the strategies and algorithms for solving the mathematical problems in a simple way.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Teaching method helps me to explain how the new information relates to previously mastered mathematical skills.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Teaching method helps me understand the mathematical problem and to explore a solution for it.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Teaching method leads me to expect the primary solution.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Teaching method increases my skills in computations.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Teaching method does not help me to collect data and choose algorithms to organise it in solving problems.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Teaching method lets enables me to translate the word problems into mathematical problems.</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Teaching method helps me to link the mathematical subjects with different life situations.</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Teaching method increases my ability to use the mathematical skills in solving some of the live a lications.</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Teaching method helps me to understand other subjects such as science and geography.</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Teaching method offers a solution for my weakness in solving problems.</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Teaching method promotes my ability to solve mathematical problems in a successful way.</td>
<td></td>
</tr>
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</table>

*Appendix 3b: Students' perspectives about teaching methods*
Observer: ..............................
Day / Date: ..............................
Parent: .................................
Grade / Class: ............................
No. of Students: ........................
Strategy Type: ...........................

<table>
<thead>
<tr>
<th>Parent's Math Teaching Skills</th>
<th>Observations &amp; Field Notes</th>
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<tbody>
<tr>
<td><strong>Introduction:</strong></td>
<td></td>
</tr>
<tr>
<td>• Explaining the assignment and the objectives of the lesson.</td>
<td></td>
</tr>
<tr>
<td>• Presenting the concepts that are needed for the lesson.</td>
<td></td>
</tr>
<tr>
<td>• Explaining the academic task and the problem to be solved.</td>
<td></td>
</tr>
<tr>
<td>• Presenting similar and small problems for discussion.</td>
<td></td>
</tr>
<tr>
<td>• Introducing the lesson in an interesting and exiting way.</td>
<td></td>
</tr>
<tr>
<td>• Linking between the objectives of the lesson and our daily life situations.</td>
<td></td>
</tr>
<tr>
<td>• Making connections between mathematical concepts, roles, facts, algorithms and problem solving.</td>
<td></td>
</tr>
<tr>
<td><strong>Exploration</strong></td>
<td></td>
</tr>
<tr>
<td>• Encouraging and monitoring the student to work properly.</td>
<td></td>
</tr>
<tr>
<td>• Helping the child if they need help.</td>
<td></td>
</tr>
<tr>
<td>• Asking the child to monitor their performance, behaviour, and functioning.</td>
<td></td>
</tr>
<tr>
<td>• Observing and listening to the students' individual ideas, discussions, procedures and strategies for solving</td>
<td></td>
</tr>
</tbody>
</table>
the problems.
- Providing additional activities for groups that finish more quickly than the others.

<table>
<thead>
<tr>
<th>Reflection and Evaluation Processing</th>
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<tbody>
<tr>
<td>- Group/ students summarizing their work and sharing their processes.</td>
</tr>
<tr>
<td>- Group/ students presenting their solutions.</td>
</tr>
<tr>
<td>- Evaluating students' achievement.</td>
</tr>
<tr>
<td>- Providing feedback after evaluation.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group Management</th>
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</thead>
<tbody>
<tr>
<td>- Explaining the positive goal interdependence, the learning task and the expectation for the group, the expected learning behavior, the procedure to follow and the definition of the group.</td>
</tr>
<tr>
<td>- Making sure of the contribution and the interaction of the students to accomplish their goal and sharing the materials.</td>
</tr>
<tr>
<td>- Supporting the students to explain, to elaborate and to encourage the students' academic achievement.</td>
</tr>
<tr>
<td>- Ensuring that students understand that they are individuals accountable for their assignment.</td>
</tr>
<tr>
<td>- Assigning students into different groups.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instruments and Materials:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Structuring the materials and the instructions for the use of the students.</td>
</tr>
</tbody>
</table>
Deciding how to distribute instructional materials.
Using different and variety instruments.
Indicate which of the following:
Yes  No
Textbook
Work Sheet
Manipulative / Games
Test
Other ( Specify.... )

Appendix 4: Guidance Observation Sheet