THE EFFECT OF USING MENTAL COMPUTATION IN IMPROVING MATHEMATICAL PROBLEM - SOLVING ABILITY AMONG STUDENTS

Talal Tayel Al Mashqabah[i]
Dr., Department of Basic Science,
Deanship of Preparatory Year,
Najran University,
Kingdom of Saudi Arabia

Abstract:

The present study aimed to identify the effect of mental computation in improving the ability of university undergraduates in mathematical problem - solving. To achieve this aim, the quasi - experimental approach was used. Participants were (80) preparatory year students at Najran University in Saudi Arabia who were distributed into two main groups using the simple random sampling. One of these groups (N = 40) was assigned as the experimental group and was taught via the use of mental computation method. The second group (N = 40) was assigned as the control group and studied through the use of traditional methods. Mathematical problem - solving ability pre-test and posttest were applied to both groups. Findings showed that there were statistically significant differences between the two groups with regard to the mathematical problem- solving posttest in favor of the experimental group.

Keywords: mental computation; mathematical problem-solving ability, numerical sense; mathematical knowledge; and computation fluency

1. Introduction

Kingdom of Saudi Arabia aims to have an educational system that keeps up with the international standards, and is parallel with the best educational systems all over the world. Teachers, on the other hand, need varied types of mathematical knowledge, which is shaped through the teaching practices and learning mathematics proficiently. Preparation standards and operations are an essential development for numerical sense and ability to analyze numbers. Developing the numerical computation requires a balance between the conceptual understanding and computational ability because training without understanding is subject to forgetting. Students should have experiences that help them choose the mental computation instead of using paper and pencil in

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[i] Correspondence: email talalmashaqbah@yaho.com

accordance with the problematic situation, specific question context, and involved numbers that allow the mental strategy.

Logical development of counting concept across school stages begins with the mental solution of some problems using the analysis strategy like: $(\frac{1}{2} + \frac{1}{4} = (\frac{1}{4} + \frac{1}{4}) + \frac{1}{4})$. In later stages, the computation operation should be developed and meanwhile students should quickly conduct computation operations. In order not to fall in computation errors and in order to reach computation fluency, an understanding of the meaning and perception of numbers is required. Moreover, to conduct computation accurately and quickly, there is a need for knowledge of multiplication and addition; reliance on reference tables that might be outside the normal tables such as the use of fingers; multiplies; bisecting and multiplicity rules by 5, 11, 12, 21; and verifying the computation operations without performing the operation again (National Council of Teachers of Mathematics, 2013).

The National Council of Teachers of Mathematics (NCTM) has called those who are interested in learning and teaching mathematics to vary the means of performing the computation operations and so started the call for mental computation very early in the eighties of the last century at the same time where the concept of numerical sense began in order to develop the mental performance (Al-Saeed, 2005).

Mental computation is a set of strategies used by the student to easily, accurately, and quickly solve or perform computation operations and, at the same time, using his human mind (Dehaene, 1997). To perform mental computation accurately and quickly, knowledge of computation operations is required mainly, making reference tables that help conducting multiplication operation outside the normal table such as using fingers for number nine (9) table. We look at the number that is multiplied by number (9) and its place on fingers, and so the number of fingers will be to the left of the number in the tens place while the number of fingers to the right of the number is in the ones place. Multiples while conducting mental computation are important and help us to multiply any large number. We can set a rule to find the outcome of multiplication by 4 and 8 by factoring number 4 = 2 x 2 and number 8 = 2 x 2 x 2. Bisecting, which is opposite to multiplication is also used. For example, when multiplying any number by number 5, we bisect the multiplied number by 5 and place 0 in the ones of the outcome if the multiplied number by 5 is odd, but if it is an even number, we place 5 in the ones of the outcome (235 x 5: bisecting 235 is 117) because 235 is an odd number, so the result is (1175).

In this respect and with regard to the effectiveness of using mental computation in teaching mathematics, a study by Abdulmalak (2018) showed that the 2×4 E model in teaching a proposed module based on mental computation was effective in developing students' skills in mathematical inference and computation fluency. Another study by Al-Aamili and Al-Kan'aani (2019) proved the effectiveness of a mental computation strategy-based- educational program in developing intermediate stage students' achievement in mathematics. The study of Ma'touk (2020) also indicated that the using mental computation was of great effect in developing some skills of students' numerical sense (Elfeky & Elbyaly, 2016).

Moreover, the ability to solve problems is a concept consisting of a problem that indicates a situation with a question that requires an answer, a requirement that needs access, a goal that should be achieved, or an issue to be validated. For the situation to be as a problem for someone, he should be interested to reach a conclusion. For the teacher to develop students' ability to solve problems, he should allow them the opportunity to think individually or in groups. He should track some steps for problem solution starting with the students' understanding of the problem through expressing it in their own language or representing it in a diagram and analyzing it into data to reach the desired (Elfeky& Elbyaly, 2017). After understanding, students resort to being empowered through translating the problem into equivalent images by modeling it in the forms of equations, inequalities, an engineering chart, or organizing the data in a table. After that, they set the solution plan, and meanwhile think about alternatives, to reach the solution. Then they check the rightness of the solution and the existence of other solutions. However, there might be problems that can not be solved because of the contradiction in its data or lack of information (William, 2010).

Teaching problem solving is one important competency of the general competencies for any developed curriculum because of its active role in identifying the problems that require solutions in multiple contexts; proposing solutions to problems and developing them; innovating new methods by applying a complex correlative system of knowledge, skills and attitudes; and cooperating with others in the context of solving problems to develop positive attitudes towards implementation and change (Al-Obeidat and Al-Otoum, 2018; Masadeh & Elfeky, 2016).

Training students to solve mathematical problems goes through three stages while solving the problem, i.e. before - during - after where each stage has a set of tasks. In the first stage, students should be mentally prepared for the task by eliciting solution strategies via brainstorming. For instance, a task involving calculating (2.76 + 13.4) can allow students to think about the answer size whether it is above 20 and explain why and why not. Many students will calculate mentally, and they should explain the logic used to get the answer to ensure understanding by being forced to rephrase the problem and solution procedures in their own words. Furthermore, they should make sure that they understand it. In the second stage, there should be an emphasis on "Leave". That is, students should be allowed the opportunity to work without directives in order to use their ideas. The teacher's role, in this stage, is only to provide hints not solutions. He should avoid being the source of information constantly or the determiner of True and False. They should be accustomed to causation, i.e. how and why. The teacher must also show interest in what students are doing. In the last stage, students' solutions should be discussed. Sharing ideas, in this stage, is the best learning for students in order to enhance the class to develop into a community of learners (Van de Walle, 2010).

Therefore, the present study seeks to investigate the effect of using mental computation in improving the ability of preparatory year students at Najran University to solve the mathematical problems.

2. Problem of the Study

The researcher, while teaching mathematics courses to students at the preparatory year at Najran University, noticed students' reliance on a single method for problem solving. Students were trained to use it without being given enough freedom to express the ideas in solving the problems facing them. They were not trained previously on using different strategies for solving mathematical problems, which is reflected in their achievement and attitudes towards mathematics. Thus, there should be an interactive technique that helps students explore new horizons, develop the skills of the twenty-first century, and enhance opportunities of education and learning for all during life span. Therefore, they have to master mental computation skills derived from an effective and productive thinking that helps them solve every day and future problems (Abu Zina, 2003; Elfeky, 2018). In this regard, several studies highlighted the importance of mental computation in teaching mathematics and the importance of using it as a way that develops numerical sense and mathematical thinking (Al-Baz & Al-Riyashi, 2000; Johansson, 2005; and Shen, 2006). Whereas, most studies concluded that mental computation depends on the development of mental skills and allows students the opportunity to generally understand numbers and realize them in terms of absolute relative quantity. This understanding can grow by focusing on examples associated with concrete things and discussion that develop students' mental skill instead of forming mental models. Furthermore, many studies have emphasized the importance of mental computation such as (Ali, 2005; Al-Banna & Kamal, 2008; and Shen, 2006). Researchers were also interested in developing students' problem-solving skills because of their positive effect in students' lives, as indicated by the findings of Salem & Al Yahya (2005); Hamadanah (2005); Al Obeidat & Al-Otoum (2018); and Al-Mohammadi (2018). In addition, other studies showed a great interest in creatively problem-solving strategy and investigated its effect in different variables. Findings of such studies showed an agreement on the fact that that creatively problem solving is effective in developing thinking skills, learning retention, and achievement (Baherm, et al., 2015 and Wa'er, 2005).

Specifically, this study tries to determine whether there is a statistically significant difference ($\alpha = 0.05$) in mathematical problem-solving ability among preparatory year students at Najran University due to the teaching strategy i.e. mental computation or the traditional method.

2.1 Importance of the Study

The present study is important because it presents various strategies by which computation operations can be performed instead of absolute dependence on paper and pencil to develop mathematical problem - solving of preparatory year students at Najran University. It also keeps pace with the modern global trends towards the use of mental computation in teaching mathematics besides keeping pace with the growing interest in the need to develop students' minds in general, and specifically university students, during teaching mathematics using mental computation that urges using students'

minds. Furthermore, mental computation fortifies students' memory and develops their ability to think. It is one of the most important skills for students in mathematics in particular. It enhances students' self-confidence when they can depend on themselves without using a calculator besides their understanding and analysis skills.

3. Operational Definitions

3.1 Mental Computation
Mental Computation is defined as "*A set of strategies used by the student to help him solve or perform mathematical operations easily, accurately and quickly at the same time using his human mind*" (Miqdadi and Al-Khatib, 2003). Operationally the researcher defines it as "*The ability to find mentally and fluently the outcome of multiplication and division operations assigned to preparatory year students at Najran University.*"

3.2 Mathematical Problem-Solving Ability
Mathematical Problem-Solving Ability is defined as "*Knowing what students do by observing and evaluating their own progress, so that they can adjust their strategies when facing problems, solve them through mental computation, and think about thinking where the teacher's role is limited to supporting students to reflect and question in order to acquire understanding check habit*" (Bransford, Brown & Cocking, 1999). It is usually measured by the total score obtained by the student in mathematical problem-solving ability test.

4. Study Limitations

4.1 Spatial Limitations
The study was applied to preparatory year students at Najran University in KSA.

4.2 Time Limitations
The study was carried out in the first semester of the academic year 2019/2020.

4.3 Human Limitations
The study was limited to a purposeful sample of (80) students at the preparatory year at Najran University.

4.4 Objective Limitations
The study was limited to mathematical operations and divisibility.

5. Methodology

5.1 Study Approach

The quasi-experimental approach was used to measure the effect of using mental computation in improving the mathematical problem-solving ability of preparatory year students at Najran University.

5.2 Participants

Participants in the present study were (80) students who were all enrolled in studying mathematics at the preparatory year at Najran University in the first semester of the academic year 2019/2020. Najran University was purposefully chosen because the researcher is a faculty member there. Participants were equally divided to two groups. Group A (N=40) was assigned as an experimental group and group B (N=40) was assigned as a control group. The choice of the experimental and control groups was via simple random sample techniques using lottery.

5.3 Study Instrument

Problem - solving ability test was prepared to measure the improvement level in preparatory year students' problem-solving ability regarding these steps: a) reviewing theoretical literature and previous studies, b) determining the lessons to which the study was applied, c) analysis of these lessons, d) building the test specification table, e) building the initial form of the problem - solving ability test, f) applying the test to an exploratory sample outside the study sample to determine the way of correcting the test, and work out its reliability and validity coefficients. The final form of the test consisted of (10) open - ended questions that measure the mathematical problem - solving ability. Each question was given two points for the correct answer, and zero for the wrong answer, and so the test scores ranged between (0 - 20) degrees.

5.4 Test Validity

To ascertain the validity of the mathematical problem-solving ability test in order to make sure that it will measure what it was set up to measure, validity of the arbitrators was used. The test, in its initial form, was presented to a group of specialized arbitrators to investigate their viewpoints with regard to questions' comprehensibility for the whole content; their suitability for students' levels; the questions linguistic and scientific accuracy; and accounting for any important and essential notes about the test. At the end, arbitrators' notes showed that they were in agreement regarding the test's applicability and suitability to measure students' problem - solving ability.

5.5 Test Reliability

To ascertain the test's reliability, it was applied to an exploratory sample of (30) students outside the main study sample, and then after two weeks, it was applied again to

calculate Pearson Correlation Coefficient using the application and re-application way. Finally, the calculated coefficient was (0.85) indicating a high degree of reliability.

5.6 Mental Computation Guide

The researcher of the present study presented a guide for the use of mental computation in teaching mathematics where there are several strategies for mental computation. Then he applied the operations' properties on numbers to facilitate performing computation operations on them. In order to empower students to do so, the teacher should help them to (1) understand the properties of mathematical operations such as substitution, merging and additive inverse, link both of addition and subtraction operations when performing computation operations. He should help them identify the different influences on operations, i.e. using multiples and powers of ten, convert numbers into a word sentence, use bar charts and how to employ them when performing the computation operations. (2) Rename numbers, which means students' ability to rewrite any number in the form of an outcome of adding or subtracting any other two numbers in order to facilitate calculations for them. In addition, students should be helped to understand how to rename the number, for example: in order to multiply (8 x 99) 99 can be renamed as (**100 - 1**) and so the problem can be written like *{8 x (100 -1)} = 800 - 8 = 792}*. (3) Using the relative effect of operations on numbers. It is known that addition and subtraction operations have an effect in the operation outcome. This effect is related to the type of operation and the numbers on which operations are performed. There are some relationships related to the outcome of each of these two operations with numbers, and in order for the student to use these relative effects of operations on numbers, he should be helped to use generalizations like : (a) The outcome of adding two numbers that are greater than each of the two numbers. (b) Whenever one of the two added numbers becomes bigger and the other number remains constant, the outcome of their addition will be bigger and the other remains constant, the product of their sum will increase. (c) The outcome of adding two numbers is greater than the outcome of their subtraction. (d). The outcome of subtracting two numbers is smaller than the number subtracted from. Therefore, it is important to identify the skills related to mental computation as mentioned by Morgan (1999) in order to activate the strategies mentioned before. These skills include: translating the issue into a picture or form that is easy to be dealt with mentally; understanding and applying the concepts of the spatial value; retrieving and remembering basic facts related to addition and subtraction operations; dealing with multiples and powers of ten, synthesizing and analyzing numbers and expressing them in a variety of ways; and using the substitution and aggregation properties of addition and subtraction operations.

5.7 Study Procedures

For the sake of achieving the study aims, the following procedures were done: first of all, all necessary approvals and permissions to conduct the study were obtained. Then, the study instrument and the guide for using mental computation were prepared. After that,

the experimental and control groups were selected randomly. Next, the problem - solving ability test in computation operations was built and applied to the exploratory sample to ensure all psychometric properties. After that, the problem -solving ability pre-test was applied to the main sample of the control and experimental groups to verify the homogeneity of the two groups. Later on, students in the experimental group were subjected to the treatment and started studying through the use of mental computation method, while the control group went on studying via the traditional teaching methods for two months. When the experiment of teaching mathematical operations ended, the problem - solving ability posttest was applied to students in the experimental and control groups. After that, the test was corrected after defining correction rules and criteria, to which the corrector should be committed because the test questions were open-ended questions. Then, collected data were organized and statistically analyzed using the (SPSS) statistical program. At the end, results were concluded, discussed and expressed.

5.8 Homogeneity of the Two Groups

In order to ascertain the homogeneity of students in both groups, control and experimental, regarding their mathematical problem - solving ability, the pre-test of the problem-solving ability was applied. Results are shown in Table 1.

Table 1: T - test for the two independent samples
regarding mathematical problem-solving ability

Group	N	M	SD	T.	DF.	Significance
Control	40	9.40	1.49	0.871	38	0.389
Experimental	40	8.40	1.00			

Results in Table 1, show that the T. value (T = 0.871) is not significant. That is, there were no statistically significant differences between the control and experimental groups with regard to their mathematical problem - solving ability.

5.9 Study Variables

The present study includes these main variables:
1) The independent variable represented in the teaching method, i.e. the use of mental computation and the use of traditional teaching methods.
2) The dependent variable represented in students' problem - solving ability.

5.10 Study Design

The present study adopted the quasi-experimental approach, and tried to investigate the effect of using the mental computation method in teaching mathematics in developing students' problem - solving ability.

The Experimental Group: O1   X   O1
The Control Group: O1   -   O1

O1: Problem-solving ability (Pre and posttest)
X: Treatment (the use of mental computation)

6. Results and Discussion

To answer the study main question, significance of the difference between the mean scores of students on the posttest of the problem - solving ability in the control and experimental groups was calculated. T. test for independent samples was used to determine the significance of these differences due to the use of mental computation and traditional teaching methods. Eta Square was also used to predict the size effect of using mental computation in improving the problem - solving ability of the experimental group students. Table 2 illustrates the results.

Table 2: T. test for the significance of differences between students in the control and experimental group due to their performance on the mathematical problem - solving posttest

Study Group	N	M	SD	T.	DF	Sig	Eta Square Size Effect	Size Effect Level
Experimental	40	16.15	1.49	5.83	38	0.0	0.472	High
Control	40	10.80	1.00					

Table 2 indicates that there are statistically significant differences (α = 0.05) between the performance of students in the control and the performance of their peers in the experimental groups in accordance with the total score on the posttest regarding mathematical problem - solving skills in favor of the experimental group (T value = 5.8300). Furthermore, calculating the size effect using Eta Square coefficient, revealed that it was (0.472) proving that the level of this size effect was high according to the equation of Cohen (1988). In other words, the use of mental computation strategies was effective in developing participant students' ability in mathematical problem - solving in computation operations in general. This effectiveness was, of course, in favor of students in the experimental group. That is, performance and competency of students who were taught through the use of mental computation was superior to the performance and competency of colleagues who were taught via traditional teaching methods. This superiority can be due to the fact that mental computation is particularly one of the most important skills for students enrolled in mathematics courses. One interesting explanation for this result is the fact that mental computation enhances students' self - confidence, because they can depend on themselves and stop relying on calculators. Furthermore, it strengthens their memory and develops their thinking ability. It improves their understanding and analysis skills and meanwhile, strengthens their auditory concentration and consequently their ability to understand the problem at hand and then solve it in an orderly manner. In addition, the superiority of students in the experimental might be due to the fact that mental computation process is one of the important skills in the field of mathematics and highly recommended to be taught to students because mental computation enhances students' self - confidence and powers. It, in the same time, grants them good planning and preparation in their lives, in general and more

specifically, in their study. This result is to a far extent, consistent with the findings of previous studies, such as Abdulmalak (2018) that revealed an effect of using the 2×4 E model in teaching a proposed unit in mental computation in the development of students' mathematical inference skills and computation fluency. It also corroborates the findings of Al- Aamili & Al-Kan'aani (2019) with reference to the effectiveness of mental computation strategies - based - educational program in developing intermediate school students' achievement in mathematics. Moreover, it agrees with Ma'touk (2020) and Elfeky (2017) with regard to the effectiveness of using mental computation in developing primary school students' numerical sense skills.

7. Recommendations

In light of these results and conclusions, these recommendations and suggestions are put forward:

1) The importance of using mental computation in teaching courses of mathematics at university because of its positive effect in developing students' problem - solving ability.
2) The importance of providing training courses and workshops for faculty members enrolled in teaching mathematics on how to use mental computation in their lectures.
3) The importance of the inclusion of mental computation in mathematics courses when setting every course description.

Conflict of Interest Statement
The authors declare no conflicts of interests.

About the Author
Talal Tayel Al Mashqabah is an assistant professor at the deanship of Preparatory Year at Najran University in Saudi Arabia. His research interests involve current methods of teaching, and the use of computer and multimedia in teaching.

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