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Studying the Effect of Mental Calculations Training with Abacus on the Learners' Cognitive and Psychological-Emotional Characteristics (Intelligent & Creative Children Institute)

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Abstract

The purpose of this study was to study the effect of mathematical mental calculations training on increasing the cognitive and emotional abilities of children and students. Two sample groups with 306 people (148 ones in the group of mathematical mental calculations training at the intelligent children's institution and 158 ones in the formal training group) were selected among male and female children and students in Tehran City who were selected by stratified sampling method. Based on three groups of age 6 old, 7 - 8 years old and 9-11 years old, mathematical ability tools, Toulouse concentration test, standard tests of mathematics, science and Persian literature, basic mathematical skills, contemporary self-control scale, Pope self-esteem and reading progress. Results based on factor analysis of variance, multivariate factor analysis of variance and t-student methods showed that there was a significant difference between the groups of mental calculations training and formal training in different age groups and these differences were related to gender in some groups.

Keywords: Mental calculations training; Abacus; Learners' cognitive; Psychological-emotional.

1. Introduction

Undoubtedly, one of the high and very complex mental activities is solving the mathematical problems. One of the ways to achieve this goal can be to develop new ways and methods and provide math education competencies. These competencies can include the abilities such as understanding the basic mathematical concepts, doing mental calculations, or writing various operations (such as adding, subtracting, multiplying, and dividing), problem solving, data interpretation, estimation, etc. Mental calculus can increase the mental self-confidence as it improves learning, concentration, creativity and memory improvement (Gilmore *et al.*, 2010).

Abacus is a tool for calculating four basic mathematical operations, which in advanced mode can be used to calculate the fraction and square root of numbers. Nowadays, it is still used for the calculations in some parts of Asia , however, it is mostly used by beginners in the field of calculations, which is called the mental calculation method. In this way, learners begin to work with abacus, then they perform calculations by manipulating the abacus in the mind. This method, in addition to allowing individuals to perform calculations faster, makes it easier for beginners to learn calculations, and has less stress for them (Gera and Kaur, 2014).

Research on the elementary children showed that those who learned to work with the abacus, had lower computational errors and higher computational ability than the control group. But in the other cognitive areas such as attention, there was no significant difference between two groups. The effect of working with abacus on physical characteristics has also been the subject of several studies. For calculations, the abacus is used from two index finger and thumb finger. Findings of Bhaskaran *et al.* (2006), in a two-year study on children aged 5-12 years old showed that those who had seen the abacus-related education were better than those who did not received these educations.

A basic question that how is the mechanism and impact process of working with abacus and mental calculation. In general, working with abacus requires coordination among seeing, sounding and finger movements. In other words, people who work with the abacus try to analyze the visual, acoustic and sensory introspection together, analyze and finally solve the problems. This process causes the synaptic communication to increase. Also, those who learn to work with the abacus, combine two right and left brain hemispheres. Therefore, since messages are exchanged between the right and left hemispheres of the brain, both hemispheres are involved in this system and grow (Bhaskaran *et al.*, 2006).

The abacus education has been used in the country for about 4 years and seems to have been welcomed by the children and their parents with great encouragement. It is essential to evaluate its effects in different areas, so that to identify its strengths and weaknesses, and to use the findings to plan courses as well as to apply its training in other official and civic institutions of the country.

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2. Research Design

The present study is done based on a follow-up plan (causal-comparative) and compares two groups of children and students, including: (1) those who, in addition to regular education in schools, spend the course of mathematical calculus with abacus at the Intelligent Children Center; 2) Those who only have regular school education.

Considering that the training course for mathematical calculus with abacus is taken based on age levels in the range of 6 to 11 years in terms of the education and content and also in order to compare with the same group of children who receive regular education, the research design was divided into three age groups of the children under study, along with the three groups of control, to be classified according to their age-specific ranges.

1- Pre-school (6 years old): In this group, variables of the basic concepts of mathematics (cognitive field) and self-control (emotional field) were compared.

2- The first and second grade of the elementary school (7-8 year olds): In this group, variables of mathematical progression, reading comprehension (cognitive field) and self-esteem (emotional field) were compared.

3- The third and fourth grade of the elementary school (age group 9 to 10 years old): In this group, variables of mathematical abilities, academic achievement in mathematics, science and Persian literature (cognitive field) and self-esteem (emotional field) were studied.

3. Statistical Population and Sample Group

The population of this study is all children and schoolchildren aged 6-10 years old in Tehran city from two communities as follows: 1) Those who, in addition to formal education, undergo a course of mathematical calculus; and 2) children who attend only formal school education.

From the first community, a sample group with 150 people (regarding 10% sample drop) was selected based on multi-stage sampling of the urban areas, gender, age and level of mathematical mental education. Sampling plan for this sample group is presented in Table 1. In the first stage, among the education districts of Tehran city, which had educational representation, 5 regions were selected randomly, in addition to comprehensiveness, reflecting the economic and social characteristics of different districts. In the next stage, the size of the sample group was randomly selected by gender and age. At this stage, the share of educational (primary, intermediate, and advanced) levels was observe in the sample group.

Table-1. Sampling plan for children and students of mathematical calculus training

		sample		gender		Age range		
row	**district**	**percent**	**numbers**	**girl**	**boy**	**6**	**8-7**	**10-9**
1	1	4	6	2	4	1	2	3
2	3	6	9	5	4	2	2	5
3	11	39	58	29	29	12	20	26
4	20	31	47	24	23	9	20	18
5	22	20	30	15	15	4	14	12
total		100	150	75	75	28	58	64

In the second community, i.e. students who only receive the formal education, a sample group with 160 students from pre-school centers was randomly selected for the first community in the selected districts. The demographic characteristics of the sample groups were presented in Table 2.

Table-2. Demographic characteristics of the sample groups

	Training calculation		Formal education			Training calculation		Formal education	
variable	**N**	**%**	**n**	**%**	**age**	**n**	**%**	**n**	**%**
group	148	48/7	156	51/3	6	23	15/5	39	25
gender					7	28	18/9	22	14/1
girl	73	49/3	89	57/1	8	31	20/9	20	12/8
boy	75	50/7	67	42/9	9	36	24/3	39	25
Grade			21	14	10	26	17/6	30	19/2
Preschool	23	15/5	39	25	11	4	2/7	6	3/8
first	28	18/9	22	14/1	**Father's education**				
second	31	20/9	20	12/8	Junior high school and less	16	8/8	17	10/9
third	37	25	39	25	Diploma	52	35/1	41	26/3
forth	29	19/6	36	23/1	Academic	65	33/9	81	40/6
					Unknown	18	12/2	26	16/7
					Education				
					Junior high school and less	69	46/6	73	46/7
					diploma	12	8/1	14	9/6
					academic	46	31/1	36	23
					unknown	21	14/2	33	21/1

As presented in Table 2, the sample drop for the mathematics computing group is 2 and for the control group it is 4.

4. Research Tool

Mathematical Ability Test (MAT): This test is used to measure four important components in math abilities, including the discovery of logical relations between numbers, the initiative in the application of mathematical operations, the speed of action in the application of mental activity, and problem solving. This test with 88 questions includes four subsamples as follows.

1- Discovering the series of numbers (19 questions). In this subscale, the student must discover the logical relations between the series of numbers and find the sequence of the series.

2- The speed of action and initiative in the application of mathematical operations (17 questions). In this subscale, students will find the answer by using the numbers and mathematical operations specified in the question.

3- Application of mental function (29 questions). In this subscale, the students should find a brief and innovative solution to solve the problem in a short time.

4- Problem solving (23 questions). In this subscale, students' skill is measured in the context of problem solving.

The coefficients of validity of this test in this study for total score and its subscales were 0.91, 0.83, 0.80, 0.81 and 0.70 respectively.

Toulouse-Piéron test (Comet squares test) Toulouse-Pyron: Comet quadratic test was constructed by Pyroun and revised by Toulouse (1986, quoted by Iravani (2004). The test content consists of a number of repetitive comet cubes. The subject must select and align the squares of the specified pattern with speed and accuracy. In the classic form of this test, there are a thousand characters randomly blended and published on a single page. At the top of the page, there are three symbols, and the subject should be able to get all the signs similar to these three signs as soon as possible within 10 minutes. The number of correct answers representing the speed of the subject and the number of incorrect and forgotten answers indicates their inaccuracy and focus. For each correct choice, one positive score and for each missed choice, negative 0.5 is considered negative (Iravani, 2004).

Standard Scale for Academic Achievement: This is the first standard test for the academic achievement to measure the academic achievement of elementary students (from the third grade) and junior high school and based on new psychometric theories in mathematics, science, history, language, Arabic, social sciences, literature, geography and religion have been developed in a sample group with 1200 students from elementary to junior high school.

This scale consisted of 232 questions from all the grades of elementary and junior high school with varying difficulty coefficient. In the experiment stage, the test was conducted on 1000 elementry and junior high school students (500 girls and 500 boys) in group and non-profit schools, and public schools of different district of education in Tehran City.

In this study, three main tests of mathematics, reading, and science were conducted in the third group. The validity coefficients of these tests for the study were 0.70, 0.72 and 0.75, respectively.

Primary Math Skills: This tool is developed to measure the initial skills in math concepts for a pre-primary group and includes a wide range of the following skills that have been developed based on the study of theoretical foundations as well as the study of the contents of pre-school math books with 49 questions (Hamnava, 2015).

- Basic concepts (sizes, colors, similarities and differences, communication, one-to-one correspondences and pattern recognition)
- Understanding the numbers and counting (one-digit, double-digit, value-recognition, account)
- Geometry and space awareness (space, geometric shapes)
- Measurement (length and surface)

Reading Skills Test

This test has been developed to measure five components of reading skills, including reading words, listening comprehension, non-word reading, and written reading comprehension. This test consists of five subscales as follows:

Reading Words: In this subtest, the number of written words in 15 seconds is correctly measured. Listening comprehension: This sub-test is adapted from the Reading and Dyslexic Test (Faramarzi and Moradi, 2013) and measures the ability to understand the readable text for the child.

Reading Numbers: In this subtest, the ability to correct pronounce a non-word is measured in 15 seconds. 61 non-words were made according to the words of the first grade literature book.

Written comprehension: This subtest measures the ability to understand child-written sentences.

Math Progress Test

This test has been developed and validated by Hamnava Institute (2016) to measure the seven mathematical skills that are considered in the first grade book and have more frequency. These skills include counting, numerical modeling, geometric modeling, problem solving, calculations, time, and measurement.

Pope Self Esteem Test Pope *et al.* (1988) with 60 questions, have five sacles of general self-esteem, educational, physical, family and social plus a lying scale. Each scale has 10 separate questions.

Self-Control Scale for Children

The self-control scale for children (Hamnava Institute, 2016), has been developed on the basis of cognitive-behavioral definitions of the self-control concept and by Humphrey *et al.* (1982). This scale is prepared and adjusted, which can be completed by mother (parent) and mentor (teacher). The scale structure has two parts or subscales:

1- Cognitive-personal: This subscale measures the ability to focus on the assignment with 10 questions.

2- Behavioral / Interpersonal: This subscale measures the disturbing or disturbing behaviors with 5 questions.

The total score of questions for each subscale is calculated and divided by the number of questions in order to score.

1- Cognitive / Personal subtest: Questions 1 to 10

2- Behavioral / Interpersonal subscale: Questions 11 to 15

5. Data Collection Method

In order to collect data, an executive group with two senior psychologists, headed by a PhD in Educational Psychology, was formed that after the training the course and mastery of the implementation, began the process of assessment individually and collectively.

In order to implement a coherent approach to the teaching mental calculus children group, the following activities were carried out:

- A representative was introduced for each study district.
- It was coordinated with families to determine the day and hours of execution.
- Places of execution were determined through cultural center, growing houses and health houses.

In the children formal education group with the education license, six elementary schools for girls and boys were randomly selected and coordinated with the managers for execution time.

The tools were implemented according to the age levels, as follows:

In the pre-school group, the tests were performed individually. First, after the necessary explanation to the subject, the basic concepts of mathematics test were performed, and after that the subject responded to the accuracy and concentration test within ten minutes. In order to measure the self-control of pre-school children, the child's parent responded to the test.

The tests for the first and second grade students included math progress tests, reading progress, and accuracy, focus and self-esteem were also performed individually. In performing the self-esteem test, the examiner provided an example following the purpose of the statement, about the scale and how to answer the questions, and asked the subjects to try to listen carefully to the questions and choose the right answer.

Tools for students in the third and fourth grades were implemented in groups with three to four people. These tests included math abilities, academic achievement (mathematics, science, and Persian literature), the speed and accuracy test, and finally self-esteem test.

Taking into account the high volume of questions and also preventing the effect of subject's fatigue on the results with the necessary coordination, the tests were performed in two stages. In this group, the self-esteem test was red and answered by the subject himself.

It should be noted that in order to avoid the effect of the order in the implementation of the tests, several copies of the tests were randomly executed in different order.

6. Data Analyzing Method

The following statistical methods were used to analyze the data and answer the research questions:

1- The statistical characteristics of the sample groups and the collection of materials of the questionnaires were determined using standard methods in descriptive statistics.

2- The validity coefficients of the set of questions in different groups were estimated using the general formula of Cronbach's alpha coefficient (in classical theory).

3- To compare the research groups, the factor analysis, multivariate analytic and t-test were used for independent groups depending on the case.

4- Statistical operation was performed with SPSS software.

7. Discussion and Conclusions

The purpose of this study was to investigate the effect of mathematical mental training on increasing cognitive and emotional abilities of children. For this purpose, two groups of children and students in Tehran city who are exposed to the training of mental math at the Intelligent Children's Institute and those who had just seen formal education, were compared in terms of cognitive abilities including mathematical concepts, mathematical ability, mathematical progress, academic achievement, concentration, accuracy, and emotional abilities including self-control and self-esteem.

7.1. Cognitive Features

The results of this study showed that there is a significant difference between two groups in some cognitive variables, so that the math group received higher grades than the formal education groups under the subscale of numbers (1st age group), math progression (second age group), mathematical ability and math progression (third age group), and accuracy test.

Also, the effect of abacus calculations training on the cognitive abilities of elementary school children causes less computational errors and higher computational ability.

The more detailed results of this study showed that in the pre-school group, children who have been trained in math calculations, received higher average for the concept. On the other hand, mathematical mental calculations can help children to understand the relationship between numbers and abstract concepts (Tang and Reed, 1993). Most children do not pay attention to the sequence of numbers in the numeric representation of numbers when they count

and move from 9 to 10 and 11, but children, when working with mathematical calculus, usually understand the significance of this move. This study confirms the results of the study done by Wang *et al.* (2015). Another finding of this study showed that students in the second grade in mental computing group have higher math progression than the control group. However, in this study, the results are close in the first grade and are significant in the third grade, but the fourth grade students in the mental calculus group scored higher scores in two sub-scales of mental activity and computational speed. These results, which are similar to the findings of, can be attributed to a change in skills (in the field of mathematical calculus to counts), which has a significant indirect effect on academic achievement in math.

The results of more sophisticated statistical analysis of this study showed that in the fourth grade, the mental training group has a higher score in two subscales of relations between numbers and subjective operations. While in the third grade, the official group got a higher average. In other words, calculating calculus with the help of abacus was more effective in the fourth grade students. This shows that the effect of mathematical mental training on performance is dependent on some other variables, such as age-related variables. For example, the duration of work with mental math can lead to more skills.

Abacus Computation Training and Student's Emotional Characteristics

The findings of this study regarding the emotional characteristics (self-control and self-esteem) generally show that there is no significant difference between two groups. However, other findings have indicated that the characteristics of individuals who are successful in computational calculus and computational estimates, are usually flexibility, confidence, and error tolerance in estimates. Therefore, it is expected that self-esteem increases as the child gains a better understanding of mathematics and rational reasoning. The process of thinking more clearly and the power to understand better is why a child can have higher self-esteem with training mathematical calculus, because the feeling of mastery can increase self-esteem.

in the present study, there was no direct relationship between computing and self-esteem training, but more detailed analysis showed that gender as a moderating factor plays a significant role, so that in the group of mental calculations, boys have significantly higher average self-esteem than the girls.

The last part of the findings of this study about the accuracy test showed that there is no significant difference between two groups of mental and formal education in the number of correct answers, but the difference between two scores for false responses and forgotten answers is significant, so that the group with the training of mathematical calculations had less errors and less responses. Given that over time, it is necessary to focus on the solution through the mathematical calculus. Because it takes away the slightest mistake in student computing, and enables the student to concentrate and to strengthen his visualization and imagination. Kiang *et al.* (2015). On the other hand, however high speeds in doing a lot of work is an advantage, it often decreases with increasing the speed. Findings of this section of the present study show that the mental training group has a more accurate focus than the formal group. Consequently, teaching mental calculus has been able to significantly increase accuracy and concentration more than strengthening the component of speed.

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