# The Effect of Activities Congruent with Brain Based Learning Model on Students' Mathematical Achievement

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**ABSTRACT**

The purpose of this study is to investigate the effects of teaching activities prepared with brain based learning model on mathematics success of primary school students. In the study, pre-test-post-test and permanence test half–experimental design with control group was used. The participants of the experiment consist of total 91 fourth-grade primary school student's continuing education in İstanbul, and also taking part in experimental and control groups. Data were collected by using "Personal Information Form" prepared by the researchers and "Mathematics Achievement Test About the Subject of Natural Numbers in the Fourth Grade" also developed by the researchers. To analyze data, it was used for SPSS package program. According to the findings of the research, a significant difference has been found in favor of the experimental group regarding mathematics achievement of the fourth grade students and persistence of knowledge they have learned.

**Key Words:** Brain-Based Learning, Mathematics Lesson, Academic Achievement

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## Introduction

Learning based on the nervous system and the brain is explained by the formation of new synaptic connections by chemical and electrical changes in the brain. It is possible to say that the learners related to this situation cause the structure of the brain to change (Açıkgöz and Madi, 1997). According to Carper (2013), there is no body organ as important as the brain that works at maximum level so that effective and meaningful learning can take place in real life. Learning occurs as a result of a number of activities such as association of sensory organs (touch, sight, tasting, smelling, and hearing), repetition, and interpretation in the brain (Demirel, 2011).

It has been researched by many scholars how learning occurs in the brain. Depending on technological developments, an increased knowledge of the biological structure of the brain has contributed to the development of brain-centered learning models. Learning approaches such as Brain-compatible learning (Ronis, 2007), Brain-friendly learning (Biller, 2003; Willis, 2008), Brain-based learning (Caine and Caine, 2002; have been developed. Scientists have gone from brain research to organizing education and training programs (Şen, Başar, Aşkın and Turan, 2015).

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After a better understanding of the work structure of the brain with developing technology, learning approaches to how to organize the appropriate learning environments for this structure have become the focus of researchers. It is possible to show one of these approaches as brain-based learning. Brain-based learning is a learning approach that aims to reveal the link between the human brain and learning by examining the relationship between the structure of the human brain and learning (Çiftpınar, 2012). Making meaning in the brain is more important than getting information. This meaning is formed through patterns and sentiments. In this learning model, not only the meaning related to the learned subject can be learned, but meaningful learning takes place by establishing links with past topics (Köksal, 2011). Brain-based learning approach does not offer people a recipe but helps in human decisions and thinking (Akınoğlu, 2007).

## Mathematics and Numbers

Mathematics is a process that has structures and connections and includes generalizations. This process is full of abstract concepts. Since abstract concepts are difficult to achieve, mathematics is difficult for students. For this reason, teaching methods of mathematics emerges as a subject that should be emphasized in today's world. An appropriate teaching system for the structure of mathematics will help learners to understand and correlate mathematical connections and associations (Alakoç, 2003).

Teaching methods in mathematics are constantly debated, especially because it is abstract and because it is thought that it is learned in a more difficult way than other sciences because the need for mathematics has always existed throughout history. However, the size of this requirement has changed from ages to ages (Nures and Brgant, 2008). The methods applied do not exactly give the desired result since every applied method is not exactly qualified to respond to every need. Afterwards, we come back to the stage where the teacher tells and the student listens (Polat, 2014). The work that has been done or to be done in our country will be a guide for both students and teachers (Kibaroğlu and Ünlü, 2015). It is hoped that this study based on brain-based learning method will investigate the effect of the student on the success of the mathematics course and contribute positively to the questions in education.

What students will first gain in mathematics at school is concept of numbers. It is directly related to the concept of reasoning and thinking with the techniques of calculation and measurement using numbers of mathematics (Pesen, 2008). The first numbers that human beings have used are counting numbers. Children also learn and use counting numbers first. When zero is added to the counting numbers, the natural numbers come up. In daily life, natural numbers and transactions with these numbers take an important place. In addition, mathematical concepts and relationships learned about natural numbers give students preliminary knowledge when learning other subjects (Baykul, 2014). Counting, the first arithmetic operation of mathematics, is not the name of events that can be observed in the nature but the images we create in our minds (Yıldırım, 2004). Since mathematics is a product of the effort to understand nature, the first mathematical terms emerged from the nature (Erdem, Gürbüz and Duran, 2011).

If we define the natural number concept; the definition of the natural number can be made on the basis of the cluster concept. One of the properties of cluster elements is its multitude property. This property of multiplicity is called natural number. So; natural number can be defined as the common feature of equivalent (similar, equal) clusters (Altun, 2008). Primary education has a very important place in the teaching of natural numbers in the first level. This is because the mathematical concepts that children encounter in their future lives and in their daily lives are acquired during this period. For this reason, primary education should be defined as improving the number and skill of instruction at the first level (Artut and Tarım, 2006). The number system we are using consists of 10 counting numbers 0, 1, 2, 3 ..... 9. The multiplicity is expressed in groups of 10. As a result of the grouping operations of numbers, the concept of step becomes important because the numbers are valued according to the steps they are in (Arslan, Yıldız and Yavuz, 2011).

## The Importance of Research and Its Purpose

In today's or even tomorrow's world, if we are going to do a mathematics program to educate children who think numerically and logically, we must first have a knowledge of how children learn mathematics and what mathematics means to children (Nures and Brgant, 2008). It is

possible to say that mathematics consists of basic dynamics such as numbers, metrics, algebra, forms and objects, space and operation, and is closely related to other dynamics of numerical mathematics. The concept of numbers is primarily a prerequisite for students to learn other subjects. As Altun (1998) has completed one of the topics in mathematics, it states that a topic must not be passed on until it is fully acquired. On the other hand, Yıldırım (2004) mentions that it is difficult for individuals to keep up with the society mechanism without knowing the basic calculations such as counting, addition and multiplication. Pesen (2008) emphasizes that it is very difficult for a child who has not sufficiently absorbed the number concept to be successful in the future. In this respect, the issue of natural numbers is emphasized in the study.

With mathematics being an abstract science discipline, teaching can be difficult compared to other disciplines. In our country where national mathematics scores are low and many students have the fear of mathematics, teaching methods need to be questioned again. Because the better a teaching method is developed or adopted, the more effective it will be (Russell, 2001). Especially during the elementary years, since the exploration of the skills and knowledge of the intended learners is necessary, the teaching model used must also reveal the skills and knowledge of the students (Russell, 2001). Mathematics can be considered as a process that requires mental processing. Therefore, it is considered that teaching approaches that are appropriate to the brain's working system will give more effective results. When the area is examined, it is seen that the teaching of mathematics is limited by the brain-based learning approach (Sadık, 2013). Hence, the brain-based learning model has been adopted as a teaching method in this study.

In the light of the explanations, the aim of this study is to examine the effect of mathematics activities prepared by the brain based learning model on the mathematical success of the students in elementary school 4th grade mathematics lesson. For this purpose, the following sub-objectives have been tried to be answered within the scope of the research.

- Is there a statistically significant difference between mathematics achievement scores in the pre-test, post-test and retention test measures of the students in the experimental and control groups?
- Is there a statistically significant difference between the mathematics achievement scores of the students in the experimental group according to the pre-test, post-test and retention test measures?
- Is there a statistically significant difference between math achievement scores according to pre-test, post-test and retention test measures of the students in the control group?

## Methods

### *Research Model*

This study was conducted with semi-experimental design in experimental research types. Karasar (2014) stated that quasi-experimental models come after actual trial models in scientific value maintenance and can be used when real trial models are not available or they are not sufficient. Semi-experimental models are written in different forms in the field. In this study, quasi-experimental design with pre-test, post-test and control group was used. In this context, experiment and control group has been determined and carried out with the application test group. It is possible to show the symbolic appearance of the experimental research design used in the research as shown in Table 1.

In Table 1, R: The subjects were assigned a group (each class was assigned as a different group and assigned as experimental group and control group at this stage) and BTÖYHMEA (BBLMMEA) was the brain-based learning method for mathematics education activities prepared for the fourth grade. It also shows Ö1.1 and Ö2.1 pre-test and post-test measurements for control and test group, Ö1.2 and Ö2.2 post-test measurements, Ö1.3 and Ö3.3 follow-up test measurements.

**Table 1.** Symbolic Representation of Semi-Experimental Pattern *

| Study Groups | Group Assignment | Pre Test | Applied Program | Post Test | Follow-up Test |
|---|---|---|---|---|---|
| **Eperimental Group** | R | Ö1.1 | BTÖYHMEA (BBLMMEA) | Ö1.2 | Ö1.3 |
| **Control Group** | R | Ö2.1 | --------- | Ö2.2 | Ö3.3 |

** Table Büyüköztürk (2017) was prepared according to the semi-experimental design*

**Table 2.** Demographic Variables Related to Participation

| Demographic Variables | | Experiment | | Control | | Total | |
|---|---|---|---|---|---|---|---|
| | | f | % | f | % | f | % |
| **Gender** | Girl | 21 | 23.1 | 22 | 24.2 | 43 | 47.3 |
| | Boy | 25 | 27.5 | 23 | 25.3 | 48 | 52.7 |
| | Total | 46 | 50.5 | 45 | 49.5 | 91 | 100.0 |
| **Age** | 9 y old | 21 | 23.1 | 11 | 12.1 | 32 | 35.2 |
| | 10 y old | 21 | 23.1 | 25 | 27.5 | 46 | 50.5 |
| | 11 y old | 4 | 4.4 | 9 | 9.9 | 13 | 14.3 |
| | Total | 46 | 50.5 | 45 | 49.5 | 91 | 100.0 |
| **Mother's Education Status** | Illiterate | 16 | 17.6 | 13 | 14.3 | 29 | 31.9 |
| | Literate | 13 | 14.3 | 5 | 5.5 | 18 | 19.8 |
| | Primary School Graduate | 9 | 9.9 | 9 | 9.9 | 18 | 19.8 |
| | High School Graduate | 6 | 6.6 | 14 | 15.4 | 20 | 22.0 |
| | University Graduate | 2 | 2.2 | 4 | 4.4 | 6 | 6.6 |
| | Total | 46 | 50.5 | 45 | 49.5 | 91 | 100.0 |
| **Father's Education Status** | Illiterate | 9 | 9.9 | 4 | 4.4 | 13 | 14.3 |
| | Literate | 19 | 20.9 | 10 | 11.0 | 29 | 31.9 |
| | Primary School Graduate | 7 | 7.7 | 10 | 11.0 | 17 | 18.7 |
| | Secondary School Graduate | 5 | 5.5 | 7 | 7.7 | 12 | 13.2 |
| | High School Graduate | 5 | 5.5 | 10 | 11.0 | 15 | 16.5 |
| | University Graduate | 1 | 1.1 | 4 | 4.4 | 5 | 5.5 |
| | Total | 46 | 50.5 | 45 | 49.5 | 91 | 100.0 |

### *Participants*

Participants of this study are 98 students who are attending to the fourth grade of a state primary school affiliated to Istanbul Provincial Directorate of National Education located in the province of Esenyurt in Istanbul and selected through easily accessible sample. Participants were identified as 91 students because their answers were not included in the findings. An easily accessible sample selection method was used in the study. An easily accessible sampling method can be used to minimize the loss of time, labor and cost, to add speed and practicality to research (Patton, 2015, Yıldırım and Şimşek, 2016). Detailed information on the participants of the survey is presented in Table 2.

As shown in Table 2, 47.3% of the students were male and 52.7% were female. Forty-six (50.5%) students were in the experimental group and 45 (49.5%) were in the control group. 23.1% (21 people) were 9 years old, 23.1% (21 people) were 10 years old and 4.4% (4 people) were 11 years old in the experimental group. Of the students in the control group, 12.1% (11 people) were 9 years old, 27.5% (25 people) were 10 years old, 9.9% (9 people) were 11 years old. 35.2% (32 people) of the students who participated in the study were 9 years old, 50.5% (46 people) were 10 years old and 14.3% (13 people) were 11 years old.

## Data Collection Tools

### *Personal Information Form*

The personal information form was prepared by the researchers to better understand the sample group and to analyze the factors that might be of interest to the research. Factors such as gender, age, educational status of parents, parents' ages, parents' professions, sibling numbers and siblings' sexes of the students participating in the research on the personal information form were examined in order to get familiar with the sample group.

### *Mathematics Achievement Test for Fourth Grade Natural Numbers*

The test used in the study was developed by researchers. Within the scope of the study, a 22-item substance pool was prepared by scanning the relevant field in the first place. The test was evaluated as "1" for correct answer, "0" for wrong answer and answer key was set. The final test was applied to a group of 44 students and it was decided to remove the 2 items that students did not understand. Thus, the 19-item test was sent to 5 specialists in terms of the validity of the test coverage. Experts were asked to evaluate the three methods of compliance, such as "appropriate", "partially appropriate", "not appropriate", taking into account the Lawshe analysis method. In the opinion of experts, the modes of expression of certain items have been changed and it has been decided to remove them from the test on the grounds that a question measures different skill.

**Table 3.** Mathematical Achievement Test Item Analysis Results

| M | pj | rjx | s | $s^2$ | rj | t | r |
|---|---|---|---|---|---|---|---|
| M1 | .57 | .61 | .216 | .464 | .131 | 6.187 | .457 |
| M2 | .56 | .76 | .222 | .471 | .168 | 7.288 | .667 |
| M3 | .78 | .39 | .172 | .415 | .067 | 3.644 | .324 |
| M4 | .59 | .79 | .231 | .481 | .182 | 7.354 | .577 |
| M5 | .60 | .61 | .231 | .481 | .140 | 5.394 | .436 |
| M6 | .35 | .82 | .252 | .502 | .206 | 9.651 | .512 |
| M7 | .74 | .49 | .196 | .443 | .096 | 4.290 | .390 |
| M8 | .75 | .76 | .191 | .438 | .145 | 8.121 | .666 |
| M9 | .59 | .55 | .216 | .464 | .118 | 4.788 | .407 |
| M10 | .58 | .33 | .246 | .496 | .081 | 2.797 | .396 |
| M11 | .60 | .67 | .238 | .488 | .159 | 5.720 | .468 |
| M12 | .35 | .79 | .250 | .500 | .197 | 7.955 | .579 |
| M13 | .59 | .67 | .219 | .468 | .146 | 6.276 | .595 |
| M14 | .80 | .39 | .161 | .402 | .062 | 3.697 | .420 |
| M15 | .60 | .58 | .242 | .492 | .140 | 4.829 | .473 |
| M16 | .71 | .39 | .208 | .456 | .081 | 4.322 | .354 |
| M17 | .64 | .51 | .234 | .483 | .119 | 4.788 | .378 |
| M18 | .37 | .42 | .247 | .497 | .103 | 3.355 | .312 |
| M19 | .39 | .70 | .247 | .497 | .173 | 5.666 | .531 |
| M20 | .58 | .70 | .228 | .478 | .159 | 7.484 | .538 |
| M21 | .70 | .52 | .212 | .460 | .110 | 4.442 | .461 |
| M22 | .60 | .61 | .236 | .486 | .144 | 4.401 | .481 |

*Note: M = item number, $p_j$ = item strength, $r_{jx}$ = item separability, s = item standard deviation, $s^2$ = item variance, $r_j$ = item reliability, t = t values, r = corrected item total correlation*

As part of the pre-pilot application for the development of the achievement test, the draft form of the achievement test was applied to 111 students. The test application took 40 minutes. As a result of the application, some items were replaced and re-tested. In line with the results obtained, the test was given the final form and the test was reapplied to a different group of 110 students. Finally, the achievement test was determined to have 22 questions. The results of test article analysis are shown in Table 3.

When Table 3 is examined, findings on the strengths, discrimination, variance, standard deviation and reliability of the items in the test will be seen. In this direction, the difficulty indices of the items range from .51 to .80. Discrimination values, with 33. Lt; / RTI & gt; When T values are examined, it is possible to say that the items are distinctive. It is said that the item value is very good if 0.40 or more, good if it is between 0.30 - 0.39, can be used if it is between 0.20 - 0.29, and it is said that the item is smaller than 0.19 (Tekin, 2000). In this context, it is possible to say that the items forming the test are within the valid range. In addition, the item total correlation values of the items change between .31 and .67. Özdamar (1997) suggests that items with a total correlation value of less than .25 should be removed from the test. When the total item correlation value of the items forming the test is examined, it can be said that it is not necessary to remove any items from the test.

The reliability of the test was determined to be .88, Cronbach Alpha (internal consistency coefficient) .88, Split Half coefficient .79 and Guttman Lambda (Li) reliability coefficients between .79 and .86. According to these values, the test can be said to be very reliable (Kalaycı, 2016). For simultaneous validity, it is seen that the correlation coefficient between students 'mathematics scores at the end of the semester and the test developed is .83, and students' mathematics achievement score at the end of the semester reveals the achievement test scores at 69%.

## Data Collection Process

In the study, the achievement test was applied to the students in the control and experiment group for the pre-test and the pre-test data were obtained for the collection of the data. Following the application of the activities in accordance with the prepared brain based learning model, the success test was applied as a final test to the experiment and control group and the final test data were obtained. Finally, the achievement test was reapplied to the students in the experimental and control groups after six weeks from the end of the application and the retention test data were obtained. The students answered the questions themselves and each application lasted for about 40 minutes.

## Experimental Processing Process

Preparation and content of learning activities prepared with brain-based learning model for fourth grade students:

Permission was obtained from the Provincial Directorate of National Education for the purpose of conducting the research. The work calendars, achievement test for natural numbers, thesis proposal form, examples of activities to be used in the study were submitted to the Directorate of National Education with a petition. The achievement scores of the students were taken from their teachers and mathematics achievement levels were compared (by pre-test). Two classes close to each other in terms of success were included in the study. For the brain-based learning activities, the researchers prepared activity and lesson plans for natural numbers and natural numbers. Two mathematics teachers and five field experts were consulted for the prepared activities. As the events were being organized, previous information was taken into account to draw attention to the children, such as repeating them before the beginning of the lesson, handling issues to be handled in connection with everyday life, and game-based preparation of activities.

Since the issue of natural numbers can be associated with everyday life and takes place in all levels of elementary school, it was decided to work on this issue. Especially, the meanings of the processing abilities in the natural numbers were emphasized and the concepts of the students were tried to be provided. Activities included slide, photo, animation, game activities, concept map, mind map and evaluation questions. While the program was being prepared, the shortcomings of the class teachers and mathematics teachers were solved.

The lessons of the students of the experiment group were carried out based on the teaching activities prepared in accordance with the brain-based learning model and the lessons of the control group students based on the National Education program provided in the textbooks. Course events started on March 3, 2017 and the subjects were numbered. In particular, the meaning of the natural numbers of the numbers and the features of the processes used in the natural numbers and what they expressed were studied with examples of non-routine problems that were not mentioned in the process questions. It was tried to make the activities more fun with logic questions and mathematical games that require addition, subtraction, multiplication, division processes related to natural numbers.

## Results

In this part of the research, the findings of the research were included. Within this scope, the answers to the sub-problems searched for in the research were sought. Before the study, it was examined whether there was a significant difference between the mathematics achievement scores of the students in the experiment and control groups according to pre-test data, and the results are presented in Table 4.

**Table 4.** T-test results for unrelated measurements related to pre-test measurements between experimental and control groups

| Groups | *N* | $\bar{x}$ | *SS* | $Sh_{\bar{x}}$ | *t* Test | | |
|---|---|---|---|---|---|---|---|
| | | | | | *t* | *Sd* | *p* |
| **Experiment** | 46 | 5.48 | 2.69 | .39 | -1.549 | 89 | .125 |
| **Control** | 45 | 6.36 | 2.71 | .41 | | | |

**p>.05*

When Table 4 is examined, it can be said that there is no statistically significant difference in the pre-test measures of the mathematical achievement scores of the fourth grade students between the experimental group (= 5.48) and the control group (= 6.36) [(t = -1.549; p> .05). The results of the analysis of the final test success scores of the students are shown in Table 5.

**Table 5.** T-test Results for Unrelated Measures Related to Recent Test Measurements Between Experimental and Control Groups

| Groups | *N* | $\bar{x}$ | *SS* | $Sh_{\bar{x}}$ | *t* Test | | |
|---|---|---|---|---|---|---|---|
| | | | | | *t* | *Sd* | *p* |
| **Experiment** | 46 | 14.20 | 4.43 | 46 | 7.150 | 89 | .000 |
| **Control** | 45 | 8.22 | 3.47 | 45 | | | |

**p<.01*

When Table 5 is examined, it can be said that there is a statistically significant difference for the students in the experimental group in the final test scores of the mathematical achievement scores between the experimental group (= 14.20) and the control group (= 8.22) [(t = 7.150; p <.01). Findings related to the retention test are presented in Table 6.

**Table 6.** T-test Results for Unrelated Measurements of Retention Test Measurements Between Experimental and Control Groups

| Groups | *N* | $\bar{x}$ | *SS* | $Sh_{\bar{x}}$ | *t* Test | | |
|---|---|---|---|---|---|---|---|
| | | | | | *t* | *Sd* | *p* |
| **Experiment** | 46 | 14.14 | 4.19 | 46 | 5.674 | 89 | .000 |
| **Control** | 45 | 9.40 | 3.86 | 45 | | | |

**p>.01*

**Table 7.** Descriptive Statistics for Pretest, Posttest, and Retention Test Measures of Students in the Experiment Group

| Measurement | $\overline{X}$ | *SS* | *N* |
|---|---|---|---|
| **Pre Test** | 5.48 | 2.69 | 46 |
| **Post Test** | 14.20 | 4.43 | 46 |
| **Retention Test** | 14.14 | 4.19 | 46 |

**Table 8.** Single Factor Analysis of Variance (ANOVA) Results for Associated Subjects for Pre-, Post-Test and Retention Test Measurements for the Experiment Group

| Variation Source | Squares Total | sd | Squares Mean | *F* | p | Difference |
|---|---|---|---|---|---|---|
| **Measurement Between** | 840.217 | 90 | 9.336 | | | 2-1 |
| **Subjects** | 2330.449 | 2 | 1165.225 | 124.813 | .000 | 3-1 |
| **Error** | 1157.739 | 45 | 25.728 | | | |
| **Total** | 4328.405 | 137 | 1200.289 | | | |

*Note: 1: Pre-Test, 2: Final Test, 3: Retention Test*

When Table 6 is examined, it can be said that there is a statistically significant difference between the experimental group (= 14.14) and the control group (= 9.40) in favor of the students in the experimental group in the retention test measures of the mathematics achievement scores of the fourth grade students [(t = 5.674; p <.05). Findings related to pre-test, post-test and retention test scores of the students in the experiment group are shown in Tables 7 and 8.

In Table 7, the mathematical achievement test for students in the experiment group is pre-test, post-test and retention test measures, pre-test average = 5.48, post-test averages = 14.20 and retention test averages = 14.19.

**Table 9.** Descriptive statistics for pre-test, post-test and retention test measure of control group students

| Measurement | $\overline{X}$ | *SS* | *N* |
|---|---|---|---|
| **Pre Test** | 6.36 | 2.72 | 45 |
| **Post Test** | 8.22 | 3.47 | 45 |
| **Retention Test** | 9.40 | 3.86 | 45 |

When Table 8 was examined, it was determined that the mathematical achievement of the students was statistically significant difference between pre-, post-test and retention test measurement scores (F (2-38) = 124.813, p <.01). It was determined that pre-test measurement scores and post-test measurement scores and pre-test measurement scores and retention test measurement scores, final test measurement scores, and retention test measurement scores were significantly different. It can be said that there is no significant difference between the posttest and retention test measurement scores. Findings related to pre-test, post-test and retention test scores of students in the control group are shown in Tables 9 and 10.

As shown in Table 9, pre-test averages X = 6.36, post-test averages X = 8.22 and retention averages X = 9.40 in the math achievement test pre-test, post-test and retention test measures of the students in the control group.

When Table 10 is examined, it is seen that there is a statistically significant difference between students' mathematical achievement scores in pre-test, post-test and retention test (F = (2-38) = 17.307, p <.01). It was determined that pre-test measurement scores and post-test measurement scores and pre-test measurement scores and retention test measurement scores, final test measurement scores, and retention test measurement scores were significantly different. It can be said that there is no significant difference between the posttest and retention test measurement scores.

## Discussion

The study was conducted to determine the effects of learning activities prepared according to the brain-based learning model on the mathematical success of fourth grade students in primary school. For this purpose, firstly students who would take part in experiment and control group were determined and it was seen that the achievement scores of the groups were close to

**Table 10.** Single Factor Analysis of Variance (ANOVA) Results for Associated Subjects for the Pre-test, Post-Test and Retention Test Measure for the Control Group

| Variation Source | Squares Total | sd | Squares Mean | *F* | p | Meaningful Difference |
|---|---|---|---|---|---|---|
| **Measurement Between** | 539.23 | 88 | 6.12 | | | 2-1 |
| **Subjects** | 212.10 | 2 | 106.05 | 17.30 | .00 | 3-1 |
| **Error** | 388.95 | 44 | 8.840 | | | |
| **Total** | 1140.29 | 134 | 121.02 | | | |

*Note: 1: Pre-Test, 2: Final Test, 3: Retention Test*

each other in the pre-test result. In experimental studies, it is expected that pre-implementation experiment and control groups should be equal in the measured variable angle. This is a precondition for the best practice of the program or activity being implemented. When the experimental and control groups are compared according to the students' mathematical achievement post test scores, it seems that there is a significant difference in favor of the experimental group. This can be interpreted as a positive effect of the applied activities on the students. This finding is parallel to the field literature (Samur, 2009). Although the success rates of the control group students in the post test measures were higher than the pre-test, it seems that there is a significant difference between the experimental group and the experimental group in favor of the experimental group. That students were more successful in the post-test compared to pre-test may be due to the fact that it was towards the end of the school term and that students completed the subjects to be covered. It is also believed that the same tests were used in the measurements and that the success may have increased with the effect of the time difference between them.

It was determined that the students in the experimental group had higher mathematical achievements in the final test measurements. From here it can be said that brain-based learning improves mathematical success. In other studies on the brain-based learning model, the results of the effectiveness of the approach are reported in the field. Loyal (2013) showed that brain-based learning was an effective method in his work on mathematics. Sel (2006) found that brain-based learning improves success in his research on foreign language teaching. Pearl (2014) emphasized that brain-based learning designs were influenced by the students' academic achievement, attitudes and retention of their learning. Bello (2007) proved that mathematics success could be improved by brain-based learning method in his thesis study with 81 students with 58 students and 23 teachers in mathematics teaching field. Caine and Caine (1995) found that there was a gradual increase in students' learning in brain-based learning applications. Similarly, Özden (2005), Avcı (2007), Keleş (2007), Hasra (2007), Usta (2008), Çelebi (2008), Samur (2009), Palavan (2012) found that brain-based learning was an effective method in researchers. However, Yağlı (2008) found that teaching activities based on the Brain-Based Learning model did not make a significant difference between the groups. It was emphasized that this situation could arise from the researcher rather than brain-based learning. Jones (2000) and Getz (2003) found that academic achievement did not increase in their brain-based learning studies. Given the work done, it can be said that the brain-based learning in general boosts success.

It was determined that there was a statistically significant difference between the pre-test, post-test and retention test measurement scores of the mathematics achievement of the students in the experiment group. Also, there is no significant difference between post-test measurement scores and retention test measurement scores. This finding is in agreement with the findings of the study conducted in the field of the brain based learning method (Çengelci, 2005, Bozbağ, 2015, Sadık, 2013, Gözüyeşil, 2012, Akyürek, 2012, Odabaşı, 2010, Aydın, 2008, Yaman, 2014). In order to determine the permanent effect of the applied activities, a one-month retention test was performed and it was seen that the brain-based learning activities had a permanent effect on the learned subject. When the field work was examined, it was determined that the brain-based learning had a lasting and permanent effect (Çengelci, 2005, Baştuğ, 2007, Odabaşı, 2010, Eyüp, 2013).

It was determined that the control group students' mathematical achievement was statistically significant difference between pre-test, post-test and retention test measurement scores. It was determined that there was a significant difference between pre-test and post-test measurement scores and retention test measurement scores in this direction. On the other hand, there is no significant difference between post-test measurement scores and retention test measurement scores. The results of the studies performed by Bozbağ (2015), Akyürek (2012), Yücel (2011), Odabaşı (2010), Aydın (2008) and Çengelci (2005) showed that there was a significant difference between control group and pre-test. A significant difference in the pre-test and post-test measures in the control group students may be related to the time spent there.

There are some limitations to the study. We can show these limitations as the scope of brain-based learning activities, the qualities that

are measured by the success test used in the research, the choice of the study group through an easily accessible sample, and some of the students' entry behavior (such as parental education level). In the scope of the study, we can include the following suggestions. The biggest problem in education and training activities is not what to teach, but how to teach. The teaching method used by the teacher, especially in the elementary school years, is influential in the learning of the learners. When the age characteristics of the learners are taken into consideration during the elementary school years, the necessity of using contemporary learning techniques in order to ensure the teaching and retention of abstract subjects is emphasized. Trainees and teachers should include learning methods and activities that keep primary school students more active in the process. The active student will also increase internal motivation while making learning more permanent in his brain. The activities to be prepared should be appropriate to the learning style of the brain. In this process, a brain-based learning model can be used. In addition, brain-based learning activities can be used for each topic and unit. Because many learning techniques and methods are used in brain-based learning, permanent learning can be made easier. In this work, the focus is on the issue of natural numbers. In other studies, longitudinal measurements of brain-based learning experiences can be made and brain-based learning and other research on mathematics can be conducted. Brain-based learning can be done with hands-on work for younger children.

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