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## The Effect of Educational Games on Success in Teaching Mathematics: Reading and Writing Natural Numbers

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## The Effect of Educational Games on Success in Teaching Mathematics: Reading and Writing Natural Numbers

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### Abstract

In this study, the effect of educational games, which are included in the alternative learning activities prepared by the researchers, on the learning environment will be investigated. In other words, the effect of educational games on the elimination of difficulties experienced by students in reading and writing natural numbers and the formation of permanent learning in students will be investigated. In the research, a quasi-experimental model with pretest-posttest control group was used. The population of the research consists of 5th grade secondary school students studying in one of the Eastern provinces of Turkey. The sample of the study consisted of 75 students studying in two branches of the 5th grade of a primary school located in the city center of the same province in the 2021-2022 academic year. According to the results of the research, while the permanence of the success in learning activities with educational games was ensured, the success achieved with the traditional teaching method was not permanent. In this context, as a result of the research, it has been seen that educational games are a successful activity in providing learning and making it permanent.

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### Introduction

The concept of number was formed as a result of studies carried out to identify and express the multiplicity or objects that exist in nature and somehow enter our lives (Albayrak, İpek, & Işık, 2006; Negen, & Sarnecka, 2012; Wynn, 1990). They are the numbers that are widely used in the relations between people in daily life and are the first to be taught to students in primary education. In the decimal system based on the digits "0, 1, 2, ... 9", multiplicities are grouped in multiples of ten. That is, the expansion of each number in the numeration system to the base-10 can be written as powers of 10 (Hacısalıhoğlu, Hacıyev, & Kalantarov, 2000; van de Walle, Karp, & Mr-Williams, 2016). In the numeration system to the base-10, the use of the concept of place value and the use of 10 symbols (0, 1, 2, ...9) defined as "digits" to express any number are the features that make this system usable and powerful (Baturu, 1997).

The place value is defined as the value that the digits take according to their position in the number (Arslan & Ubuz, 2014; Kari & Anderson, 2003). Place value is an abstract concept that is important for many arithmetic operations such as mental calculation, reading and writing natural numbers, as well as for other branches of

mathematics, especially algebra (Burns, 1994; Kari, & Anderson, 2003; Richardson, 2003). In addition, the concept of place value is a basic concept for students to acquire many skills such as basic arithmetic operations related to mathematics such as addition, subtraction, multiplication, operations that require decimal or decimal fractions (Merenluoto & Lehtinen, 2004; Siegler et al., 2013).

The concept of place value develops in a process covering primary and secondary school periods and is expected to be understood by students exactly in these periods (Gelman & Gallistel, 1978; Mix & Sandhofer, 2007). Although this concept is seen as a simple concept in general terms, as a result of the studies, it is seen that students have difficulties even in basic arithmetic operations because they cannot fully grasp the concept of place value in the primary and secondary school periods (Albayrak, Yazıcı, & Şimşek, 2019; Chambris, 2008; Dinç Artut, & Tarım, 2006; Garlikov, 2000; Thomas, 1996; Thomas, 2000; Thompson, 2003; Thompson & Bramald, 2002; Wynn, 1992). As a matter of fact, Vareles and Becker (1997), in their study with students who had sufficient prior knowledge about the concept of place value, determined that 96.5% of students confused place value with the concept of number value.

As a result of the concept of place value, there is a decreasing or increasing relationship, in terms of place value, to powers of 10, with the digits to the right or left of a digit in any number, if any. In more general terms, if a digit in the number moves one digit to the left, its value increases 10 times, or if a digit in the number moves one digit to the right, its value decreases 10 times. Figure 1 shows this relationship in the numeration system to the base-10 (Arslan & Ubuz, 2014).

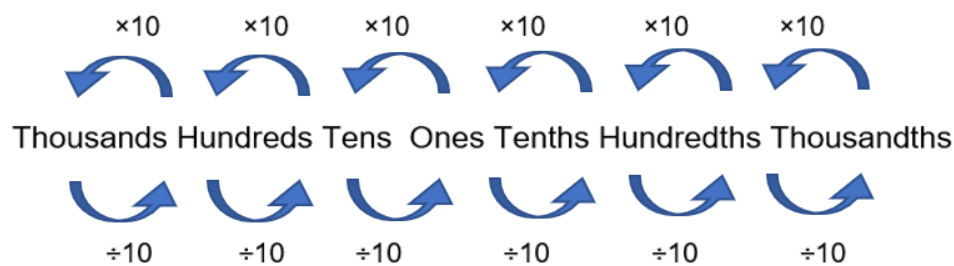


Figure 1. Multiplication relation in Numeration System to the Base-10

As seen in Figure 1, the majority of the students have difficulties in establishing the relationship between the digits, distinguishing the digit and number values, or grouping the numbers according to the place values. Therefore, students cannot write a verbally spoken number with numbers mathematically (Albayrak, Yazıcı, & Şimşek, 2019). We can see in the study of Thomas (1996), how much difficulties are experienced by students while expressing a verbally given number mathematically. Thomas (1996) determined that 40% of 6th grade students still cannot tell the place of “tens of thousands” in place value. Also, in addition to this study, Kamii and Joseph (1988) asked students about the place value of the digit in the tens place of a two-digit number and determined that nearly half of these students could not answer this question correctly.

In the first level of primary education, when students cannot learn meaningfully about the concept of place value, they have problems in reading and writing natural numbers in the following years (Sarnecka, 2021; van de Walle,

Karp, & Bay-Williams, 2016). For this purpose, during the teaching of the concept of place value, it is necessary to enrich the learning environments and to use concrete materials that will provide permanent learning for students. For effective teaching, teachers need to address the concept of number by using different teaching methods such as grouping, analyzing, using step tables and number blocks, and making sense of the combination of values in numbers and the diversity of values in numbers (Sarnecka & Wright, 2013; van de Walle, Karp, & Bay-Williams, 2016). For this purpose, it is necessary for teachers to focus on activities that will enable all students to actively participate in the lesson, rather than in-class practices that cause memorization of information, in terms of permanence of what has been learned and meaningful learning (Shuell, 1990; Vallori, 2014). One of the activities to be used in this sense is educational games. Educational games include activities that allow students to repeat this information in a comfortable environment where they enjoy learning and take part in it (De Freitas, 2018; Giannakos, 2013; Pivec & Kearney, 2007).

Games have existed in every period of humanity. Toy remains and game depictions found in excavations all over the world support the fact that games have been a part of human life since ancient times (Halmatov, 2017; Kapp, 2012). Play is a phenomenon that supports the mental development of primary school students, allows students to express themselves, and is always present in human behavior (Bodrova, Germeroth, & Leong, 2013; Park, 2019). The child learns many behaviors, knowledge, skills and attitudes necessary for his life in the game environment (Koçyiğit, Tuğluk, & Kök, 2007). Play helps children develop their ability to create, experience and communicate (Boyer, 1997; Hirsh-Pasek, Golinkoff, & Eyer, 2004). Game can be expressed as the most effective and productive learning process of language, emotional and social development (Broadhead, & Burt, 2012; Russo, 2009; Yazıcıoğlu & Çavuş-Güngören, 2019). According to Karabacak (1996), there are many benefits of using the game technique in the teaching process. We can summarize these benefits as follows: Increasing students' interest in lessons by regulating their short attention spans, making the lessons more lively and cheerful by saving them from being boring, making the learned information more permanent. According to Chateau, educational games create a framework and give the child seriousness and endurance. For this reason, play should be embedded in school activities (Chateau, 1979). Therefore, both children's skills should be developed and the quality of education should be increased through games. On the other hand, it is known that students have difficulties in reading large natural numbers (Albayrak, Yazıcı, & Şimşek, 2019). In this sense, in this study, the effect of educational games, which are included in the alternative learning activities prepared by the researchers, on the learning environment will be investigated. In other words, the effect of educational games on the elimination of difficulties experienced by students in reading and writing natural numbers and the formation of permanent learning in students will be investigated. In this context, the research problems were determined as follows:

1. Is there a significant difference between the learning environment enriched with educational games and the traditional learning environment on the academic success of primary school students in reading and writing natural numbers?
2. Is there a significant difference between the learning environment enriched with educational games and the traditional learning environment on the permanence of the knowledge that primary school students have learned about reading and writing natural numbers?

## **Method**

### **Research Design**

The research is based on the quantitative paradigm. In the research, a quasi-experimental model with pretest-posttest control group was used. The difference that distinguishes the quasi-experimental design from the experimental design is that instead of randomly selecting the participants one by one, one group from the equivalent groups is randomly assigned as the experimental group and the other as the control group (Creswell, 2014; McMillan & Sally, 2014). In the research, a pre-test was applied to the experimental and control groups to determine that they were equivalent before the application, and then activities were carried out for the experimental group with the help of educational games and the control group with the traditional method for reading and writing natural numbers. After the application, a post-test was applied to compare the achievements of the groups, and after three months after the post-test, the retention test was applied to compare the permanence of the information learned by the students.

### **Research Group**

The population of the research consists of 5th grade secondary school students studying in one of the Eastern provinces of Turkey. The sample of the study consisted of 75 students studying in two branches of the 5th grade of a primary school located in the city center of the same province in the 2021-2022 academic year. One of the groups contains 37 students and the other 38 students.

Sampling was done by cluster sampling method. In this method, instead of selecting the members of the sample, the groups are selected as a whole (McMillan & Sally, 2014). The participants included in the research were informed about the research before the research and the condition of voluntariness in participation was taken into consideration. At this stage, the participants were also informed that the confidentiality of the collected data would be taken care of, that this data would not be shared with third parties and that they would only be used in the current scientific research by hiding personal data.

### **Data Collection Tool**

In the study, the Number Reading and Writing Achievement Test [NRWAT] was developed by the researchers to measure the success of the students in reading and writing natural numbers. During the development phase, the resources related to the subject were scanned and the questions in the resources were examined and 10 questions were prepared on the subject. The prepared questions were first examined by 2 experts in the field and necessary arrangements were made as a result of their feedback. This process contributed to content validity of the test. Then, NRWAT was applied to 85 students as a pilot study.

In this application, the situations related to reading and understanding the questions were examined and the Cronbach Alpha reliability coefficient of NRWAT was calculated as 0.72. Using the data obtained from the pilot study, NRWAT was made ready for use. The test consisted of 10 questions and each question was evaluated over

10 points.

### **Darts Game and Application Process**

The material to be used in the game activity applied in this research is a dartboard with a different number in each part. The dartboard has the innermost number 9. The number 1 is on the outside. Therefore, getting the number 9 is less likely, while getting the number 1 is more likely. Shooting outside the dartboard corresponds to the number 0. An example of a dart board that can be used in the game is given in Figure 2.



Figure 2. Sample Dartboard

The aim of the game is to put the numbers won from the dartboard on the place value chart so that the largest 12-digit number can be obtained. Before starting the game, an empty place value chart should be drawn on the board with ones, thousands, millions and billions of divisions. At the beginning of the game, a shot can be made to determine which student will start first.

The student who gets the higher number starts the game first. Each student then takes turns making a shot at the dartboard. He writes the number that comes at the end of the shot to the desired digit in the step table. Here students need to develop a strategy during the game to get the largest number. For example, a strategy might be to write the number 9 to the far left, and to try to leave the leftmost digit blank unless the number 9 appears. The necessity of playing strategically makes the game more playable and meaningful. In Figure 3, an example place value table that emerged in a game played with two students is given. The game can also be played with more people. For this, it will be sufficient to increase the rows of the place value table.

	Billions			Millions			Thousands			Ones		
Student 1 Bora	9	6	8	7	3	5	2	4	1	2	1	3
Student 2 Cansu	8	7	5	6	5	4	6	3	2	1	0	0

Figure 3. Sample Place Value Table

At the end of the game, the numbers created are read together with the class. In this way, the active participation of all students in the class is ensured in the process of orally reading the numbers given in writing. In the game, a dice that can be obtained with a regular dodecahedron can be used instead of a dartboard. In this case, while numbers from 0 to 9 are written on 10 sides of the dodecahedron, "smiling face" and "sullen face" smiles can be added to the other two faces. Of these smileys, the smiling face corresponds to the number 9, while the sullen face can represent the number 0. In Figure 4, an example of a dice obtained with a regular dodecahedron is given. It is thought that an activity that appeals to psychomotor skills will emerge when a dart board is used in the game. On the other hand, it is thought that the development of psychomotor skills will be less in the game played with dice. Therefore, it is recommended to use the dart board as much as possible for a more effective game.



Figure 4. Example of a Regular Dodecahedron

During the implementation process, routine teaching processes were followed in the experimental and control groups. Only in the experimental group, after the teaching of the subject, the dart game was played for 2 lesson hours. The active participation of the students was ensured by playing the game repeatedly. The numbers formed at the end of each game were read together with the class. NRWAT was applied to the experimental and control groups before and after the application, just before the pre-test subject was taught, right after the post-test subject was learned, and the retention test was administered 3 months after the subject was taught.

## Data Analysis

The obtained data were analyzed with SPSS 22 package program. Independent sample t-test was used to determine whether there was a significant difference between the scores of the experimental and control groups for each of the pre-test, post-test and recall test scores. In addition, a single factor ANOVA test was used for repeated measures to examine whether the pre-test, post-test and recall test scores for each group differed significantly. Bonferroni Test, one of the Post-Hoc tests, was used for pairwise comparison of repeated measurements. It was checked that the data provided the assumptions of the relevant model.

## Results

In this section, the effects of the designed educational game on the difficulties of secondary school students in reading and writing natural numbers are presented. Accordingly, the t-test results of NRWAT's pre-test, post-test and retention scores according to the experimental and control groups are presented in Table 1.

Table 1. T-test Results of NRWAT Scores According to the Experimental and Control Groups

	Group	N	$\bar{X}$	S	df	t	p
Pre-test	Experimental	37	49,19	12,11	73	1,78	.080
	Control	38	45,00	7,97			
Post-test	Experimental	37	86,76	11,56	73	11,94	.000
	Control	38	59,21	8,18			
Retention	Experimental	37	84,86	10,70	73	13,60	.000
	Control	38	49,21	11,94			

When the pre-test results are examined, the achievement score of the experimental group is ( $\bar{X}$ =49.19), while the achievement score of the control group is ( $\bar{X}$ =45.00). There is no significant difference between the pretest achievement scores of the experimental and control groups,  $t(73)=1.78$ ,  $p>0.05$ . This finding can be interpreted as the pre-application levels of the experimental and control groups were equal. Post-test averages were found for the experimental group ( $\bar{X}$ =86.76) and for the control group ( $\bar{X}$ =59.21), and it was seen that there was a significant difference between these two scores,  $t(73)=11.94$ ,  $p<0.05$ . According to this finding, at the end of the application, the students in the experimental group were more successful than the control group. The achievement scores in the retention state were found to be ( $\bar{X}$ =84.86) for the experimental group and ( $\bar{X}$ =49.21) for the control group, and a significant difference was found between these scores  $t(73)=13.60$ ,  $p<0.05$ . According to this finding, it can be said that the level of remembering the information learned by the experimental group students is higher than that of the control group.

The ANOVA results of the experimental group's pretest, posttest and recall test data applied using NRWAT are shown in Table 2.



Table 2. Experimental Group NRWAT ANOVA Results

Source of Variation	SS	sd	MS	F	p	Significant Difference
Between Subjects	9958,56	36	276,63			
Between Measures	33147,75	2	16573,87	280,63	,000	2-1, 3-1
Error	4252,25	72	59,06			
Total	47358,56	110				
1: Pretest	2: Posttest	3: Recall				

When the ANOVA results for the NRWAT were examined, it was found that there was a significant difference between the pre-test scores ( $\bar{X}=49.21$ ) and the post-test ( $\bar{X}=86.76$ ) and recall ( $\bar{X}=84.86$ ) test scores of the experimental group. It was observed that there was no significant difference between the post-test and recall test scores. Accordingly, it can be said that the success of the students increased and the permanence of this success was ensured with the education process applied in the experimental group.

The ANOVA results of the control group's pretest, posttest and recall test data applied using NRWAT are shown in Table 3.

Table 3. Control Group NRWAT ANOVA Results

Source of Variation	SS	sd	MS	F	p	Significant Difference
Between Subjects	6485,09	37	175,27			
Between Measures	4049,12	2	2024,56	41,41	,000	2-1, 3-2
Error	3617,54	74	48,89			
Total	14151,75	113				
1: Pretest	2: Posttest	3: Recall				

According to the NRWAT ANOVA results of the control group, between the pre-test ( $\bar{X}=45.00$ ) scores and the post-test ( $\bar{X}=59.21$ ) scores of the control group, and between the post-test scores and the recall ( $\bar{X}=49.21$ ) test scores. significant difference was found. In addition, it is understood that there is no significant difference between the pre-test scores of the control group and the recall test scores. According to these findings, it is seen that there was an increase in academic achievement in the control group compared to the pre-training period, but this increase could not be sustained. When the research findings are examined as a whole, both the learning activities with educational games and the traditional teaching method significantly increased the success of the students in

reading and writing natural numbers. In addition, while the permanence of the success in learning activities with educational games was ensured, the success achieved with the traditional teaching method was not permanent.

## **Discussion and Conclusion**

As a result of the research, it was seen that the teaching process using the dart game significantly increased the success of the students in reading and writing natural numbers. This result is similar to the results of the study conducted by Broadhead and Burt (2012) and Karabacak (1996) on the effect of learning environments enriched with games in the teaching process. Therefore, it can be said that the effect of educational games on success is higher than the traditional teaching method.

According to the results of the research, while the permanence of the success in learning activities with educational games was ensured, the success achieved with the traditional teaching method was not permanent. Thomas (1996) and Kamii and Joseph (1988) revealed students' deficiencies in permanent learning about place values. As a result of this research, it was revealed that the shortcomings of Thomas (1996) and Kamii and Joseph (1988) regarding permanent learning in students can be eliminated by using the dart game.

As a result of the research, it has been seen that educational games are a successful activity in providing learning and making it permanent. Dinç Artut and Tarım's (2006) finding about the necessity of using different teaching methods instead of traditional for effective teaching was supported by the results of this study. However, the findings of Yazıcıoğlu and Çavuş-Güngören (2019) regarding the contribution of educational games to the permanence of learning are similar to the results obtained in this study. Again, Saracaloğlu and Aldan Karademir's (2009) finding about the necessity of active participation of students in the lesson for permanent learning was supported by the results of this study, which was conducted in the context of the contribution of educational games to permanent learning.

As a result of the research, the following recommendations were made. In this study, the success of learning activities with games for reading and writing natural numbers was examined. In studies that may be the continuation of this study, it may be useful to examine the effect of similar activities on the success of teaching different mathematics subjects. On the other hand, the contribution of educational games to students' attitudes and beliefs towards mathematics is also worth investigating. In order for teachers and teacher candidates to use educational games in lessons and to create rich lesson environments, pre-service and in-service trainings can be given for the preparation and implementation of such activities.

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