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The role of math games based on participation in learning and retention of third grade elementary students

M. Alizadehjamal[1*], S. J. Langari[2]

The purpose of the present study was to determine the effect of education using mathematical games on learning and retention of third grade elementary students. This research in terms of purpose was conducted as an applied research. Also in terms of implementation and data collection method, the quasi-experimental method and pre-test-post-test design with a control group was used. The statistical population of the present study included all 6,500 female third grade elementary school students in District 1 of Mashhad- Iran. The sampling method in this study was in convenience form that included 60 students and were selected through convenience sampling method, thus two classes with 30 female students for each classroom were selected among the elementary girls' schools in District 1 of Mashhad- Iran. In order to collect data, two researcher-made tests of learning and retention were used, the validity of which was confirmed by experts and its reliability was calculated based on Cronbach's alpha equal to 0.81 and 0.83, respectively. Multivariate analysis of covariance (MANCOVA) was used in order to test the hypotheses inferential analysis. The results of data analysis showed that math games are effective on students math both learning and retention (P <0.01). Therefore, it can be concluded that education using math games is effective and has increased students' learning and retention.

Keywords: *Game, Math, Learning, Retention, Students*

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1. Introduction

Teaching mathematical concepts has a special place in both ordinary and special education. Educators are increasingly realizing the practical role of mathematics in ordinary human life and discovering its importance in fostering logical thinking. Although the importance of teaching mathematical concepts is increasing every day, ways to achieve these goals are not available for all teachers (Afari, Aldridge, Fraser & Khine, 2013). Many students do not enjoy math classes and a large number of special students can not learn the simplest practical concepts of mathematics. The need to discover efficient and effective methods in teaching mathematics is fully felt (Ghobari Bonab and Mirakhorli, 2014). In the tradition of formal education, unfortunately, the promotion of unrelated to the reality of life mathematics has a high status, and students deal mainly with the inanimate and abstract aspects of mathematics, but the more

* Corresponding Author.
[1] Department of Mathematics, Farhangian University, Tehran, Iran, alizadehjamal.m@gmail.com
[2] Department of Mathematics, Farhangian University, Tehran, Iran, Jalal_langari@yahoo.com

meaningful aspect of mathematics is that which is embedded in the lives of children. This meaningful aspect of mathematics makes formal math and its traditional methods difficulty challenging in the informal setting, anxiety gives way to calmness and vivacity, fear and passivity to boldness and activism, and finally aversion to passionate enthusiasm (Tokac, Novak & Thompson, 2019). This type of learning and mental constructions is more compatible with human nature. In particular, it provides an opportunity for students to grapple with different aspects of mathematics and, from the heart of such an experience, feel the need for formal mathematics and eagerly seek it (Gooya, 2013).

Play is a spontaneous and enjoyable activity and that is why people are eager to play game and want to continue it. The flow of the game itself is fun for the child, not necessarily the product that is likely to come from the game. The next characteristic of the game is that the child must actively participate in the game, in addition, this activity is usually done voluntarily and at the will of the child (Brezovszky, McMullen, Veermans, Hannula-Sormunen, 2019). Finally, another important feature of play is that play depends on other aspects of the child's development, including language, motor skills, creativity and problem-solving abilities, socialization, and acceptance of social behaviors (Ke, Parajuli & Smith, 2019). Just as a baby's body needs a variety of useful foods and vitamins from birth and grows and develops through it, so does his/her psyche. Play is a kind of mental food for children and is one of the most important needs of children (Turgut & Temur, 2017). Because the game has unique features and various benefits, including all-round mental, physical, personality and social developments for children, experts in the field of education pay special attention to it.

Mathematical games provide a good platform for cultivating mental powers, creativity, imagination, initiative, problem analysis to face life and social problems and issues, and make learners understand that the world of knowledge is exciting and fun (Meletiou-Mavrotheris & Prodromou, 2016). Fengfeng and Barbara (2018) in their research stated that playing is more effective than mere training in promoting mathematical performance and so participatory games are more effective in promoting positive mathematical attitudes regardless of individual differences. Fengfeng & Grabowski (2014) in their research showed that playing is more effective in performing mathematics than mere teaching and participatory games are effective in promoting positive attitudes toward mathematics regardless of individual differences. Shamsizadeh (2018) also showed that education through games leads to improved learning of math lessons. Math games lead to math lessons being attractive to the learner throughout life and use mathematics in his/her live. Math education in the form of children's favorite games is one of the best ways to consolidate and accelerate math learning (Salimi, 2016). If math instruction is playful, the learners will understand it faster and will forget later. Using play in math instruction, while it may make the instruction longer, but will lead to deeper, more enjoyable, and more practical learning (Turgut & Temur, 2017).

Pulos, S., & Sneider(1994) concluded in their research that if the educational game is chosen correctly, it will increase the ability to learn new mathematical concepts and skills. Pulos, S., & Sneider (1994) stated that games should be used as ancillary activities in the mathematics curriculum. Education practitioners believe that cognitive and motivational variables are

effective factors in educational performance. They believe that in addition to cognitive factors, the motivational and attitudinal factors also affect learners' educational performance, which in turn affect directly on the time spent doing homework, how information is processed, interest and importance in the lessons, how to use learning strategies, perseverance and persistence when faced with challenging assignments (Greene, Miller, Crowson, Duke & Akey, 2014). The National Council of Mathematics Teachers in the USA and Canada after conducting lots of studies in the field of mathematics teaching methods, has emphasized that the best method for teaching math is that the students build the math concepts by themselves. Also, they have emphasized play as an effective method in teaching mathematics to primary and preschool children. (Mann, 2009). In parallel with the growth of the child and the transition from primary school, we see less play in an educational way. The use of games is a natural tool to promote a positive attitude towards learning (Hwa, 2018). Play is an ideal option for interaction between school and the world of children, and considering that the rate of educational dropout in mathematics is one of the common problems of Iranian students in all grades, Iran being in the last ranks in TIMMS and TIMMS-R studies showed that Iranian students have not been very successful in mathematical performance (Pahlevan Sadegh, Farzad and Naderi, 2005). The strategies which can reduce math dropout seem necessary.

The application of the results of the present research for those involved in education is that in order to improve the progress of mathematics, the role of learning and the amount of retention should be considered and the mathematical teaching methods should be directed towards the interest in this course. Today, learners ask about why concepts and methods. They need to know whether mathematics has anything to do with their daily lives and whether it has played a role in modern human civilization. They make a cognitive effort to learn math if they enjoy it and find it interesting, important, and rewarding. Mathematics will not make learners interested in learning mathematics until it be a painful, boring, frustrating lesson, and leading to increased student anxiety and avoidance. For this reason, the teaching of this course should be changed from a dry, inflexible and a unique way of lecture-giving into a variety of ways that are appropriate to the learners' learning style, especially in the early years of formal education where the laying of objective foundations for mathematical thinking and understanding of its abstract concepts is of particular importance. Considering these cases, the present study seeks to identify a way in teaching mathematics that makes learning mathematics easier and students' attitudes toward it more positive. Accordingly, the main purpose of this study is to investigate the effectiveness of teaching mathematical games on the rate of mathematics learning and retention.

2. Method

The present research in terms of purpose is an applied research and in terms of implementation and data collection method, uses the quasi-experimental method of pre-test-post-test design with a control group. The statistical population of the present study includes all female students in the third grade of elementary school in District 1 of Mashhad- Northwestern Iran, numbering 6,500. This study was conducted through convenience sampling method and so the study consisted of 60 female students, thus from the girls' third grade elementary classes in District 1 of the city, two classes of 30 students were selected.

Data Measurement Tool: In this research, learning and retention test is used to collect information.

Learning: For this purpose, the researcher designed 20 questions related to the division lesson in the third grade of elementary school and took a test from the students. This test was also made by the researcher and the maximum score was 20.

Retention: A test other than the learning test was used for the retention test; but the retention test in terms of type of questions, number of questions and the level of difficulty was parallel to the learning test. This test was also made by the researcher and the maximum score was 20.

The validity of both instruments was confirmed by experts and their reliability was calculated based on Cronbach's alpha equal to 0.81 and 0.83, respectively.

Research Method

After the necessary coordination with the Department of Education of District 1 of Mashhad in order to receive the letter of introduction and select the desired school, two classes from among the primary schools of District 1 where selected by convenience sampling method. Firstly, a pretest was performed from each class and then one class was identified as the experimental group and the other class as the control group. In the control group, the concept of division was taught by the traditional method and in the experimental group, it was taught by the game method (by the researcher). Both groups in 6 sessions of 45 minutes correspondingly, were taught the concepts of One-digit divisions by one digit, number divisions by itself, two-digit divisions by one-digit, relation of division by subtraction, division of number by one, division of number by zero, corresponding multiplication and divisions, division of number by zero, with remaining division and division correct check. In order to teach by the game method in the experimental group, some games were designed in accordance with each of the mentioned concepts. The games were in such a way that the students divided a number of almonds, walnuts and nuts into equal groups and then divided these objects into other students. After the training sessions , post-test was performed from both groups and at the end, the difference between pre-test and post-test was taken and the difference between the groups was determined through inferential statistics.

Multivariate analysis of covariance (MANCOVA) was used to test the hypotheses inferentially. Since the design used in this study may have factors threatening internal validity, the covariance method was used to remove these factors.

3. Findings

Of the 60 female students in the present study, 30 were in the control group and 30 were in the experimental group.

Descriptive Findings

Table 1: Mean and standard deviation of mathematics scores in three stages of measurement by experimental and control groups

Group	Stage	Number	Mean	S.D
Control Group	Pre-test	30	15.30	2.298
	Learning	30	15.65	2.355
	Retention	30	15.48	2.207
Experimental Group	Pre-test	30	15.58	2.025
	Learning	30	17.55	1.566
	Retention	30	17.16	1.456

Table 1 shows the descriptive statistics related to the mean and standard deviation of mathematics scores separately for the experimental and control groups in three stages of assessment (pre-test, learning and retention). As can be seen, the mean scores of the control group in the post-test do not show much difference rather than the learning and retention stages. While in the experimental group, we see a greater increase in scores in the learning and retention stages than in the pre-test.

In order to evaluate the effectiveness of education using mathematical games on students' learning, one-way analysis of covariance was used. The results of this test and testing the hypotheses showed that the assumption of normal distribution of scores is accepted.

Table 2: Results of analysis of covariance to compare learning in the experimental group and the control group

Source of Distribution	Sum of Squares	D.F	M.S	F	Sig	Effect Size
Pre-test	130.181	1	130.181	72.880	0.001	0.561
Group	42.941	1	42.941	24.040	0.001	0.297
Error	101.815	57	1.786			
Total	285.672	59				

Table 2 shows the results of analysis of covariance in order to compare mathematical scores in experimental and control groups in the learning phase. The value of F obtained is equal to 24.04 and its significance level is less than 0.01 ($P < 0.01$). Therefore, the null hypothesis is rejected and the research hypothesis is confirmed. Based on this and considering the higher average scores of the experimental group in the learning stage, it can be concluded that teaching using math games is effective and has increased the learning rate of students.

Table 3: Moderated average learning scores

Group	Mean	Standard Error
Control Group	15.751	0.244
Experimental Group	17.447	0.244

As can be seen in Table 3, the average learning scores of the experimental group (17.447) after moderating the scores were higher than the control group (15.751), which indicates the effect of teaching using math games on increasing the learning of students in the experimental group.

Table 4: Results of analysis of covariance to compare retention scores in the experimental group and the control group

Source of Distribution	Sum of Squares	D.F	M.S	F	Sig	Effect Size
Pre-test	97.531	1	97.531	52.843	0.001	0.481
Group	33.768	1	33.768	18.296	0.001	0.243
Error	105.204	57	1.846			
Total	244.736	59				

Table 4 shows the results of the analysis of covariance for comparing mathematical scores in the experimental and control groups in the retention phase. The value of F obtained is equal to 18.296 and its significance level is less than 0.01 (P <0.01). Therefore, the null hypothesis is rejected and the research hypothesis is confirmed. Based on this and considering the higher average scores of the experimental group in the retention stage, it can be concluded that teaching using math games is effective and has increased the students' retention.

Table 5: Moderated mean scores of retention

Group	Mean	Standard Error
Control Group	15.568	0.248
Experimental Group	17.072	0.248

As can be seen in Table 5, the average retention scores of the experimental group (17.072) after moderating the scores were higher than the control group (15.568), which indicates the effect of education using math games on increasing the retention of students in the experimental group.

4. Discussion and Conclusion

The purpose of the present study was to investigate the effect of teaching mathematics using mathematical games on learning and retention of female third grade elementary students in District 1 of Mashhad- Iran. In order to test the research hypotheses, one-way analysis of covariance (ANCOVA) test was used and the results of data analysis showed that teaching mathematics using mathematical games is effective and has increased students' learning. This result is in compliance with research of Shamsizadeh (2018), Salimi (2016), Feng Feng and Barbara (2018), Vankus (2015).

In the explaining these findings, it can be said that children are always interested in different games. If we can link the pleasure of the game to the math lessons, we can positively change the students' attitude towards this course of study. According to Todd and Wolpin (2018), students who had a positive attitude toward math were more motivated to think about math, do math homework, and commit to classrooms than those who had a negative attitude, so if the game could positively affect students' attitudes and it causes more effort, motivation and commitment to the math lessons, higher educational performance can be expected from them.

By examining the theories of thinkers about the relationship between play and education, it can be said that play has an important role in teaching, learning and cognition and so play can be marked as a natural and indirect phenomenon in education. In the training, which is indirect, the goal is developed and more and more concepts are recognized, the child has more freedom in his/her activities and the education changes from formal to entertaining (Kiili, Devlin, Perttula, Tuomi & Lindstedt, 2015). Not only can play include targeted activities, but if play is accompanied by a lesson activity, the pleasure gained from the play is linked to the lesson and the child becomes interested in the lesson and the lesson materials, thus he/she will become more motivated and powerful in the lessons materials (Knipping, Reid & Straehler-Pohl, 2015). Mongelo says that games have a positive effect on students' cognitive and behavioral abilities (Mogillo, 2016).

One of the most important principles in education today is the issue of learners being active. Education is a two-way and interactive communication, and it is obvious that if learners are passive, learning will not be possible. In this method, all persons are involved and actively work during the learning process. The game method is a useful exercise in overcoming some of the limitations of traditional methods, while in traditional methods with a knowledgeable teacher, information is transmitted to students completely passively, the game requires both teacher-student relationships and purposeful and active student engagement. (Kiili, Devlin, Perttula, Tuomi & Lindstedt, 2015). Math education is basically creating an environment in which a child's cognitive structures are revealed. Piaget believes that the development of cognitive constructs is possible only when the learners begin their learning experiences by themselves. Accordingly, the learning process should be spontaneous and the learning environment should be full of diverse experiences. Math is not like any other course, it is not just about showing and saying; rather, in teaching mathematical content and concepts, the cognitive, emotional, and psychomotor development of the learner should be considered (Ke, Parajuli, & Smith, 2019).

The results also showed that mathematics education using math games is effective and has increased students' retention, which is in line with the findings of Dortaj (2013), Shamsizadeh (2018), Vankus (2015). In their research, these researchers concluded that educational games increase seriousness, diligence, decision-making, problem solving, collaboration, and initiative in learning process (Turgut & Temur, 2017). The math games also increases motivation and education achievement (Dortaj, 2013), and improves attitudes toward mathematics and reduces fear and anxiety about mathematics in students (Bahrami, 2013). So with the help of math games can motivate students to learn math lessons and teach some math skills with it (Vankus, 2015) However, there is a significant difference between learning math concepts through games in boys and girls (Shamsizadeh, 2018). Therefore, it can be concluded that math games can be used to introduce new concepts and develop critical thinking and problem-solving strategies, and to teach mathematical skills or processes such as reasoning, inference, and modeling through games. Play stimulates interest and motivates and establishes mathematical concepts in the minds of students and deepens their learning. Through games in indirect and direct education, the important educational goals in various topics can be achieved and games lead to active and efficient learning in education (Hwa, 2018). Some educators have emphasized the use of play and play equipment as the main means of educating children to learn different subjects. Decroli, Montessori and Quizter were among those who used games in education and believed that games can not only motivate the individual, but also provide self-efficacy and self-regulation (Angji and Asgari, 2017).

Cockcraft believes that math lessons should be based on practical, fun, and enjoyable topics, and that one of the elements that can help with math teaching and learning is game. Play is an active way of learning that has a much better understanding and can be enjoyable and engaging for learners. Math teaching through play changes students' attitudes toward mathematics and improves their attitudes (Naipitt, Reid, & Strachler-Pool, 2015). Mathematics has always had a special place in the school curriculum and it has been mentioned as an essential knowledge and has always been included in the curriculum in the early years of school. In elementary school, mathematics places more emphasis on arithmetic. Calculation plays an important role in everyone's life, and today learning mathematical knowledge is a necessity for everyone (Tokac, Novak & Thompson, 2019). Accordingly, it is better to pay attention to direct experience-based education than formal and school education, so it is better for the teacher and the school to provide these opportunities to the learners as much as possible in order to improve learning and students to better understand mathematical concepts. In early childhood, play is the main source of learning for children so that provides the basis for learning different concepts (Afari, Aldridge, Fraser & Khine, 2013). Play is an element that stimulates children's thoughts and creativity. Play provides favorable conditions for children to acquire different knowledge and skills (Shamsizadeh, 2018). Because the child has a strong power of attraction, discovery, imagination and curiosity, he learns quickly and more than others through play, and thus active and spontaneous learning takes place (Hwa, 2018).

This research, like any other research, has some limitations, including the fact that the research conducted in relation to the subject of the present study (mathematical game) was very limited, especially for elementary school students and the statistic population of the study was the girl

students of third grade elementary schools of district 1 Mashhad, and therefore, generalizations to other educational levels and cities are facing problems. According to the results of this study, which showed that teaching through games has a significant effect on improving the progress of students in math course, and given that these methods are teachable, they can be taught to teachers along with other methods of teaching math in education officially all over the country. It is suggested that in future research, play-based education be studied in male students too and its effectiveness be compared with girls.

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