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The Effect of Educational Digital Games on Creativity, Motivation and Academic Progress in Elementary School Students' Mathematics lessons

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ABSTRACT

The aim of the research was to investigate the effect of educational digital games on creativity, motivation and academic progress in the mathematics lesson of the first elementary school students. The research method was a quasi-experimental with pre-test-post-test and a control group. The statistical population included all first grade students of Islam-Shahr in the academic year of 2021-2022 equaled to 1552 students. The sample size consisted of 72 students (36 in the experimental group and 36 in the control group) selected by the available sampling method. The measurement tools included the Torrance creativity test (1974), Elliot's Mathematical Motivation Questionnaire (2006), and some tests to measure knowledge, attitude and mathematical skills. In Iran, the reliability of Elliot's Mathematical Motivation Questionnaire was obtained by Aminifar and Saleh Sedeghpour in 2015 using the internal consistency method as .70. The reliability of each component was obtained as .80, .709, .82, .94 and .85 respectively. The experimental variables 'group game', 'exploration' and 'individual game' were implemented in three steps in 12 sessions for the experimental group. Descriptive statistics and inferential statistics such as Kolmogorov-Smironov, Levene and Box's test and Multivariate Covariance Analysis were used for data analysis. The results showed that using digital educational games has been effective on creativity (fluidity component), mathematical motivation (desire, avoidance) and academic progress (knowledge, attitude and skill) of students ($F= 8.610$, DF: 1, $P=0.005$; $P <0.05$). Also, there was a significant relationship between these variables. However, no significant difference was observed between the two experimental and control groups in the components of expansion, flexibility and innovation related to the variable of creativity. The results also revealed that the level of creativity, motivation and academic achievement of students who used educational digital games was significantly higher than those of the students who were trained in the usual way.

Keywords: Academic achievement, Creativity, Educational digital games, Mathematics, Motivation

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Introduction

According to most psychologists and education experts, the suitable learning environment for children in early school age is the environment based on play and activity. Providing this environment is vital for the development of children's cognitive, attitudinal, and motor skills (Fishelson, & Hershkovitz, 2020). Researchers and experts believe that through games, children practice the experiences needed for their future life. Moreover, many researchers consider game-based learning as an educational method encouraging children to actively participate in learning by cooperating with each other (Dadheech, 2019). The game makes children get involved in learning without realizing it and acquire knowledge and skills more than other methods (Bodnar, 2019).

Traditional teaching and learning patterns have changed with the integration of new technologies in education. This might have profound implications for education, as technology can facilitate new forms of learning (Yamimi et al., 2021). One of the technologies that is widely used to focus and attract people's attention is digital games (Spark, 2016). Learning based on digital games is a method that combines educational content with the rules of learning with video games to facilitate learners' interaction and involvement (De Freitas, 2015). Digital game is a system that enables humans and computers to interact based on a set of implicit and explicit rules in an electronic domain for entertainment or education (Fullerton, 2014). Learning based on digital games is a new approach in education including digital games in creating effective learning environments. Games, if well designed, can improve higher level thinking skills. Learning based on digital games as a means to create motivation and efficiency in wide levels of educational fields such as science, mathematics and economics help learners to achieve the desired goals (Hsu et al., 2017).

Learning motivation means a comprehensive driving force that can lead to learning and ensure and facilitate the achievement of expected learning goals. Motivation is the heart of the learning process. Academic motivation in learning environments depends on two basic factors, the degree of involvement in academic activities and the degree of autonomy of learners (Alborzi et al., 2022).

Digital games facilitate learning and provide opportunities for growth and promotion of transferable skills such as problem solving, critical thinking, participation and cooperation. These cases are considered real life skills of children in the 21st century (Allsop, 2012). These games have a flexible and fluid nature that people choose according to their different motives and attitudes. In addition to the fact that digital games are a popular activity, studies have shown that there is a direct relationship between these games and various cognitive skills (Green, 2007). Digital games also increase students' motivation to learn valuable scientific content and skills in and out of the game (Barab, 2010). These games are sensory experiences that include images, music, voice dialogue, movement, animation, and interactive narration. An expert in game-based learning should pay attention to the aesthetics of the game environment and how to support processes and goals (Dickey, 2015). According to Gao, digital games directly affect the speed of thinking. Players learn and think about game transfer strategies and methods (Gao, & Diao, 2014).

Digital games are a combination of three basic principles of e-learning, game-based learning and serious games (Michael, 2006). A digital game-based learning environment helps students gain experience while choosing actions to achieve a goal. When students make mistakes, a risk-free environment allows failures to be challenged, then encourages them to design and revise their actions until they realize the right action (Shaffer, 2005). This is very important for primary school students since in addition to being called the digital generation, elementary school students have many problems in concentrating and learning abstract concepts. On the other hand, games are considered a learner-oriented educational approach that help students learn objectively and concretely through acting (Sukran, 2015).

According to Karadag (2015), learning based on digital games is more effective for primary school students because the students of this level are at the age tend to be active and have fun and at the same time, be involved in their life affairs and learning based on digital games provides entertainment and active involvement for these students. He also stated that elementary school students have problems in learning the abstract concepts and methods presented to them in schools, and learning based on digital games can solve this problem by providing an objective environment (Karadag, 2015).

On the other hand, digital technology can be used as a tool for creativity in learning (Loveless, 2007). Torrance (1981) was among the people who paid attention to the concept of creativity in educational fields and facilitated the emergence of the psycho-educational movement. In line with the conceptualization of creativity, he believed that problem solving and creativity are closely related to each other and goes through specific stages like the scientific method. In describing problem solving, he focused on five stages with emphasis on creativity. In the first stage, a person is faced with a problem, if s/he is capable of creative thinking, s/he emphasizes possible solutions and tries to

give multiple answers in relation to a specific problem. Identifying possible solutions is the first step in creative thinking. After that, he extracts hypotheses, tests these hypotheses, and evaluates them.

Torrance defined the last stage of creative thinking as identification, scientific discovery or communication that a person presents the achievements of creative thinking to others. He postulated creativity as a construct that includes four elements: fluidity, flexibility, innovation (originality) and expansion. Therefore, the tests designed by Torrance to measure creativity are designed with an emphasis on the age range and constructive dimensions of creativity. He defined the components of creativity as follows: fluidity: It refers to the total number of meaningful and interpretable related opinions and responses; Innovation or originality, which refers to unusual answers and always statistically emphasizes rare answers, represents constructive discovery and original thinking; Originality referred to as the birth of pure and practical ideas, which will be more effective if they are accompanied by skill or attention to details and insight in various aspects of accountability; and Elaboration referring to the ability of people to pay attention to details while performing an activity (Torrance, 1981).

Research studies show the positive impact of games on creativity, learning, and the development of social skills of children and students (Del Moral et al., 2018). Duncan, in his research entitled "Investigation of the impact of game-based learning on involvement, growth, participation, communication, creativity and critical thinking of learners" concluded that not every game can increase the variables of engagement, growth, participation, communication, and creativity and critical thinking and it depends on the strategy used in using the game. Therefore, a suitable strategy should be used to achieve the result (Duncan, 2020). Avdiu, in a research, entitled “Game-based learning experiences in Australian primary schools”, found that game-based teaching methods are effective methods for primary school students' learning and increase their learning and social skills (Avdiu, 2019).

Considering the fact that cultural industries create ideas, produce and distribute products and services, they play a significant role in culturalization of societies. At the end of 2021, the annual revenue of digital games in the global market has reached more than 180 billion dollars. This is while this figure in Iran was reported to be 4300 billion Tomans in 2018 (Direk, 2020). On the other hand, per capita consumption of games in the country was about 93 minutes per day in 2019 which indicates that digital games are a serious media in Iranian families (Sharifi & Nasrolahi, 2021). In this regard, Lacasa also stated that in today's era, computer games have entered the daily life of children, teenagers and young people.

However, despite this influence and importance, their educational potentials and capabilities in strengthening thinking has been neglected (Lacasa et al., 2014). Also, Butler (2015) stated that computer games are new media and experts in the field of learning and teaching are facing various challenges in using this new media in learning and teaching, including paying attention to the educational basics and matching the games with the goals of the program. There are lessons to be learned. We can also consider Craft's claim, which sees creativity as a basis for learning and living in the 21st century, as a necessity for conducting this research. He introduced children as inheritors of problems and limitations inherited from us, and it is only through the help of creativity that they can find solutions to their problems (Craft, 2004). Finally, studies show that students can learn deeply and acquire the essential 21st century skills through digital games.

Also, the report of the "International Association for the Evaluation of Academic Achievement" stated that Iran's educational system has failed in teaching students creative thinking skills. Based on the results of Timss and Pirls tests, this association has declared that students’ average scores are lower than the world average at the primary level in Iran. The ideal curriculum does not introduce students as mere learners and teachers as mere transmitters of subject matter; rather, it assigns a multidimensional role to each one. Therefore, one of the goals of education and the duties of teachers is to cultivate creative thinking (Hojati et al., 2021). Therefore, the present research was conducted to examine the following hypotheses:

The first Hypothesis: Educational digital games affect the creativity of first grade elementary school students in mathematics.

The second Hypothesis: Educational digital games affect the motivation of first grade elementary school students in mathematics.

The third hypothesis: Educational digital games affect the academic progress of first grade elementary school students in mathematics.

Method

The research design was a quasi-experimental pre-test-post-test type with a control group and was from the applied type. This design consisted of two groups that were compared before and after presenting the independent variable. The statistical population of the research included 72 male first grade students of the primary school in Islamshahr (36 in the experimental

and 36 in the control groups), who were selected using the available sampling method.

Instruments

The instruments included Torrance creativity test (Form A), math motivation questionnaire, and tests for measuring knowledge, attitude and math skills. Torrance's creativity test was created by Torrance in 1974. Torrance's creativity test (Form A) actually measures the four factors of creativity, i.e. fluidity, originality, flexibility and expansion, and includes three activities of image creation, image completion and parallel lines.

The actual time of the students' activity in the visual tests was 30 minutes, and a 10-minute time period was considered for each activity. This test has a high content, construct, and face validity. Torrance has reported the average reliability coefficient for this test from .88 to .96 (1974, Form A). In terms of test-retest reliability, Goralski (1964, cited by Torrance, 1974), reported a test-retest coefficient of .82 for fluidity, .78 for flexibility, .59 for creativity, and .83 for total reliability with a ten-week interval. In the Iranian sample, Pirkhaefi (1994) obtained a reliability coefficient of .80 in a two-week interval by test-retesting 48 students. The reliability coefficient of Torrance's creativity test (form A) was calculated for each creativity component using Cronbach's alpha method. The following results were obtained for each of the four factors: extension: .65, ingenuity: .97, fluidity: .86, flexibility: .92, and these figures are significant at the alpha level of 0.01.

The second measurement tool was the mathematical motivation questionnaire. To measure motivation, a mathematical motivation questionnaire with 19 items, including desire and avoidance motivation, was used. This questionnaire was created by Elliot in 2006. In Iran, the reliability of this questionnaire was obtained by Aminifar and Saleh Sedghpour in 2009 to be .70 using the internal consistency of questions. Mathematical motivation questionnaire included desire motivation and avoidance motivation. Desire motivation included eight questions (questions 2, 3, 10, 11, 14, 19, 23) with direct scoring and question 1 with reverse scoring. Avoidance motivation includes nine questions, questions 4, 6, 9, 12, 20, 22 with direct scoring and questions 5, 8, 13 with reverse scoring.

In order to measure knowledge, attitude and mathematical skills, an objective-table of contents was compiled and then questions were designed in a four multiple-choice, matching and descriptive formats. After designing the questions, the test was conducted in a trial form, during which 40 students answered the questions in a 45-minute session. The reliability coefficient of the tests measuring knowledge, attitude and skill was obtained as .82, .94 and .85 respectively. After collecting the papers and grading, the item difficulty and item discrimination coefficients of the questions were calculated. Data analysis was done using descriptive and inferential statistics. At the descriptive level, mean and standard deviation indicators were used, and at the inferential level, the Kolmogorov-Smirnov, Levin and Box test and multivariate covariance analysis were used.

Findings

After collecting the scores of creativity, motivation and academic achievement of the students participating in the research, the average and the standard deviation of scores were obtained (Table 1).

Table 1.

The Mean and Standard Deviation of the Pre-Test and Post-Test Scores of Creativity, Motivation and Academic Progress in the Groups

Group	Variables	Subscale	Pretest		Posttest	
			Mean	SD	Mean	SD
Experimental	**Creativity**		137.97	11.749	153.47	13.054
		Fluidity	52.67	4.544	56.03	4.810
		Innovation	24.90	2.893	27.57	3.319
		Flexibility	35.27	5.420	41.07	4.533
		Expansion	25.13	3.288	28.80	2.882
Control	**Creativity**		136.20	13.900	136.63	13.720
		Fluidity	50.23	5.211	50.47	5.124
		Innovation	25.10	5.026	25.40	4.889
		Flexibility	36.07	4.856	35.70	4.879
		Expansion	24.80	3.478	25.07	3.138

Group	Variables	Subscale	Pretest Mean	SD	Posttest Mean	SD
Experimental	Motivation		70.83	4.58	108.8	6.35
Control	Motivation		83.80	4.44	85.02	4.31
Experimental	Academic Achievement		68.44	6.34	74.52	3.54
Control	Academic Achievement		70.19	4.66	70.58	4.14

In order to test the hypotheses of the research, the performance of the experimental and control groups was measured through the pre-test and post-test of creativity, motivation and academic progress using multivariate covariance analysis test. Before performing the analysis, the assumptions of this test were examined. One of the preconditions of MANCOVA is the equality of the covariance matrix. The results of the Box's test showed that there is no significant difference between the covariance matrix in the research components.

Table 2.
Box's Test to Check the Equality of the Covariance Matrix

Box's M	F	DF1	DF2	P Value
23.808	1.203	1	70	.059

Next, Levene's test was used to check the homogeneity of the variances and the results of all components were in favor of the equality of variances.

Table 3.
Levene's Test of Homogeneity of Variances for the Experimental and Control groups

Component	Post-test	F	df1	df2	Sig.
Creativity	Fluidity	.269	1	70	.606
	Innovation	.760	1	70	.387
	Flexibility	1.287	1	70	.083
	Expansion	1.093	1	70	.075
Motivation	Desire	2.546	1	70	.116
	Avoidance	2.047	1	70	.127
Academic Achievement	Knowledge	3.104	1	70	.214
	Attitude	2.017	1	70	.134
	Skill	2.158	1	70	.138

Another presupposition of covariance analysis is the normality of the groups, which was measured using the Kolmogorov-Smirnov test.

Table 4.
Kolmogorov-Smirnov Test for Variables of Creativity, Motivation, and Academic Achievement

Variable	Kolmogorov-Smirnov Value	P value
Creativity Post-Test	.891	.406
Motivation Post-Test	.782	.427
Academic Achievement Post-Test	.858	.471

According to the z-statistics obtained from the non-parametric Kolmogorov-Smirnov test and according to the significance level of each of the variables, which is above 0.5, the results are not significant. Therefore, the null hypothesis is confirmed and the distribution of the scores of the dependent variables (post-test) for the experimental and control groups is normal. Considering that all assumptions of covariance analysis were met, multivariate covariance analysis was used. The findings of multivariate covariance analysis to investigate the effect of the experimental procedure are reported in Table 5. According to the significance of Pilai's and

Wilks's lambda effects for the independent variable (group), ($p<0.05$) the intervention had a significant effect on the dependent variables.

Table 5.
The Results of Multivariate Covariance Analysis of Creativity, Motivation and Academic Achievement

Variable	Effect	Value	F	Df	Error Df	P
Creativity	Pillais Trace	.277	4.884	4	61	.002
	Wilks Lambda	.723	4.884	4	61	.002
Motivation	Pillais Trace	.516	13.603	4	61	.000
	Wilks Lambda	.484	13.603	4	61	.000
Achievement	Pillais Trace	.759	40.127	4	61	.000
	Wilks Lambda	.241	40.127	4	61	.000
Group	Pillais Trace	.529	14.319	4	61	.005
	Wilks Lambda	.471	14.319	4	61	.005

The results of MANOVA showed that there was a significant difference in the post-test scores of the control and experimental groups, and a significant part of this difference was the result of the experimental procedure. However, it was not clear which of the research variable components has caused the difference in the post-test. Thus, in order to examine the differences more precisely, the single-variable covariance analysis test was performed .

Table 6.
The Results of Multivariate Covariance Analysis for Creativity Component

Variable	Effect	Value	F	Df	Error Df	P
Fluidity	Pillais Trace	.591	18.404	4	63	.000
	Wilks Lambda	.409	18.404	4	63	.000
Innovation	Pillais Trace	.729	34.272	4	63	.000
	Wilks Lambda	.271	34.272	4	63	.000
Flexibility	Pillais Trace	.562	16.381	4	63	.000
	Wilks Lambda	.438	16.381	4	63	.000
Expansion	Pillais Trace	.370	7.487	4	63	.000
	Wilks Lambda	.630	7.487	4	63	.000
Group	Pillais Trace	.249	4.228	4	63	.005
	Wilks Lambda	.751	4.228	4	63	.005

Table 7.
The Results of Multivariate Covariance Analysis of Academic Motivation Component of the Two Groups

Variable	Effect	Value	F	Df	Error Df	P
Desire	Pillais Trace	.277	4.884	2	67	.002
	Wilks Lambda	.723	4.884	2	67	.002
Avoidance	Pillais Trace	.516	13.603	2	67	.000
	Wilks Lambda	.484	13.603	2	67	.000
Group	Pillais Trace	.529	14.319	2	67	.000
	Wilks Lambda	.471	14.319	2	67	.000

Table 8.
The Results of Multivariate Covariance Analysis of Academic Achievement Component (Knowledge, Attitude and Skills)

Variable	Effect	Value	F	Df	Error Df	P
knowledge	Pillais Trace	.517	13.604	3	66	.000
	Wilks Lambda	.454	13.605	3	66	.000
Attitude	Pillais Trace	.748	40.127	3	66	.000
	Wilks Lambda	.274	40.128	3	66	.000
Skill	Pillais Trace	.588	15.942	3	66	.000
	Wilks Lambda	.456	15.943	3	66	.000
Group	Pillais Trace	.525	14.314	3	66	.000
	Wilks Lambda	.471	14.314	3	66	.000

Table 9.
The Results of Single-Variable Covariance Analysis of the Sub-Components of Creativity, Motivation and Academic Achievement

Source	Dependent Variable	Mean Squares	Df	Mean Square Error	F	Sig.	Eta Square
Educational Digital Game	Fluidity post-test	79.942	1	79.942	8.610	.005	.138
	Innovation post-test	14.523	1	14.523	3.646	.062	.063
	Flexibility post-test	4.442	1	4.442	.472	.495	.009
	Expansion post-test	277.080	66	4.19			
Educational Digital Game	Desire post-test	242.522	1	242.522	21.952	.000	.289
	Avoidance post-test	83.954	1	83.954	24.360	.000	.311
Error	Desire post-test	569.595	66	9.03			
	Avoidance post-test	186.101	66	2.81			
Educational Digital Game	Knowledge post-test	83.954	66	1029.364	24.146	.000	.311
	Attitude post-test	465.753	1	465.753	54.085	.000	.500
	Skill post-test	20.7237	1	20.7237	58.138	.000	.518

Table 9 shows the results of covariance analysis of one variable in the two groups on the sub-components of creativity (initiative, fluidity, flexibility, and expansion), motivation and academic achievement. considering that F = 8.610, DF=1 (P=.005; P < 0.05), it can be claimed that the research hypotheses are confirmed and it can be stated that the level of creativity, motivation and academic achievement of the students who used educational digital games was significantly higher than the other group.

Discussion

The First hypothesis of the study examined if educational digital games affect the creativity (fluidity, expansion, flexibility and innovation) of first grade primary school students in mathematics. The findings revealed that digital game-based learning can improve students' creativity. In his book entitled "Reflection of some creative designs in childhood", Csikszent Mihalyi depicted some characters whose life and environmental conditions have glinted great sparks in their minds. For example, Vera Roubin is an astronomer who doesn't pay any attention to the sky above his head when he lives in Chicago. However, moving to the outskirts of the city and being away from his friends and his loneliness makes him interested in the sky and stars when he sleeps in his bed at night, and with the support of his father, he builds a telescope and watches the sky (Csikszent Mihalyi, 2012).

Online digital educational games are like the same change of conditions that give students the opportunity to escape from stereotypes and routines, to put themselves in it and let the mind flow in another space. In teaching and learning based on digital games, students experience environments that are the result of the integration of components that are apparently unrelated to each other, such as life in the sea and numerical symbols, or the addition and subtraction game. This is one of the techniques of fostering creativity, which is called forced displacement technique (Creativity is a

learnable skill, 2016, p. 14). According to Torrance (1981), creative teaching models are one of the fields of increasing creativity. By combining the two statements, it can be stated that digital educational games lead to fluidity of the mind while playing games, by creating meaningful connections between apparently unrelated components.

Regarding the expansion component, there was no statistically significant difference between the means of the control and experimental groups (F=3.646, DF =1, P=.062, P<0.05) and educational digital games did not make a difference on this component compared to the traditional method of teaching. This finding is consistent with the results of Khaef (2015) and Saberi (2013), but it was inconsistent with the finding of Gholami Toran Poshti and Karimzadeh (2011) who reported the reduction of the expansion component. Expansion is the ability to pay attention to details while performing an activity. Extended thinking deals with all the details necessary for a plan. In explaining why educational digital games have not been able to increase the expansion component, it seems that using games from two similar sites cannot be without reason as the two sites are similar in terms of attention to details. In addition, these games are designed for the purpose of education, and the requirements that are considered in a purely entertainment game during design are not fully considered in these types of games. In other words, because these games pay special attention to the cognitive improvement of the students, their performance in attending to details does not seem very successful.

Regarding the component of flexibility, the results of the research showed that teaching based on educational digital games did not have a significant effect on this component compared to the traditional teaching method (F=.472, DF=1, P=.495, P<0.05). Flexibility is the ability to think in different ways to solve a new problem. Flexible thinking designs new patterns for thinking. Torrance referred to flexibility as the number of different classes of different responses, thereby emphasizing clusters or groups of responses that refer to the diversity of the spectrum. A person who gets a high score in flexibility, in facing a problem, pays attention to different angles and provides various layers of answers. In explaining this finding, it can be stated that the component of flexibility and achieving different ways of solving the problem is a complex issue for cultivating creativity. It is multi-faceted and needs a multi-faceted approach. With this definition, it can be said that in order to increase flexibility, an issue must be examined from different angles, and this is what Imam Juma (2006) asserted in his research. When this feature of reviewing the issue from different angles is not present in a problem and the activity becomes routine, multiple visions and finding different solutions and variety of answers will not grow. It seems that playing in the environment of digital games for first grade primary students lacks this feature; that is, they cannot achieve different classes of answers due to their age and habituation to this environment.

Considering the creative component, the results of the research showed that there was no statistically significant difference between the control and experimental groups using educational digital games on the creative component of the students compared to the traditional teaching method (F=1.141, df= 1, P=.290, P<0.05). In explaining this finding, it can be stated that innovation or originality refers to unusual answers and always statistically emphasizes rare answers and represents constructive discovery and original thinking. The present research was carried out in a group manner. The students in their groups used to think and consult with each other about the flow of the game and the achievement of educational goals, which made the students' ideas available and publicized.

The second hypothesis of the study investigated the effect of educational digital games on the motivation (desire and avoidance) of first grade primary students. The findings of this research showed the effect of educational digital games on students' desire motivation (F= 21.952, df=1, P= .000, P<0.05). The results are in line with those of Gholamrezaei (2011), Zadeh Dabagh (2010), Moradi and Maleki (2015), Velayati (2012) and Brom et al. (2015). The possible reason for this finding is that in traditional methods, mathematic lessons are presented in the form of lectures and without special appeal, but in the method based on educational digital games, students' interest in playing in an attractive computer environment makes them fascinated in mathematical concepts. According to Bishar (1990), games that have three characteristics of control, complexity and challenge increase the involvement of learners; therefore, it seems that the games used in this research had the above three characteristics and, accordingly, increased the involvement of the learners. Hence, it can be said that the involvement of learners with the subject to be taught has strengthened the motivation in them as the player faces three elements of control, complexity and challenge while playing the game. In terms of complexity, it is important that the complexity of the game increases over time and with the progress of the game and passing the initial stages, which according to the researcher, this feature causes a kind of excitement in the learner to go to a higher level of growth and learning. On the other hand, sharing goals, helping others, and sharing the feeling with the team also increases motivation.

Also, the research findings demonstrated the effect of educational digital games on students' avoidance motivation (F=24.360, DF=1, P=.000, P < 0.05). The findings are in line with the results of Gholamrezaei's research (2013), dealing with avoidance motivation separately, Moradi and Maleki (2014), Velayati (2014), Zhao and Sun (2016) and Chan et al. (2014). However, the findings are inconsistent with the findings of Zadeh Dabagh (2009). The studies conducted on the impact of information technology and the related technologies on learning express the fact that learning based on educational digital games provides a learning environment that concerns individual differences in which students are not compared with others and their weaknesses are not revealed to all students. Also, since the digital games of this research were used in a group and consultative manner, and the group members were given the necessary guidance and helped their friends, this might have interested them in math lessons providing enough motivation to succeed in this lesson. The ability to personalize education through digital games increases the learner's interest in their educational and academic assignments.

The third hypothesis of the study probed to see if educational digital games affect the academic achievement (knowledge, attitude and skills) of the first grade elementary school students. The findings of the research showed the effect of education based on educational digital games on the progress of students' mathematical knowledge (F = 24.146, DF=1, P=.000, P < 0.05). This result is aligned with the result of Ismaili Gujar (2017), Derikvandi (2013), Bijari (2013), Bahreini Monfared (2010), Sak et al. (2015), Brom et al. (2015) and Chan et al. (2014). From the point of view of active learning, collective and group games in a class have an important role in increasing involvement and cognitive participation (Brom et al., 2015). Since technology is part of the social networks that are currently used, using computers and learning based on digital games in education can help students gain new knowledge and strengthen learned skills. Moreover, learning based on digital games can provide the opportunity to improve current knowledge related to the curriculum (Ferguson, 2014). The possible reason for this finding can be attributed to Piaget's cognitive development theory: the first grade students are in the stage of objective operation and the more objective and engaging the teaching method is for the student, the better and deeper learning occurs. Of course, this finding is also consistent with Dale's learning cone: attractive and beautiful environment, music, story and three-dimensional environment, giving points and encouragement while playing the game, the possibility of repetition and practice, competition and evaluation of what has been learned and feedback to the student are among the factors that have contributed to the academic progress of the students. On the other hand, when educational goals and game features overlap more, the educational effect will be much greater, which was fully observed by the researcher in the selected games.

The findings of the research showed the effect of educational digital games on the academic achievement (attitude dimension) of the first grade elementary school students (F=54.085, DF=1, P = 0.000, P < 0.05). In other words, it can be stated that there was a statistically significant difference between the means of the two groups. The game-based learning method can cause an internal transformation for learning and motivation, and as a result, the mathematical attitude in the individual, because motivation from Ausubel's point of view is a type of internal motivation that comes from the learner's curiosity and interest in discovery. It originates from manipulation, understanding and dealing with the environment (Seif, 2011). Considering that the attitude has three aspects: cognitive, emotional, and readiness for action, it can be concluded that the cognitive aspects of the attitude are the result of the academic progress resulted from using the game. On the other hand, the emotional aspects of the attitude result from the interaction of the cognitive aspect, as well as the characteristics of attraction (emotional dimension) along with the desire motivation strengthened by the game.

Also, the results showed that there is a statistically significant relationship between educational digital games and academic achievement (skill dimension) of the first grade elementary students (F=58.138, DF=1, P = 0.000, P < 0.05). To the researcher’s knowledge, no domestic and foreign studies have been found that specifically investigated the effect of digital games and the skill dimension of academic achievement as they have studied academic progress in general. The significance of this study is that it confirms educational digital games are effective tools for skill development. Digital game players perform better in processing visual stimuli and using fingers and hands, as well as hand-eye coordination. Therefore, it is very clear that this teaching method is directly related to the development of math skills.

Conclusions

According to the results of this research, the use of educational digital games significantly affected the creativity in the fluidity component and made a difference between the means of the two groups, but in the expansion, flexibility and innovation components, this difference was not significant. No difference was observed between the two groups in these components.

Regarding the motivation of mathematical progress, the results of the analyses showed a statistically significant difference between the experimental and control groups. To put it another way, the desire and avoidance motivation of the students who were trained by the educational digital games was higher than the students receiving the traditional method of education. In the variable of academic progress in all three dimensions of knowledge, attitude and skill, there was a statistically significant difference between the experimental and control groups. In other words, the improvement of knowledge, attitude and skill of students who experienced educational digital games was more than students taught in the traditional way.

In general, most of the studies in Iran and the world have emphasized the mathematical knowledge dimension but they have not examined the relationship between the teaching method based on educational digital games and learners' attitudes. The significance of this finding can be due to the fact that in line with the use of this method, the attitudinal aspects of the students improved as well. Academic achievement in mathematics is not only affected by knowledge structures and information processing procedures, but also it is related to motivational factors such as beliefs, attitudes, values and anxieties (Rostami, 2016).

Moreover, the attitude towards mathematics is a multi-dimensional construct that includes the enjoyment of engaging in mathematical tasks - both in academic experiences and in everyday life - about the value and importance of mathematics and the degree of fear of facing situations requiring the application of mathematical knowledge (Aiken, 1979). According to Yenilmaz (2007), there is a relationship between high motivation and positive attitude with math performance. Attitude is a very important subject in teaching mathematics and can create factors such as enjoyment of mathematics, self-confidence in mathematics, as well as success and failure in mathematics (Safavi, 2009). Also, Aiken (2007) showed that mathematical attitude predicts academic success in mathematics; therefore, there is a close relationship between the knowledge dimension of mathematics and its attitude. This study had some limitations as unavailability of the domestic version of the games or the small size of the sample which limits the scope of generalizability. Future studies can investigate the effects of educational digital games on other educational levels, age ranges, and across genders.

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Conflicts of Interest

No conflicts of interest declared.

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