

Research Paper

The Impact of Modern Technology on Learning and Retention Outcomes in Elementary School Mathematics

Khadije Fadaei Moghadam¹ , Majid Reza Razavi^{2*} *1. Department of Educational Sciences, Faculty of Education, Taybad Branch, Islamic Azad University, Taybad, Iran.*

Citation Fadaei Moghadam, Kh., & Razavi, M. R. (2024). The Impact of Modern Technology on Learning and Retention Outcomes in Elementary School Mathematics. *Journal of Practice in Clinical Psychology*, 12(4), 335-344. <https://doi.org/10.32598/jpcp.12.4.918.3>

<https://doi.org/10.32598/jpcp.12.4.918.3>

Article info:**Received:** 18 Jul 2024**Accepted:** 15 Sep 2024**Available Online:** 01 Oct 2024**Keywords:**

Media in education,
Elementary education, Gender
studies, Improving classroom
teaching

ABSTRACT

Objective: This study aims to investigate the application of modern educational software (MES) in the mathematics classroom environment to the learning and retention process.

Methods: The present study was applied in terms of purpose and quasi-experimental in pre-test-post-test design. The statistical population included 18794 fourth-grade female students in the elementary school in 2020-2021 in Mashhad City, Iran. Then the test group was taught using the creative technology program (CTP) in six sessions, and the control group was taught the traditional teaching method in six sessions. At the end of the training, math tests were performed in the test and control groups and the scores of the two groups were compared to measure learning. Then, two months later, to measure the amount of retention in the two groups, the math test was repeated and the results were compared with the pre-test results.

Results: Based on the results, the CTP has a significant effect on learning and teaching mathematics to fourth-grade elementary students in Mashhad City.

Conclusion: With the advancement of fundamentals of education, the implication of educational software has proved more favorable effects than traditional systems in education and has a higher success rate.

*** Corresponding Author:***Majid Reza Razavi, Assistant Professor.**Address: Department of Educational Sciences, Faculty of Education, Taybad Branch, Islamic Azad University, Taybad, Iran.**Tel: +98 (915) 1564060**E-mail: drmrzazavi@gmail.com*

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Highlights

- The creative technology program (CTP)-based teaching improved the learning of mathematics in elementary school girls.
- The CTP-based teaching improved the retention of mathematics in elementary school girls.
- The CTP is more effective than traditional methods in teaching mathematics to elementary school girls.

Plain Language Summary

Today, the use of games by teachers in elementary schools to facilitate learning has become more common. Educational software programs support the teaching-learning process and should be used because of increasing creativity, innovation, and critical abilities of the learner. This study aims to investigate the effect of using modern educational software based on a CTP for teaching mathematics on the learning and retention of elementary school girls in Iran. Then test group was taught using the CTP in six sessions, while the control group was taught using the traditional method in six sessions. Based on results, the CTP had a more significant effect on learning and retention of mathematics than the traditional method.

Introduction

In today's world, human beings are looking for ways to retrieve and process information quickly, and such an approach is possible with the extensive knowledge of information and communication technology in educational environments and the emergence of modern educational software (MES) (Chevalier et al., 2022). In the traditional method, with scattered learning of subjects and not focusing on the relationship between different scientific concepts and on the other hand, not transferring this information and independent teachings to extracurricular situations, students have not benefited enough from their studies (Gunduz & Hursen, 2015). The main drawback of traditional education design is that goal approaches are based on the independence of knowledge and learning from learners' education and therefore, the individual characteristics of learners are not considered; as a result of such training, the learner is not free to take the initiative, creativity, exploration, and responsibility for learning. Research shows that the use of MES in the field of instructional technology facilitates learning the most (Weast & Neiman, 2016; Alimisis, 2019; Saffariantoosi & Khaleghi, 2024). The creative technology program (CTP) is a kind of educational software that allows children to learn math concepts through computer games (Partovi & Razavi, 2019; Gonabadi & Razavi, 2021). In recent years, due to the growth of technology in all social dimensions, including education and its positive effects on learners' learning, education has gradually changed

its direction from teaching to learning (Chevalier et al., 2022). Because technology enhances students' learning, its application in teaching and learning mathematics is essential (Mahayukti, 2018).

Over the past decade, many changes have been made in the way different courses are taught, therefore modern methods have replaced traditional methods to learn faster and better. Therefore, students are widely faced with the application of modern educational technology in the form of MES in the classroom. Some believe that this method creates a fundamental change in the quality of learning and student retention (Mahayukti, 2018; Ehsanpur & Razavi, 2020).

Instruction is a process of create learning environments in which learners' desired activities to build knowledge and acquire the ability to think are maximized (Alevriadou & Pavlidou, 2014). For such a process to be as effective as possible, the learner must be active and directly involved in what he/she teaches (Zhang et al., 2012). For student's participation in learning, one of these modern methods is the use of computer-assisted instruction and multimedia MES (Atiyah et al., 2015; Hraste et al., 2018). Lee et al. (2014) stated that multimedia tools help students gain a better understanding of the fourth-grade elementary mathematics lesson. Barbeta (2023) showed that through multimedia education, the student achieves deeper learning. Perez et al. (2023) found social media as a teaching and learning tool in higher education. Educational multimedia software means educational software

that includes text, images, animation, video, audio, etc (Jangi Sangani & Razavi, 2024). This software has advantages, such as instant feedback, attention to individual differences, power of choice, deepening learning and expanding the scope of the learner, increasing the power of choice, adjusting the speed of learning, reducing operating system costs, saving startup costs, and access to educational equipment (Witte et al., 2015; Hraste et al., 2018). Learning tool technology, such as multimedia, allows students to engage in learning and learn with interest (Taghani & Razavi, 2022). Student involvement has a crucial effect on their learning and the use of strategies to draw students' attention to the content of the lessons is effective (Deldar et al., 2022). In addition, the use of these multimedia tools, such as MES can help the child to gain a better understanding of world phenomena. Mathematics education in elementary school with the help of software is one of the issues that has been somewhat neglected due to the necessity and position of elementary mathematics in the Iranian educational system. Spears (2011) introduced the smartboard as a modern technology and an interactive tool to enhance learning.

The application of technology has many positive effects on students, including changing the roles of students and teachers, increasing their self-esteem and motivation, creating modern practical and technical skills, performing more complex tasks, and more classmate cooperation (Razavi, 2019). When students use educational technology, or in other words, teaching aids, they are more involved and active than when they receive only the material (Hadley & Dorward, 2011). Technology in education turns students into analysts and critics of scientific material, allowing them to solve their problems faster than before and to answer their mental ambiguities. The use of this technology also helps them to be more productive than before, rather than just receiving the curriculum (Atiyah et al., 2015).

Retention is bringing to life and presenting past learnings and events in the mind (Weast & Neiman, 2016). The best way to maintain the acquired knowledge and skills is to combine knowledge, attitudes, and skills in an environment leading to experiences for learners (Siemens, 2006; Hung, 2015); while up-to-date education methods lead to changing educational methods, improving the quality of learning and retention of learned material and ultimately affect the learning- retention process and interaction between the two (Kim et al., 2011). In this regard, research that shows the importance of educational software has shown that education based on multimedia software can help students understand and retain (Vlach & DeBrock, 2019; Sapounidis & Alimisis,

2020; Hartley et al., 2020). Figure 1 shows the conceptual framework of current research.

The advantages of using MES include ease of learning, easy access, and creating a desire and enthusiasm for learning in learners. In the process of teaching and learning, the student is at the center of learning and interacts with his environment. Students gain the necessary ability to solve problems and learn using the content provided by the software, and the result is the training of students to live in the community and to take jobs suitable for the community (Kim et al., 2011).

Today, the use of games in the classroom to facilitate learning has become common among teachers. Play improves students' motivational strategies for practicing skills and builds a strong foundation for their learning (Hong, 2015). Playing games, as a teaching tool, helps students solve problems. Playing games also gives them a chance to deal with issues and develop strategies for solving problems in a non-threatening environment (Bastable, 2013). Play is one of the most effective and best ways to teach children. Math games can help children learn and love math better, in addition to sweetening instruction for students in the first place, reducing burnout and hard work for teachers, as well as facilitating the teaching of math for parents at home. Lack of attention to the use of educational game software deprives individuals and society, including students, teachers, parents, and education at both micro and macro levels of these benefits.

Learning is defined as the process of making relatively lasting changes in behavior or behavioral ability resulting from experiences that cannot be attributed to temporary states of the body, such as those caused by illness, fatigue, or medication. A change can be called learning that results from experience. Experience in defining learning means the interaction between stimuli (external and internal) and the learner. As a result, reading a book, listening to a lecture, a child falling, or thinking about a subject are experiences that may lead to learning (Light & Cox, 2009).

Educational software programs support the teaching-learning process and should be used due to increase creativity, initiative, and critical abilities of the learner. Sedrakyan et al. (2020) showed that the application of technology has created great interest in learners to explore behavior and learning analysis in science lessons.

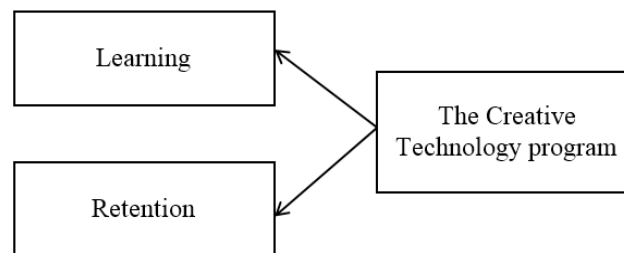


Figure 1. The conceptual framework of the current study

Kondratieva (2013) indicated that the use of three-dimensional software to teach and learn analytical geometry is more effective than the traditional method. Shaughnessy et al. (2013) showed that educational software, compared to traditional methods, has a greater effect on deepening learning. Denbel (2014) stated that the use of dynamic geometry software tools in high schools in Ethiopia has improved student learning. Lessani et al. (2017) stated that due to the teacher-centered traditional method, student participation in this method is less in learning. While in modern teaching methods using new software, the teacher plays the role of facilitator with the participation of students in various activities and knowledge construction. Hraste et al. (2018) indicated that the results of using modern software in mathematics and geometry are more successful than traditional methods (control group).

Today, due to the great change that has taken place in education in the world, unfortunately, in many Iranian schools, the traditional method is still used in teaching all subjects, including mathematics. Methods that are teacher-centered and student-centered. Meanwhile, most students' approach to math is that some math topics are complex. As a result, they are afraid of these mathematical issues, which is a great weakness of the Iranian educational system. This research helps teachers to use educational software in their curriculum design and teaching. By conducting this research on the efficiency and impact of using software in teaching courses and comparing it with the traditional method, educational centers can choose the method and use the software more carefully. Therefore, this study was conducted to investigate the effect of mathematics education through the CTP on the learning and retention of this course among fourth-grade elementary school girls in Mashhad City. The main goal of this research is to assess the effect of implementing educational software in mathematics on students' learning and retention and to compare the effectiveness of this method with the traditional method. In this regard, this study seeks to answer the main question of whether the use of the CTP affects the process of learning and memorizing mathematical concepts in the fourth-grade elementary school environment.

The main objective

Determining the effect of using the CTP on the process of learning and retention of mathematical concepts in the fourth grade of elementary school.

The main hypothesis

The use of the CTP has an impact on the process of learning and retention of mathematical concepts in the fourth-grade elementary school environment.

Materials and Methods

The present study is a quasi-experimental method with a pre-test-post-test design. In this research, the participants are divided into test and control groups. In the test group, the impact of the CTP in the mathematics course on the learning and retention of this course is examined. In this study, subjects included 18794 female students in the fourth grade of elementary school in 2020-2021 in Mashhad City. These subjects were attended in 314 schools and 785 classrooms. The cluster sampling method was implemented to select two fourth-grade girls' classrooms. Based on the results, and sampling, two 25-person classrooms were selected in two schools, Shahid Fatemeh Kafash and Shahid Rajabi (Figure 2).

Procedure

The data collection method of this research was library and field methods. The library method (referring to the library, using the database of articles, database of dissertations, reputable sites, etc.) was used to collect information related to the background and literature of the research. Then, in the field method, the researcher refers directly to the members of the statistical sample. In this research, before teaching, first, a complete explanation of the ongoing study was provided for students and their parents, and then a math test, including the topics of the first chapter of the math book, consisting of 20 questions (maximum score of 15). Regarding this chapter, pre-test was taken from students (sample members) and individuals' scores

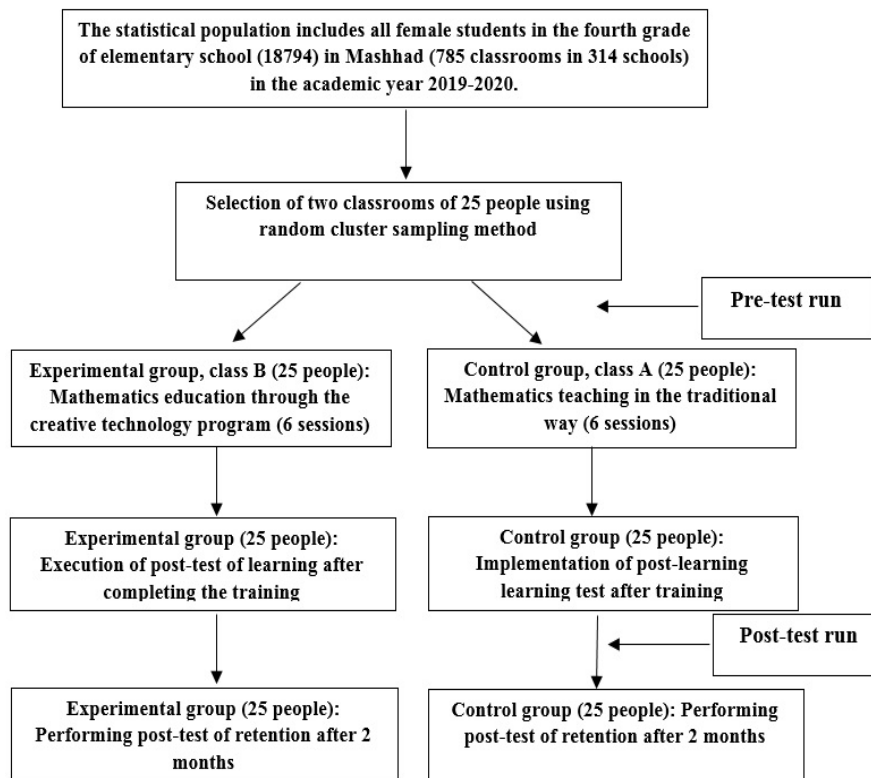


Figure 2. Schematic diagram of the study process

were recorded. Then, in six sessions, the control group was taught the first chapter of the math book in the traditional and normal way of the studied schools, and the test group was taught the concepts of the first chapter of the fourth-grade math textbook in six sessions with the help of the CTP. Then the math test was repeated for both test and control groups and the scores of the two groups were compared to measure learning. Then, two months later, to measure the amount of retention in the two groups, the math test was repeated and the results of the initial test were compared. The amount of retention is calculated through the difference in retention and detection or repetition of re-learned material after two months, after the post-test. The specialized teachers confirmed the validity of the questions with the relevant experience and their opinions on the questions of the course. Cronbach's α (0.88) was used to estimate the reliability of the test before execution.

Data analysis

To analyze data, SPSS software, version 23 was used. Data were analyzed by descriptive (Mean \pm SD) and inferential (multivariate analysis of covariance [MANCOVA], and two-way covariance analysis) statistics. The analysis of the tests was performed at a significance level of 5%.

Results

Table 1 presents the mean scores of math learning in the control group in the pre-test (13.64) and post-test (14.04) and in the test group, in pre-test (13.73) and post-test (16.69). Also, Table 1 presents the mean scores of math retention in the control group in the pre-test (13.64) and post-test (14.03) and in the test group, in pre-test (13.73) and post-test (16.06).

Investigation of research hypothesis

The use of the CTP has an impact on the process of learning and retention of mathematical concepts in the fourth-grade elementary school environment.

MANCOVA was implemented to test the above hypothesis. Also, to control the effect of pre-tests, as a random variable, the effect of both pre-tests has been controlled by the sphericity test. Using this test requires the following basic assumptions. These assumptions include the normality of the distribution of scores, the homogeneity of variances, the homogeneity of regression slopes, and finally the relationship between the dependent variables.

Table 1. Descriptive statistics of mathematics learning and retention in control and test groups in pre-test and post-test

Variables	Group	Mean±SD	
		Pre-test	Post-test
Learning	Control	13.64±2.747	14.04±2.35
	Test	13.73±2.637	16.69±2.305
Retention	Control	13.64±2.747	14.03±2.119
	Test	13.73±2.637	16.06±2.306

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Table 2. M Box’s test statistics to test the homogeneity of variance-covariance matrices

M Box’s Statistics	F Statistics	df1	df2	P
2.391	0.761	3	414720	0.516

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Considering that the level of significance in M Box’s test is 0.516 and greater than $\alpha=0.05$ ($P<0.05$, $F=0.761$ [3, 414720]) and as a result, it can be said that the homogeneity of variance-covariance matrices of the variables is established (Table 2), therefore the assumption of homogeneity of variance-covariance matrices is also established.

Due to Levene’s test in mathematical learning ($P>0.05$, F [1.48]=0.021) and retention ($P>0.05$, F [1.48]=0.992) (Table 3), the equality of variances between the control and test groups is established.

Because the significance of mathematical learning ($P>0.05$, $Z=0.329$) and retention ($P>0.05$, $Z=0.335$) (Table 3), it is assumed that the distribution of scores of both variables is normal.

According to the results of Table 4 ($\eta^2=0.7$, $\text{Lambda}=0.30$, $P<0.05$, $F_{(2, 46)}=53.666$), it can be said that educational and entertainment software has a significant

effect on mathematical learning and retention of the fourth-grade elementary students in Mashhad City.

The results obtained in Table 5 show that the control and test groups in the post-test of mathematical learning (F [1]=107.783, $P<0.05$, $\eta^2=0.696$) and retention (F [1]=71.327, $P<0.05$, $\eta^2=0.603$), were significantly different. This difference in math learning has been greater than in math retention. In other words, according to the partial eta squared coefficient (η^2), the effect of game software and educational entertainment on mathematical learning in students (0.696) was more than mathematical retention (0.603).

Discussion

This study was conducted to investigate the effective role of MES on the process of learning and retention in the classroom environment. Based on results, the CTP/ MES significantly affect the learning and teaching mathematics than mathematical retention in fourth-grade elementary students in Mashhad City. Therefore, the main hypothesis of this research was that:

Table 3. Levene’s test statistics (equality of variances) and Kolmogorov-Smirnov test (normal data distribution)

Test Statistics	Levene’s Test				Kolmogorov-Smirnov Test	
	F	df1	df2	P	Z	P
Learning	0.021	1	48	0.885	0.949	0.329
Retention	0.992	1	48	0.324	0.944	0.335

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Table 4. MANCOVA test results to investigate the effect of educational and entertainment software on mathematical learning and retention

Effect	Test	Value	F	Hypothesis df	Error df	P	η^2
Group	Pillai's trace	0.7	53.666	2	46	0.001	0.7
	Wilks' Lambda	0.3	53.666	2	46	0.001	0.7

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Table 5. MANCOVA test results for comparison of math learning and retention post-test in control and test groups

Effect	Dependent Variable	Sum of Squares	df	Mean Square	F	P	η^2
Group	Learning	83.04	1	83.04	107.783	0.001	0.696
	Retention	48.061	1	48.061	71.327	0.001	0.603

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The use of the CTP has an impact on the process of learning and retention of mathematical concepts in the fourth-grade elementary school environment.

The results of MANCOVA showed that the CTP significantly affects the mathematical learning and retention. A comparison of the obtained results showed that the two groups of control and experiment in the post-test of mathematical learning and retention were significantly different and this difference was more in mathematical learning (0.696) than mathematical retention (0.603). These results are consistent with the results of [Denbel \(2014\)](#), [Kondratieva \(2013\)](#), [Atiyah et al. \(2015\)](#), [Lesani et al. \(2017\)](#), [Hraste et al. \(2018\)](#), [Baig and Yadegaridehkordi. \(2023\)](#), [Criollo-C et al. \(2023\)](#), and [Akintayo et al. \(2024\)](#).

Explaining this hypothesis, it can be said that today, due to the influence of CTP in all aspects of life, other traditional methods of teaching based on lectures and retention cannot provide the requirements of students in the present society. Considering that the use of audio-visual tools can affect the central knowledge, creativity, and meaning of concepts in students, the effect of the CTP on learning and memorizing mathematics lessons among fourth-grade elementary students can be justified. Because this software has audio and video capabilities which students watch as a game. The CTP causes the student to develop visual and auditory skills and strengthen spatial and software comprehension to represent visual interaction and to argue concepts and mathematical skills. As a result, the learning rate is improved, and with the help of creative school games and math software, the motivation and interest to learn math, which is a boring

and inflexible lesson, increases, and the learning rate increases. Capabilities are not learned in educational settings; rather, they are acquired through adequate practice in various situations. However, the best way to acquire and maintain capabilities, especially in subjects, such as math, which are difficult for students, is to combine the knowledge, attitudes, and skills that give students experience in the environment. As a game and entertainment software, CTP provides background education through which the student's attitude towards mathematics is affected, and with better learning of this course and related concepts, the rate of retention of lessons is also affected. Students will be able to memorize math topics learned through the CTP for longer.

Conclusion

This study investigated the effectiveness of MES in the process of learning and teaching in the classroom environment. Based on the results, the teachers' teaching method causes students to be interested in learning and doing homework, which is confirmed by other studies. In addition, students who study in environments rich in teaching aids are more likely to succeed. Therefore, the use of these tools has made teaching better and deeper. Therefore, the use of educational technology increases the student's attention to learning.

Instructional technology can be considered as education technology. If teachers are well trained, this method changes the speed and retention of learning in the mind. The results show that when using a computer and learning through educational software, learners' attention is drawn to the computer screen instead of the classroom,

teacher, and other classmates, and this leads to concentration and thinking, and ultimately, better reaction. And the faster they are the better they learn. Therefore, students cannot be expected to achieve a high level of learning in classes where modern teaching tools and equipment are not used and have a boring environment due to the use of traditional teaching methods. In such classes, students are left without interest in the lesson. It can be concluded that with the advancement of fundamentals of education, the implication of educational software has proved more favorable effects than traditional systems in education and has a higher success rate.

Limitations and further research

Because this study was conducted in a specific statistical community, care should be taken in generalizing the results to other statistical populations. Also, according to the research conducted during the school closure period, coordination with families to hold educational classes and the general process of conducting the study was prolonged and was associated with difficulties.

The practical benefits of research

Implementing educational software provides an opportunity for better understanding, therefore you should think of measures and maximize the rate of learning in schools. It is recommended that all schools be equipped with appropriate teaching tools and that teachers who use educational technology be encouraged. In this regard, the Ministry of Education should adopt policies so that teachers are interested in using educational technology in teaching. In primary schools, the necessary facilities, equipment, and infrastructure should be created for the use of teaching aids, and necessary investments in this field to facilitate the use of this software in the educational process for teachers (extensive intelligence schools).

Originality/value

The current research showed the importance and application of MET in the learning and retention process.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if de-

sired, the research results would be available to them. A written consent has been obtained from the subjects. Principles of the Helsinki Convention was also observed

Funding

The paper was extracted from the master's thesis of Khadije Fadaei Moghadam, approved by the Department of Health Psychology, Faculty of Psychology, **Taybad Branch, Islamic Azad University, Taybad, Iran.**

Authors' contributions

Conceptualization and supervision: Khadije Fadaei Moghadam, and Majid Reza Razavi; Methodology: Majid Reza Razavi; Investigation and writing: All authors.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors consider it necessary to thank the all fourth-grade female students in the elementary school year of 2020-2021 in Mashhad and all the people who helped in conducting this research.

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