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Computer Games: Potential Opportunities for Educating Master's Students at Iranian Universities

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Abstract

The purpose of this study was to determine the potential power of teaching using urban simulation software such as the SimCity computer game (SC4), for educating master's students at Iranian Universities. This quasi-experimental study was conducted considering two groups: one control group and one experimental group, including a pre-test and a post-test design. The sample of the study consisted of 60 students of three public universities of Art (Tehran, Isfahan, and Yazd) in 2017-2018pThirty master's students in urban planning and urban design were selected from the population using a random sampling method, and were randomly divided into two groups: one experimental group and one control group (30 participants in each). The pre-test and the post-test included the Torrance test in creativity with Abedi's questionnaire and the open-ended and close-ended "workshop course learning skills" questionnaires were distributed in both groups. The experimental group was trained by the SimCity computer game, while the control group received normal classroom training. The pre-test and post-test results were analyzed using the IBM SPSS, and the inferential statistics in the form of the Pearson correlation, the Analysis of Covariance (ANCOVA), and independent samples t-test were investigated. Findings showed that the SimCity positively improved the participants' skills of learning workshop courses in the aforesaid fields, and increased their overall scores. Regarding the components of the learning skills in this course, it improved problem-solving and the planning skills of the students. However, the status of these components did not considerably improve the creativity and systems thinking of postgraduate students.

Keywords: Creativity, learning tools, serious games, SimCity, urban simulation

Introduction[#]

Once upon a time, mankind's interest in experimenting and education would be sparked after hearing stories. The ancient Persian literature and the sweet Persian language have survived on the stories in Shahnameh, which have entertained people in the post-Islamic eras. Shakespeare's "to be or not to be" was interwoven with popular entertainment. At that time no one knew it was a serious game that was inadvertently fostering the tree of knowledge. Creative thinking, optimal learning, teaching technologies, and educational computer games (such as SimCity) are the century's challenges to the researchers in different fields, influencing the prospect of human life. In today's world, due to complex and dynamic daily experiences, conventional approaches to find solutions to existing educational problems become ineffective and the need to implement new approaches is being felt more than ever (Ogheneakoke, et al., 2019). One of the appropriate solutions that is being used more and more to increase the efficiency of the educational system and overcome many issues and challenges in this system, is information technology in the context of educational environments. The rapid development of information technology in our age creates new opportunities in every aspect of our lives. The use of information technology in educational environments has become an important element in creating enriched learning environments (Alkan & Mertol, 2019). The correct application and effective use of these

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technologies in educational environments have led to the emergence of technologies in schools as tools to make significant changes in learning outcomes (Pauline Graf & Mendel, 2019), and to become integral parts of the workplace and classroom (Abili, et al., 2018). The reason for the appropriateness of this approach in the educational system towards educational technology can be attributed mostly to its potential in reducing expenditures, increasing productivity, and overcoming limited resources through its virtual applications such as servers, storage devices, and networks (Abdel Maksoud, 2018). On the other hand, E-learning has accomplished many educational goals such as learning in any place and time, participatory learning, self-assessment, and self-strategy (Sarboland, 2019). Human beings' scientific advances and achievements have also produced a large volume of information and knowledge, while the rapid changes and continuous advances made by humans in different scientific fields have been the major causes of the instability of knowledge and the resulting knowledge boom and the outdated information (Zeynouldini Meymand, 2011). Mallon (2018) was among the very first researchers to study digital games and their potential for involving students more than the routine classroom activities. Butler, Forsit, and Millis (2013) analyzed the application of games to different levels of knowledge. Their findings mirrored the higher effectiveness of learning that is based on educational computer games and technology. Hence, the present research is an attempt to encourage the higher education system to use educational games. The other goals are to bridge the gap in the learning system on the higher education level (i.e., postgraduate education) in assessing the effect of educational computer games on the creativity and learning skills of students in master's programs.

Creativity refers to the talent for divergent thinking, involving in novel and genuine thoughts, and renouncing conventional beliefs (Amini, 2010). Clifford (1962) refers to the difference between divergent and convergent thinking in his mental structural theory and introduces divergent thinking as the key to creativity. He also describes divergent thinking with the following three characteristics: flexibility, fluency, and originality (Sa'atchi & Kamkari, 2010).

Digital game is defined as a system wherein players have predetermined artificial encounters according to rules, outcomes, and measureable outputs. According to the game system, a digital game involves technologies, simulations, augmented realities, and traditional video games (Salen & Zimmerman, 2004). SimCity educational-entertaining game is a computer simulation of urban management, urban engineering, and urban planning. This game was designed by Maxis Company, a subsidiary of Electronic Arts. Will Wright, one of the well-known designers of computer games, came up with the basic idea of this game (Maxis, 2001). Problem-solving skill: The SimCity simulation game was designed based on a series of problems that needed to be solved. This process is called problem-based learning (Hung, 2002). Systems thinking: Based on Shawn's theory (2003), technological, theoretical, and social systems come into existence through their mutual effects. Changing one system triggers changes in another, while the understanding of these effects is known as systems thinking. Professional planning skill: It is a learning outcome whereby learners manifest their abilities to acquire knowledge and learn rules or a general skill of a certain activity (Garris, & Ahlers, 2002). Teaching: A creative action based on theoretical knowledge that varies by teacher, course, and student type. Teaching is an interpersonal interactive activity based on verbal communication, learning, or changes in the behavior of one or several students (Gage, 2016).

The research of Momeni Mahmouei et al. (2012) entitled, "The effect of software (WikiNiki) on the level of creativity and academic achievement of mathematics" showed the positive effect of this software on the level of creativity among fifth-grade students. The results of Sattari and Mohammadi's (2011) research on the relationship between the use of information technology and educational success of high school students showed that there is a significant relationship between the use of information technology and educational success and its components (including critical thinking, creativity, self-discipline, optimal homework, encouraging students to use electronic devices, inclination to the classroom).

Also, the results of Zamani and Kardan (2010) entitled, "The effect of the use of information and communication technology on learning mathematics" showed that the use of information and communication technology in changing attitudes, stabilization and stability of course materials, reasoning skills and the power of creativity, and finally the active learning of math lessons is effective. Farhoudi (2008) in a study examined the effect of using computer educational games on increasing the creativity of third-grade elementary school children. He presented a computer educational game (I Spy, Treasure Hunt) to 40 students and by performing pre-test and post-test stages, measured the dimensions of creativity and observed that by playing this game, two

factors of originality and flexibility increased. However, the two dimensions of fluidity and expansion did not change. Asadi (2008) believed that computer games cause children to explore and search, and this promotes memory and concentration. In most games, children choose different options in their play environment, such as commanding, guiding, searching carefully, and exploring, most of which involve discussion, conversation, anticipation, keyboard decisions, etc. Exercises promote creative factors, including Expansion (talent for attention to detail), Originality (talent for innovative, unusual and fresh ideas), Flexibility (talent for generating ideas, or very different methods), and Fluidity (talent for generating abundant ideas). The research study conducted by Jackson et al. (2012) showed that sharing and interacting with video games increases children's creativity and ingenuity. This research was originally designed to test the relationship between technology users and creativity. But only video games were shown to have a significant impact on creativity in boys and girls. Other technologies such as smartphones, computers, and the Internet have not shown similar results. The test was performed on a sample of 491 12-year-old children in Michigan. In (2001), Colin T. McCarthy conducted a study entitled, "The impact of computer simulation games on learning and teaching, intelligence and creativity", and concluded that the use of computer simulation games on the learning and teaching of high school students is somehow effective, but does not affect students' intelligence. He also found that these games affect students' creativity in two dimensions: fluidity and flexibility.

Computer games: Learners that participated in the current study belong to another generation that is surrounded by computers, computer games, video cameras, cell phones, and other digital devices and tools. This new generation could be called the "network generation", the "digital generation", or the "digital natives" generation (Doran, 2012). Digital games are known as gameplay in this generation. Thomas H. Epperly (2008) wrote in his book, "Gameplay is the interaction with a computer game according to its rules. It refers to the relationship between a player and a game and the acts of competing with and defeating the rivals, plotting, and communicating with the game". The development of gameplay started in 1980 within the video framework or the framework of the computer games. Computer or video games are forms of interactive entertainment controlled by an electronic device equipped with a processor or microcontroller. Many computer games are also considered to be video games because of generating animated pictures displayed on a TV or a computer screen. The audience of computer games has grown drastically in quantity in recent years and these games are currently among the most popular forms of entertainment. Computer games have grown since 1980, and have evolved into the key form of entertainment in the 21st century. Despite the 2008 recession, the computer games industry (including hardware and software parts) has earned a profit of 49.9 million dollars on a yearly basis (Hjorth, 2011). Kryzwinska and King (2017) classified computer games into the simulation, strategic, action, and role-play categories, and assert that strategic games have the minimum cinematic associations among all these genres. In an article titled, "Challenge Everything?", Maaike Lauwaert (2013) stated that, "Simulation games became famous when they evolved into computer games.

When SimCity was introduced in 1989 as the first simulation game, the development of simulation games started. Will Wright and his associate Jeff Braun created the first version of SimCity when they founded their company Maxis (which was purchased by Electronic Arts in 1997). This game proved to be a huge success, and thus the sequels to the first version including *SimCity 2000* (1993), SimCity 3000 (1997), *SimCity 3000* Unlimited (1999), *SimCity 4000* (2003), and *SimCity 4: Rush Hour* (2003) (both titles are currently given to *SimCity 4 (SC4)*) were created. This game is one of the first and biggest strategic simulation games on the market (the goal is to design and build a sustainable developing city). The players determine the land use (i.e. residential, industrial, or commercial), and they have to face problems such as pollution, crime, waste management, and transportation as the mayors of their cities. They control different components of an urban system by building a city and contributing to the survival of a dynamic system. This process mirrors the direct associations among economics, mathematics, and sciences because all the charts, tables, and other items are provided to the user.

SimCity mainly involves strategic activities. Particularly in *SC4*, the players must collect information from several screens and grade them to influence an ongoing progression process. The players must manipulate the simulation as they move forward to obtain the best result with maximum efficiency. The players must analyze the information, contemplate, and plan all situations faced on a daily basis by planners. These situations include population growth, population density, housing shortage, improvements in infrastructure, lack of public open spaces, greenhouse effects, and the shortage of health and educational

services. Those professors of geography, urban planning, and sociology that used SimCity in their classrooms realized that the students are highly motivated to play this game due to its game-like features. In addition, they adopted an educational approach to the role of urban planners, designers, and policy makers. *SimCity* is a game designed to provide a quick and effective view of the basic principles of urban planning to the user (Wilson, 1990).

Teaching with the aid of simulated computer games such as SimCity is a method of empowerment that sets the scene for problem-based learning. This computer game provides an active decision-making environment to enable the learner to pursue the following three educational goals: systems thinking, problem-solving skill, and craft (Gaber, 2013). The key to SimCity is the interaction between private lands and the state budget (Starr, 2003). The objectives and hypotheses of this study include demonstrating creativity by teaching computer games to senior students majoring in urban planning and urban design, and investigating the effect of the Sim City urban simulator game on learning urban planning and urban design workshop lessons**.** Hypothesis 1: The SimCity is an educational game that fosters master's students' creativity in urban planning and urban design**.** Hypothesis 2: The SimCity educational game improves the essential skills of workshop courses in the students of urban planning and urban design**.**

Method

This study was a quasi-experimental study which was performed in two groups (one control group and one experimental group) with a pre-test and post-test design**.**

Participants

The statistical population consisted of master's students in urban engineering at three public Iranian universities, namely Tehran, Isfahan, and Yazd universities of Art. Due to educational limitations, each university allocated two classes to the researcher, and thus the research had access to a total of six classes. The research samples were collected from the students in these six classes.

Instruments

A questionnaire, which was developed according to Abedi's scale based on Torrance Test of Creative Thinking (TTCT), was used to measure students' creativity. The original version of this test consisted of 75 questions. The highest score on Abedi's Creativity Scale is 120, and it consists of four subscales: 1) fluency (questions 1 to 22), or the talent of coming up with numerous ideas; 2) elaboration (questions 23 to 33) or the talent of paying attention to details; 3) originality (questions 34 to 49), or the talent of coming up with novel unconventional ideas; and 4) flexibility (questions 50 to 60) or the talent of coming up with various ideas or methods. Afterwards, a 4-item researcher-made test was carried out within an hour. The first two questions assessed the systems thinking (with a score of 10), the third question assessed the problem-solving skill (with a score of 5), and the last question assessed the planning skill (with a score of 5).

To test the validity of the researcher-made test of essential skills for workshop courses, the test questions were listed and were sent to five experienced professors of urban planning and urban design teaching in master's programs, and they were asked to express their opinion based on a four-point Likert scale (completely inappropriate, partly inappropriate, appropriate, and completely appropriate) on the questions about the six workshops. Next, using the expected value formula or numerical sigma, the resulting fitness or validity of the test was found to be 0.85, which is acceptable. The equivalent forms reliability method was used to assess the reliability of the researcher-made questionnaire because the questions in this test are analytical questions that may remain on the mind of the respondents and affect their scores the second time.

To determine reliability, the correlation of the scores earned by the participants (N=30) on the first test with the first form, and their scores on the second test with the second form was calculated using the Pearson correlation coefficient formula. The resulting coefficient, which shows the reliability of the test, was calculated to be 0.97. During the data analysis, after calculating the raw scores in the creativity test (by conducting the pretest at the beginning of the academic term and the posttest at the end of the term) and the classroom scores of the students (at the end of the term), the pretest and posttest scores in the creativity test (originality or original thinking, elaboration, flexibility, and fluency of thought) and the essential workshop skills of the experimental and control groups were described using the measures of central tendency and dispersion (i.e., mean, standard deviation), as well as the box plots on the descriptive statistics level in SPSS. Then, to determine the effect of the SimCity educational game on the creativity and essential skills of the aforesaid course on the level of inferential statistics, the analysis of covariance (ANCOVA) and the independent samples t-test were performed.

Procedure

The research phases are as follows: 1. selecting and assigning the participants into two groups using the random distribution method; 2. selecting one group as the control group and another group as the experimental group using the random distribution method; 3. assessing the creativity of the students in urban planning and urban design (as the dependent variable) in both groups prior to the experiment; 4. making changes to the experimental group through the independent variable (i.e., teaching with the aid of SimCity educational game). SimCity is a city-building and urban planning simulation that is mostly multi-player and online, and has been developed by Maxis Emeryville and published by Electronic Arts (Phillips, 2012). Players can create a settlement that can grow into a city by zoning land for residential, commercial, or industrial development, as well as building and maintaining public services, transportation, and utilities (Mallory, 2012). 5. re-assessing creativity as the dependent variable in each group; 6. assessing the academic skills, namely systems thinking, problem-solving skills, and professional planning skills in each group (control and experimental); 7. conducting a statistical comparison between the scores of the participants in both groups in the pretest and posttest phases (i.e., creativity test); 8. conducting a statistical comparison between the total classroom scores of the students and their systems thinking, problem-solving, and professional planning skill scores in both groups (control and experimental).

Findings

The results of the descriptive statistics of this research have been presented as follows.

Table 1.
Definition of Frequency of Respondents' Gender

Gender	Frequency	Percentage	Average	Variance
Female	50	83.3		
Male	10	16.7	1.17	0.376
Total	60	100		

According to (Table 1), the number of women participating in the workshop was 50 equivalent (83.3%), the number of men was 10 equivalent (16.7%), the mean (17.1) and the variance (0.376).

Table 2.
Definition of Frequency of Respondents' Gender

Age	Frequency	Percentage	Average	Variance
-30	46	76.7		
+30	14	23.3	1.23	0.427
Total	60	100		

According to (Table 2), the number of people in the age group under 30 was 46 (76.7%), the number of people in the age group 30 years and above was 14 (23.3%), and the mean and variance were 1.23 and 0.427, respectively.

Hypothesis 1: SimCity is an educational game that fosters creativity among the students of urban planning and urban design in master's degrees. In the experimental group (30 participants), the mean score of creativity before playing the educational game (i.e., the pretest) and after playing the educational game (i.e., the posttest) were 136.63 and 139.40, respectively. In the control group (30 participants), the mean score of creativity the first time (i.e., the pretest) and the second time (i.e., the posttest) of playing the game were 134.53 and 137.90, respectively (Table 3). The effect of the SimCity educational game on creativity was studied using the covariance analysis method. Before drawing any statistical inference about the effects of the game, the normality of error distribution was tested using the Kolmogorov-Smirnov test, and the equality of the error variances of the two groups was investigated using Levene's test to assess the validity of the statistical model (Table 4). Since the calculated p-value in both tests was not lower than the 0.05 significance level, the assumption about the normality of distribution of the error of creativity score and the equality of the error variances of the two

groups was not rejected, and thus the statistical model F had not been violated. In addition, since the calculated p-value (0.800) was not below the significance level (i.e., 0.05) in the covariance analysis table (Table 5), the null hypothesis ($H_0 : \pi_1 \infty \pi_2$) was not rejected. In other words, the mean creativity score of the experimental group in the posttest was not significantly higher than that of the control group. Hence, SimCity educational game did not positively affect the creativity of the students. The effect of this game was only 0.001% considering the eta-squared coefficient. Therefore, it could not be stated that SimCity educational game improves creativity in the master's degree students of urban planning and urban design.

Table 3.
Descriptive Statistics on the Pretest and Posttest Scores

Time / Groups	pretest		Post-test	
	Average	**Standard deviation**	**Average**	**Standard deviation**
Test	136.63	10.92	139.40	11.25
Control	134.53	11.44	137.90	12.23

Table 4.
Levene's and Kolmogorov-Smirnov Tests for Assessing the Validity of the Analysis of Covariance Model

Kolmogorov-Smirnov tests	**Levene test**		
P	**Z**	**P**	**F**
0.964	0.500	0.690	0.160

Table 5.
The Analysis of Covariance of the Effect of SimCity Educational Game on Creativity

Source of change	**Sum of squares**	**Degree of freedom**	**Mean square**	**F**	**P**	**Eta-squared**
Pretest	963.848	1	963.848	7.799	0.007	0.120
Education	8.025	1	8.025	0.065	0.800	0.001
Error	7044.052	57	123.580	-	-	-

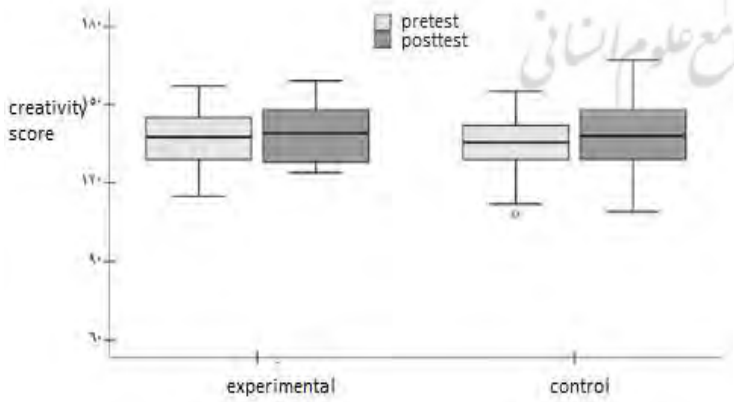

Diagram 1.
The Box Plot of the Distribution of the Pretest and Posttest Scores of Creativity in the Experimental and Control Groups

Hypothesis 2: SimCity educational game improves the essential skills of workshop courses among the students of urban planning and urban design in master's degrees. In the experimental group (30 participants) and the control group (30 participants), the mean score of the essential skills of workshop courses were 16.63 and 15.07, respectively (Table 6). The effect of SimCity educational game on the essential skills of the aforesaid courses was studied using the t-test procedure. Since the calculated p-value (0.003) provided in the table is smaller than the significance level (i.e., 0.05), the null hypothesis ($H_0 : \pi_1 \infty \pi_2$) was rejected on this level. In other words, the mean score of the learning skills in the experimental group was significantly higher than the control group. Hence, SimCity educational game improves the essential skills of workshop courses in the students of urban planning and urban design. Considering the eta-squared coefficient, the effect (improvement) was 0.127% (Table 7).

Table 6.
The Descriptive Statistics of the Scores on Essential Skills in the Experimental and Control Groups

Control group		**Experimental group**	
Standard deviation	**Mean**	**Standard deviation**	**Mean**
2.18	15.07	1.98	16.63

Table 7.
The Independent Samples T-test for Comparing the Scores

Mean difference	Standard deviation	Degree of freedom	t	P	Eta-squared
1.57	0.539	58	2.909	0.003	0.127

Hypothesis 2-A: SimCity educational game improves systems thinking in the students in urban planning and urban design. The mean scores of systems thinking in the experimental and control groups were 8.98 and 8.55, respectively. Moreover, the box plot depicts the distribution of the systems thinking scores of the experimental and control groups. The effect of SimCity educational game on systems thinking is analyzed using the t test. Since the calculated p-value in the test table is (0.101) and is not lower than the significance level 0.05, the null hypothesis ($H_0 : \pi_1 \infty \pi_2$) is not rejected on this level. In other words, the mean score of systems thinking in the experimental group is not significantly higher than the control group, and thus SimCity educational game does not improve systems thinking in the students in urban planning and urban design because the improvement is only 0.028% considering the eta-squared coefficient.

Hypothesis 2-B: The SimCity educational game improves the problem-solving skill in the students in urban planning and urban design. The mean scores of problem-solving skill in the experimental and control groups were 4.15 and 3.70, respectively. The effect of SimCity educational game on the problem-solving skill was analyzed using the t-test procedure. Since the calculated p-value listed in the test table (0.004) was lower than the significance level (i.e., 0.05), the null hypothesis ($H_0 : \pi_1 \infty \pi_2$) was rejected on this level. In other words, the mean score of the problem-solving skill in the experimental group was significantly higher than that of the control group. As a result, the SimCity educational game improved problem-solving skills in the students of urban planning and urban design because the improvement was only 0.117% considering the eta-squared coefficient.

Hypothesis 2-C: The SimCity educational game improves the professional planning skill in the students of urban planning and urban design. The mean score of professional planning in the experimental and control groups were 3.50 and 2.82, respectively. In addition, the box plot illustrates the distribution of the scores on professional planning in the experimental and control groups. The effect of the SimCity educational game on the professional planning skill was also analyzed using the t-test procedure. As seen in the test table, the calculated p-value is 0.008, which is lower than the significance level (i.e., 0.05). Hence, the null hypothesis ($H_0 : \pi_1 \infty \pi_2$) was rejected. In other words, the mean score on the professional planning skill in the experimental group was significantly higher than that of the control group. Hence, the SimCity educational game improved the professional planning skill in the students of urban

planning and urban design. The improvement was 0.0098% considering the eta-squared coefficient.

Discussion and Conclusion

Identifying creative people is not enough for fostering creativity; rather, it is important to know the development mechanism of creativity. The studies on creativity (e.g., Pirkhaefi, 1997) suggest that this ability starts to grow during the early years and it is stabilized during the high school years. However, if it grows during this period, its richness increases by the end of an individual's life. In fact, creativity always seeks refuge to grow from childhood to adolescence, and this precious research experience reveals the need for teaching creativity on different academic levels from elementary school to high school using scientific methods, and the need for respecting the creative abilities of students in different artistic, cultural, scientific, and sports fields. These creative abilities must be valued and fostered properly. All educational psychologists and specialists believe that creative abilities and divergent thinking styles can be taught to humans, especially children and adolescents (Seyf, 2004).

In this research study, the creativity of the students in the experimental group playing the educational game did not improve probably because the sample included the postgraduate students aged +22 whose creativity had been stabilized and was not influenced by the environmental stimuli. It is also concluded that the state-of-the-art technologies, especially learning technologies, can significantly serve student classes. As regards creativity, the results from this research study indicated that creativity probably grows more during the early years (from elementary school to high school) due to environmental stimuli, and the creativity improvement solutions are more effective at these ages. However, at higher ages, creativity is stabilized and the use of educational computer games proposed in this study does not influence creativity. More importantly, the students in the experimental group benefited less than the new generation from educational technologies in their pre-university years, and thus they were less familiar with computer games, which could be the cause of the smaller influence of this teaching method on them. The cyberspace technology, which has found its way into the educational environments for young students, is creating a generation who sees it as a platform for thinking, communicating, and learning, and will most probably respond better to the new learning-teaching methods in the postgraduate period. As suggested by similar studies, computer games positively influence children, improving their creativity. Therefore, it is recommended to use educational technologies and educational computer games from the elementary school stage to improve students' creativity. In addition, the short duration of education can be one of the determinants of the inadequate effect on the creativity of students. Evidently, increasing the improvement in creativity is a continuous long process that does not end within a short period of time. Finally, other solutions for improving creativity at higher ages must be studied in future research studies, and other researchers are recommended to analyze other solutions and study the effect of educational computer games on other age groups in other fields. Considering the essential learning skills of other courses, it is necessary to determine the categories influenced by educational computer games and to determine whether these games improve learning. Given the speed of technological advances in the educational system and their annual updates, it is recommended to carry out research on these systems within different periods of time to assess the effect of educational computer games on different generations.

Currently, we are faced with epidemics such as COVID 19, which have affected face-to-face training, and the need to provide alternative methods is felt more than ever, especially in practical courses of medicine, piloting, architecture, and urban planning that require close interaction of students with topics and practical courses as the basis of education. It seems that this problem can be tackled with the virtual educational simulators. Given the speed of technological advances in educational systems and current quarantine policies all over the world, it is recommended to conduct more research on these kinds of software that include entertainment in addition to educational purposes.

Some of the limitations of the study are as follows. The majority of students, especially in public universities, were very interested at the beginning of the course, but faced difficulties due to the pressure of the course, the number of courses, and intensive classes. Lack of cooperation in some universities to assign classes to teach SC4, in the short time of the semesters was another limitation in the study. Furthermore, professors and some students did not believe in teaching with such software.

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