

Research Article

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Impact of Computer Games on Learning Concepts in the Subject of Technology with ICT

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Abstract

Background/purpose. In the modernized society with advanced technology, as education becomes increasingly dependent on information technology, there is a need to prepare the next generation of students with a wide variety of skills and abilities necessary for future scientific careers. Modern educational challenges include the task of engaging students, stimulating their interests, and maintaining their attention. Computer games are an interactive technology that can promote learning in an effective and motivating way, especially among lower secondary school students. Computer game-based learning uses the game as a tool for elaborating learning content. Given this, the purpose of this scientific research is to examine the impact of this computer game on increasing motivation and increasing student success during the process of learning the concepts of integrated circuits, computer hardware, and software concepts.

Methodology. The methodology of this scientific research includes empirical research, where the chosen design is the quasi-experimental method to evaluate the causal impact of the intervention. A quantitative method was used to analyze this study in more detail. The sample consists of 458 students from 12 schools, with students in grade IX from the Republic of Kosovo. The sample was selected using the non-probability method, which is a purposive sample. The instruments for data collection are tests and questionnaires.

Results. The results of this study indicate that the use of computer games in the Technology subject with ICT has a positive impact on academic outcomes and student motivation.

Conclusion. The findings of this study indicate that the use of computer games in the teaching process has significantly improved the academic results of students in the experimental group compared to the control group.



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1. Introduction

Education reforms have undergone significant changes in recent years, both internationally and in Kosovo, particularly with the integration of technology into the teaching and learning process, aimed at improving teaching and enhancing learning outcomes. Therefore, this scientific paper provides a brief overview of some new technologies that can be used to enhance learning and motivate students to be more engaged in the learning process. The technologies discussed include computer games developed for desktops and portable devices.

The field of study for this research is learning the concepts of integrated circuits, computer hardware, and software concepts by playing computer games (learning games). The consideration of such a model affects student engagement, as one of the applications of new educational practices, and student motivation to learn (Duncan, 2020; Yurdaarmagan et al., 2015; Adipat, Laksana, Busayanon, Asawasowan, & Adipat, 2021). Educational computer games are based on the principles of learning, developmental psychology, and pedagogy to have the most effective application in the teaching and learning process. Learning through play is an interdisciplinary methodological approach to learning. Educational games promote learning motivation, enabling students to learn learning content more easily and actively (An & Bonk, 2018; Plass, Homer, & Kinzer, 2021). Teachers need to overcome reservations and several obstacles related to the use of game-based learning in the classroom to ensure the highest quality results. The educational game-based learning approach can be challenging, but additional support will be beneficial for both teachers and students. The use of technology in the teaching and learning process is integrated into all subjects and curricula, with a particular emphasis on the impact of computer games to help develop students' skills and abilities. It appears that game-based learning can have a profound impact on students and teachers, so teachers should support developers of educational games in introducing and planning innovations in the curriculum to implement digital competence (MASHT, 2016). In accordance with existing curricula, these games are intended as an additional asset, not a replacement for our existing learning environments. Therefore, in this context, there should be a greater focus on the design of educational computer games. Another advantage of computer games in education is the motivation of students to participate in the learning process actively. A study by Wang et al. (2022) found that ICT-based educational games increase students' motivation, helping them develop a positive attitude towards technology and improving their academic achievement (Wang, Chen, Hwang, & Guan, 2022).

The use of computer games in education has been viewed as an innovative approach that not only enhances student engagement and motivation but also helps develop critical and practical thinking skills essential for everyday life and the job market (Plass, Homer, & Kinzer, 2021). Computer games can create a rich environment in which students can develop complex problem-solving skills and acquire knowledge more interactively (Clark, Tanner-Smith, Killingsworth, & Bellamy, 2020).

Research shows that computer games can help develop a learning environment where students acquire knowledge naturally by experimenting, collaborating, and making independent decisions. Through simulations and real-life challenges, students can improve not only their conceptual understanding but also their practical skills, making them better prepared to apply their knowledge in real-world situations (Clark, Tanner-Smith, Killingsworth, & Bellamy, 2020).

Despite increased global interest in integrating digital game-based learning (DGBL) into school curricula, there is limited empirical evidence on its effectiveness within transitional education systems, such as Kosovo's. In particular, it remains unclear how educational computer games impact the learning of complex technological concepts—such as integrated circuits, hardware, and software—in lower secondary school students.

This study addresses this gap by applying a quasi-experimental design in a national context that has been underrepresented in the DGBL literature. It provides large-scale, quantitative data on how

game-based learning affects both academic outcomes and student motivation in the Technology with ICT subject. The research further adapts and applies the “ICT Game” within the national curriculum of Kosovo, offering a context-sensitive model for integrating educational games into formal instruction.

Furthermore, while existing studies largely examine motivational outcomes, this study also measures specific academic gains through pre- and post-intervention testing, enabling a more comprehensive evaluation of educational game effectiveness.

Therefore, the importance of this research extends beyond improving academic results and student motivation to learn, as it also has a parallel impact on the development of soft skills, such as collaboration, communication, and conflict resolution in groups (Ritzhaupt & Higgins, 2020). This is particularly important in areas such as ICT, where technical skills must be matched with teamwork and project management skills (Ke & Xie, 2021). Teachers, by understanding these aspects, can choose activities that are not only creative but also adapted to develop these skills in an integrated way. This new pedagogical approach fosters a more interactive and engaging environment, enabling students to explore complex concepts through practical and simulation-based experiences (Clark, Tanner-Smith, Killingsworth, & Bellamy, 2020). Furthermore, computer games in education are effective in acquiring skills important for careers and professional life, such as digital skills and entrepreneurship, thereby helping to prepare students for the 21st-century labor market (Ke & Xie, 2021; Liang, Lau, Jiang, & Maddison, 2020). Computer games not only help in acquiring technical knowledge but also in developing cross-curricular skills, such as creativity, critical thinking, and problem-solving skills in a more in-depth and comprehensive way (Stieglitz, Lattemann, & Brockmann, 2021).

On the other hand, motivating students to learn is a growing focus these days due to the decline in student motivation. This research studies this phenomenon, exploring how computer games can be used to motivate students in lessons related to Technology with ICT.

This study presents an original contribution, addressing the identified research problems. This research study aims to serve as a guide to the use of contemporary methods in teaching and learning by integrating and applying computer games in activities and the learning process. Computer games have the potential to have a long-term impact on student outcomes, as they are developed for a social environment that aligns with contemporary trends in teaching methods. This study adds a new dimension to the existing scientific literature on the use of computer games in this subject. With the analyses based on the collected data and the assessment of the impact of games, the study presents strong arguments for their integration as an effective teaching tool. Furthermore, this study contributes to the design of necessary changes and reforms at the educational level. Internationally, this research will be a significant contribution to the scientific literature, providing empirical data from a country in transition. The study will contribute to improving the current situation in our country in terms of fulfilling the digital competencies of the Kosovo curriculum framework. The use of computer games in learning concepts from this field through fun activities can be a powerful tool for transforming learning. This study has the potential to contribute to our teaching approaches and adapt learning experiences to meet the needs of all students.

Despite the increasing use of educational technologies, there is a limited amount of empirical research in transitional education systems, such as Kosovo's, that examines the direct impact of digital game-based learning on students' academic performance and motivation. This study addresses this gap by evaluating how integrating a custom-designed ICT Game affects learning outcomes and engagement. Unlike previous studies, this research provides large-scale experimental data from Kosovo's public education system.

2. Literature Review

In recent years, it has been emphasized that the conventional approach to teaching does not adequately address the social, emotional, mental, and motivational needs of the younger generation. Nowadays, children are frequent users of games and digital applications. The popularity of computer games among the younger generation has sparked the interest of the educational community, with many researchers seeking various approaches to incorporating computer games into the classroom environment (Li, Xu, Hao, Xiao, & Liu, 2022).

Digital Game-Based Learning (DGBL) is an educational approach that utilizes digital games to integrate learning content with game elements, thereby creating an interactive and engaging experience for learners. This method aims to foster engagement, motivation, and improve knowledge acquisition through active interaction, rewards, and structured challenges within the game. DGBL is based on the theory of game-based learning, where players solve complex problems and apply practical skills in a controlled and often simulated environment (Boyle et al., 2016; Wouters et al., 2013).

Therefore, the main motivation for using this approach is that game-based learning combines learning with elements of a game to create an engaging experience. The integration of theories in digital game-based learning often incorporates elements from constructivist, cognitivist, and behaviorist theories, resulting in a diverse learning experience. Behaviorist strategies, such as rewards and reinforcements, can be used to maintain motivation and focus, while cognitivist approaches ensure that students understand and apply the concepts involved in the game. Constructivist elements allow students to construct their knowledge through exploration and interaction within the game world. By integrating these theories, digital game-based learning offers a comprehensive and balanced learning experience that addresses various aspects of the learning process (Anderson & Krathwohl, 2020).

By adopting game-based learning, organizations can utilize technology to facilitate a modern version of experiential learning, enabling students to master some of the challenges of learning in the 21st century. Game-based learning harnesses the imagination of an adult learner by creating a world to explore that motivates them to repeat challenges, achieve learning outcomes, reflect on the experience, and create new knowledge through the transformation of the game experience. It is suggested that experiential learning can be used as a theoretical basis for game-based learning. The ultimate goal of game design for game-based learning is to create engaging experiences for students. Experiences are the result of the interaction between the current situation and past experiences. This is one of the principles of game-based learning design (Odendaal, 2018).

The study by Jong, Lai, Hsia, and Lin (2013) demonstrates that computer games facilitate peer association through a competitive-cooperative learning style and effectively integrate game content with course material (Jong, Lai, Hsia, & Lin, 2013). The two games, BattleThreads and Process State, have been evaluated for their effectiveness, providing some insights into what makes a good classroom game for teaching operating systems concepts and how existing games can be improved (Hill, Ray, Blair, & Carver, 2003). Meanwhile, Malone and Lepper (2022) examined the factors of intrinsic motivation for learning and constructed a taxonomy of these factors. They found that educational games that are designed to be fun and engaging can increase students' intrinsic motivation, helping them become more engaged in the learning process (Malone & Lepper, 2022).

Charlier, Ott, Remmele, and Whitton (2021) found that learning-based games are not limited to children but can also be beneficial for adults. Their study demonstrated that educational games can help adults acquire new concepts and develop new skills, thereby creating engaging and motivating experiences for this age group. (Charlier, Ott, Remmele, & Whitton, 2021). Clark, Tanner-Smith, Killingsworth, and Bellamy (2020) conducted a systematic review and meta-analysis of the impact of digital games and their design on learning. They found that digital games have a positive impact on

student engagement, motivation, and learning outcomes. Their meta-analysis provided strong evidence for the effectiveness of digital games in education (Clark, Tanner-Smith, Killingsworth, & Bellamy, 2020).

On the other hand, according to author Despeisse (2018), it is clear that technology education faces the challenging task of equipping the new generation of technologists with skills and knowledge that go beyond the traditional focus on technical subjects. New technological developments in the industry and societal challenges have obvious implications for the content of educational programs. This is especially true in science, technology, engineering, and mathematics (STEM) education, which must keep pace to ensure that the next generation of engineers can meet the future industry's needs. The author emphasizes that most universities also have computer labs, design studios, workshops, robotics labs, and other high-tech equipment to provide a more applied learning experience (such as problem-based learning or industry projects). This study by the author examines alternative teaching methods and presents the theoretical foundations for incorporating computer games into engineering education (Despeisse, 2018). It is essential that the learning of concepts is not limited to a theoretical aspect, but rather is achieved through a theoretical-practical interweaving, which can be facilitated through games and computer simulations.

Computer games have had a significant impact on students' academic performance, sparking considerable debate among students and teachers about their positive or negative effects. One of the primary ways computer games impact academic performance is by enhancing student engagement. Several studies have demonstrated that the use of digital educational games can enhance student engagement, resulting in improved academic performance. According to Partovi and Razavi (2019), educational computer games have been successfully used to increase students' academic engagement in primary schools, thus improving their academic performance (Partovi & Razavi, 2019).

While numerous studies report positive outcomes from digital games in education (Clark et al., 2020), some researchers caution against over-reliance on them, citing issues of distraction and superficial engagement (Despeisse, 2018). Furthermore, few studies have explored how such games perform in post-socialist education systems or addressed curriculum alignment. This study addresses these gaps by integrating a game specifically designed for the Kosovar curriculum.

3. Methodology

The methodology of this scientific paper includes empirical research with students on how much they have been motivated and achieved higher results in the Technology with ICT subject by integrating computer games. The research includes an empirical analysis of the achievement of learning outcomes of lower secondary school students from the Technology with ICT subject. The chosen design is the quasi-experimental method to assess the causal impact of the intervention. This design has also been used by the authors Liang, Lau, Jiang, and Maddison (2020), Hamari et al. (2016), and Alf, Wijse, and Trautwein (2023) in this context. As Liang, Lau, Jiang, & Maddison (2020), Hamari et al. (2016), Alf & deWijse (2023), and Liang et al. (2020) point out, the use of the quasi-experimental method in the ICT subject allows for a clearer assessment of the impact of pedagogical changes, such as the integration of computer games, on student achievement (Liang J., Lau, Jiang, & Maddison, 2020). The current study aims to follow this research tradition by applying the quasi-experimental method to a group of lower secondary school students to measure the effect of computer games on their motivation and academic outcomes. This method involves selecting an experimental group that receives the intervention (integration of computer games into learning) and a control group that continues to follow traditional teaching methodologies. As suggested by Hamari et al. (2016), this type of design facilitates the creation of a robust framework for analyzing the various impacts of new technologies on education (Hamari, Koivisto, & Sarsa, 2016).

A quantitative approach was used to analyze this study in more detail. The quantitative approach of this study aimed to uncover trends in student achievement and attitudes regarding the integration of computer games into the learning process. These analyses rely on data collected through structured tests and assessments of student performance, thus creating a strong basis for drawing statistical conclusions. As Alf et al. (2023) also mention, quantitative approaches are crucial for ensuring that the data collected is interpreted in a manner that supports the overall conclusions of the study (Alf, Wijse, & Trautwein, 2023).

3.1. Purpose of the study

This study is linked to previous research from recent years around the world, as positive perceptions of student learning and engagement while using computer games have been confirmed by various independent studies over the years (Schindler, Burkholder, Morad, & Marsh, 2017; Papadakis, 2018; Simões, Oliveira, & Nunes, 2022).

Therefore, the purpose of the scientific research is to examine the impact of this computer game on increasing motivation and student success during the learning process. Of particular importance are the students' perceptions regarding the integration of this game into the Technology with ICT subject in the Life and Work curriculum area.

3.2. Research questions and hypotheses

Main question and hypothesis:

How much do computer games affect the learning of the concepts of integrated circuits, hardware, and software in the Technology with ICT subject in the Life and Work curriculum area?

Hypothesis 1: Learning based on computer games affects the learning of the concepts of integrated circuits, hardware, and software in the subject of Technology with ICT in the curriculum area of Life and Work

Question and supporting hypothesis:

What are the differences in the learning outcomes of students in the control group compared to the experimental group in achieving results for integrated circuits, hardware, and software?

Hypothesis 2: There are statistically significant differences in the learning outcomes of students in the experimental group compared to the control group.

3.3. Population and sample

The population of this research comprises lower secondary school students in Kosovo, with a particular focus on grade 9 students, totaling approximately 22,100 students. This age group was chosen due to the importance of the educational period in the development of their technological skills and learning through computer games. In Kosovo, lower secondary schools constitute a critical phase in the education system, where students begin to explore technology and digital skills in depth, which will accompany them in their further educational and professional development.

The sample for this research is represented by approximately 458 students, who were selected from 12 lower secondary schools in Kosovo. This number was considered sufficient to provide valid statistical data and to enable a reliable analysis of the impact of the intervention. The selection of schools was made to represent a diversity of educational settings, including schools with different profiles and pedagogical challenges, to ensure that the results of the study are generalizable to a wider population of students of this age group in Kosovo. The sampling method was non-probability, with a purposive approach. This method was used to ensure a selection of students who are suitable for the specific purposes of the study, including the willingness of schools to integrate computer games into their curriculum and the willingness of teachers to cooperate in this initiative.

3.4. Research instruments

Within the framework of this research, two instruments were used to collect quantitative data, including knowledge tests and questionnaires. These instruments were designed to collect reliable and valid data that enable a detailed analysis of the impact of integrating the "ICT Game" into the teaching and learning process in the subject of Technology with ICT.

Quantitative data were collected from the results of knowledge tests and the students' responses to the questionnaire. The quantitative approach helps to assess the understanding and learning of the concepts investigated through knowledge tests, according to the scores obtained by the students and the answers to the questionnaire questions, to determine the students' perceptions regarding the motivation to learn by playing computer games.

The knowledge tests were carefully prepared to assess the impact of the computer game on the understanding and acquisition of important concepts by students. During the preparation of the tests, questions and problems are foreseen to be from different levels, such as memorization and conceptual design, according to Bloom's taxonomy, which will fulfill the learning outcomes for the subject of Technology with ICT (RNL) in the curriculum area Life and Work.

Also, the questionnaire used in this study was the Academic Motivation Scale (AMS), which is a standardized instrument for measuring students' academic motivation (Vallerand et al., 1992) and provided us with quantitative data. Based on the structure of the "Academic Motivation Scale (AMS)" and adapting it to the context of our study on the impact of computer games on learning and motivation in the Technology with ICT subject, we have formulated an adapted questionnaire of 20 questions. The questions are divided into three categories: Intrinsic motivation, extrinsic motivation, and amotivation.

3.5. Action plan

The action plan was also planned to be developed in several phases. The research lasted for some time as it was planned to explain the selected learning units in the Technology with ICT subject, about 6-8 teaching hours. The action plan focused on the use of the "ICT Game" among the students of the experimental group. These interventions were used to introduce practical concepts learned through computer games. The research analyzed the impact of the independent variable, which was the computer game, on the dependent variable, which was the students' success in learning and motivation. The variables were controlled, which means that both groups are equivalent in terms of knowledge and level of learning.

The first phase of the action plan included the assessment of students' initial knowledge through a pre-test, which served as a basis for comparing the knowledge of the experimental group and the control group before the computer game intervention. The second phase consisted of implementing the main intervention of the action plan, where selected learning concepts were addressed through computer games with the experimental group, while the control group continued with the traditional teaching methodology. The third phase included testing the hypotheses put forward regarding improving learning outcomes and student motivation through the use of the "ICT Game". The final phase involved reflecting on and summarizing the results of the action plan, with a focus on the impact of computer games on learning and student motivation.

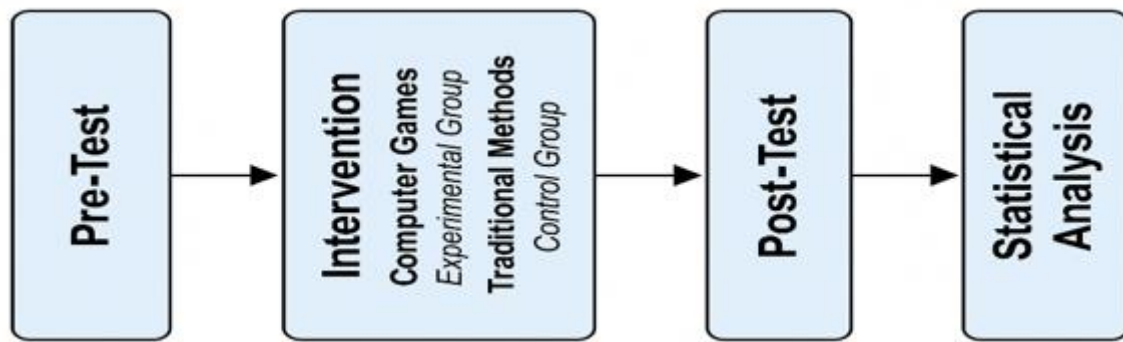


Figure 1. Action plan

3.6. Data analysis

To ensure the reliability and consistency of the instrument used in this study, a reliability analysis was conducted using Cronbach's Alpha coefficient. This coefficient measured the internal consistency of the questions within the questionnaire and was an important indicator of the accuracy of the measurements made. The Cronbach's Alpha coefficient was calculated to be 0.853, using 20 questions in this analysis. This value indicates a high internal reliability of the instrument used to measure the variables of motivation and students' perceptions of the use of computer games in the learning process. A Cronbach's Alpha value of .853 indicated that the questions within this instrument are consistently and reliably related to the measurement of the concept studied.

To determine whether the data follows a normal distribution, two main testing methods were used, the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Results from the Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess whether the data followed a normal distribution. The Kolmogorov-Smirnov test yields a statistic of 0.088 with a p-value of 0.080. Since $p > .05$, this indicates that there is insufficient evidence to reject the hypothesis that the data follow a normal distribution. The Shapiro-Wilk test, which is more accurate for smaller samples, yields a statistic of 0.976 with a p-value of 0.009. Since $p < .05$, this result indicates that the data do not follow a normal distribution. However, given the large sample size of $N = 458$, the distribution can be considered approximately normal according to the central limit theorem, and some parametric analyses may still be valid. Since the data follow a normal distribution, parametric tests are more appropriate for this study. Specifically, the paired t-test was used. Sample t-test) to compare the pre-and post-test results within each group. Also, the t-test for independent samples (Independent Sample t-test) was used to compare the pre-and post-test results of the experimental group with those of the control group.

To assess whether the data from the questionnaires are suitable for factor analysis, which helps in grouping the questions into intrinsic motivation, extrinsic motivation, and amotivation, we used the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity. From the results, we note that $KMO = .814$, indicating a high level of correlation among the questions on motivation (intrinsic, extrinsic, and amotivation), making them suitable for further analysis. The Chi-Square value is 1108.468, and it has a significance level of $p < .005$, indicating that the questions have significant correlations with each other. With a high KMO and a statistically significant Bartlett's result, this suggests that the questions on motivation follow a clear factorial structure and can be grouped into three main categories: intrinsic motivation, questions related to students' desire to learn for personal satisfaction, and their interest in technology. Extrinsic motivation questions related to the desire to get high grades, to please teachers/parents, or to gain recognition from others. Amotivation, questions indicating a lack of motivation or indifference to games as a learning tool.

To answer the first research question, the normal distribution of the data was initially tested, and it was decided whether parametric or non-parametric tests would be used. The hypothesis

testing was done with the t-test of two independent samples (Pallant, 2020). To answer the second research question, the knowledge of the students from both groups was analyzed through pre- and post-tests. These analyses included the use of statistical analyses, the t-test, and the Wilcoxon signed-rank test for independent groups (Field, 2018).

3.7. Ethical issues

The scientific research conducted has taken into account ethical issues at all stages of the research process, where strict measures have been taken to guarantee respect for the rights and privacy of the participants. The confidentiality of the participant's personal information has been an absolute priority, ensuring that identifying data remains secure and inaccessible to unauthorized persons. The data collected have been used exclusively for this study, thus meeting the high standards of ethics in scientific research (Resnik, 2021).

The main objective of the ethical approach in this study was to ensure that all participants were not subject to any abuse or violation of their rights. Research ethics was a constant guide throughout the process, ensuring that every action was by the highest standards of professionalism and respect for the dignity of the participants (Wiles, 2013).

Ethical approval for this study was obtained from the Municipal Education Directorates in Kosovo.

4. Results

4.1. Test results

In this section, the results of the test conducted to assess the effect of the computer game on students' learning in the subject of Technology with ICT are presented and analyzed. The test was used as an objective tool to measure the acquisition of students' knowledge and practical skills related to concepts from ICT, integrated circuits, computer hardware, and software. The analysis of the test results helped determine the impact of the "ICT Game" on students' academic performance and motivation. The tests were administered as part of a quasi-experimental method, where the experimental group used the computer game as a support tool in the learning process, while the control group followed the traditional teaching method. These results are analyzed to assess whether there are statistically significant differences between the groups and to identify the relationship between the use of computer games and learning outcomes.

In the control group, 28 students (out of 229) have a basic level of technological knowledge, 198 students have average knowledge, and only three students have advanced knowledge. Whereas, in the experimental group, 30 students have basic knowledge, a number similar to the control group, 189 students have average knowledge, a number slightly lower than in the control group, and 10 students have advanced knowledge, which is a significant increase compared to only three students in the control group.

Table 1 Pre- and Post-Test Results (Control Group)

		ICT	IC	Hardware	Software	Total
		Mean	Mean	Mean	Mean	Mean
Group	Control (Pre-test)	15.2	14.2	14.2	14.4	58.0
	Control (Post-test)	19.5	11.7	14.7	14.8	60.7

The results from the control group, which followed traditional teaching methods (without computer games), show a limited improvement in learning. The ICT topic marked the largest increase, from 15.2 to 19.5 points, perhaps due to the students' more frequent exposure to these concepts in everyday life. Meanwhile, hardware and software had a minimal increase (only 0.5 and 0.4 points, respectively), indicating that traditional methods had a weak impact in these areas. Worryingly, the results for integrated circuits fell from 14.2 to 11.7 points, signaling significant difficulties in this topic without the help of interactive methods. The total score increased slightly – only 2.7 points (from 58.0 to 60.7), which means that the overall improvement in learning was modest and uneven. Traditional teaching improves results somewhat, especially in the most popular topics, but has a limited or even negative impact on more complex topics such as integrated circuits. This reinforces the need for more innovative methods, such as computer games, in education.

Table 2 Pre- and Post-Test Results (Experimental Group)

		ICT	IC	Hardware	Software	Total
		Mean	Mean	Mean	Mean	Mean
Group	Experimental (Pre-test)	14.2	11.5	13.2	14.7	53.5
	Experimental (Post-test)	20.3	13.1	15.8	16.0	65.3

The experimental group, which used the “ICT Game” during the learning process, showed significant improvement in all subjects. The overall average increased from 53.5 to 65.3 points, an increase of 11.8 points, which proves the effectiveness of the method. The greatest increase was recorded in ICT (from 14.2 to 20.3), while integrated circuits – the most challenging area – also improved (from 11.5 to 13.1). Hardware and software also increased significantly (from 13.2 to 15.8 and from 14.7 to 16.0). Compared to the control group, which did not use the game, the experimental group showed higher growth in every subject, especially in the most challenging subjects, such as integrated circuits, where the control group experienced a decline. The integration of computer games into learning has had a positive and significant impact on the acquisition of technological knowledge and increased student motivation.

Table 3 Paired Samples Statistics – Control Group (Pre-test vs. Post-test)

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total (Pre-test)	57,969	229	18.8108	1.2431
	Total (Post-test)	60,742	229	18.3874	1.2151

The control group showed a slight performance improvement, increasing from 57.97 to 60.74 points, only 2.77 points more after the test. The standard deviation decreased slightly (from 18.81 to 18.39), indicating a more stable distribution of scores. The standard error of the mean remained almost unchanged. The change is minimal and likely related to common factors, such as the repetition of the material, which reflects the limited effectiveness of the traditional method.

Table 4 Paired Samples T-Test – Control Group (Pre-test vs. Post-test)

		Paired Differences			95% Interval Difference Lower	Confidence of the Upper	the df	Sig.(2- tailed)
		Mean	Std. Deviation	Std. Error				
Pair	Total (Pre-test) Total (Post-test)	-2,77	13,74	,91	-4,56	-,98	-3,05	228 ,003

The results of the dependent samples t-test for the control group indicate a slight, yet statistically significant, improvement in the academic performance of the students after completing the learning process using traditional methods. The mean of the post-test results was higher than the pre-test with a mean difference of 2.77 points, indicating that the students made modest progress in learning. The standard deviation of 13.74 suggests that there is a large dispersion between the individual results, implying that some students have benefited more than others from this process. The standard error of the mean of .91 is relatively small, which makes the mean of the change a reliable value. The confidence interval at the 95% level (-4.56 to -0.98) and the p-value (.003) indicate that this difference is statistically significant and not the result of chance. Although the control group showed a small but statistically significant increase in test scores, the gain was minimal. This suggests that traditional instruction had a limited impact on student learning in the given period. However, the improvement remains limited compared to the experimental group, which followed the learning process with the support of the computer game. This suggests that, while traditional methods may lead to slight increases in performance, they are less effective for the deep acquisition of technological knowledge, underscoring the need for more innovative approaches to teaching.

Table 5 Paired Samples Statistics – Experimental Group (Pre-test vs. Post-test)

		Mean	N	Std. Deviation	Std. Error Mean
Pair	Total (Pre-test)	53,472	229	19.7092	1.3024
	Total (Post-test)	65,253	229	17,8391	1,1788

The results for dependent samples show a significant mean difference between the pre-test and post-test scores for the experimental group. The overall mean before the test was 53.47, while after the test it increased significantly to 65.25. This result indicates that students who used the computer game in the learning process experienced a significant improvement in their scores. The standard deviation for the pre-test was 19.71, while for the post-test it was 17.83, indicating that the variation between students' scores remained relatively high, but there was a slight stabilization after the intervention with the computer game. The standard error of the mean (1.30 for the pre-test and 1.17 for the post-test) is low, indicating that the mean is reliable and not a random result. The significant increase in the mean from 53.47 to 65.25 indicates that computer games had a positive impact on the acquisition of knowledge by students. The experimental group exhibited a substantial and statistically significant improvement. This supports the hypothesis that computer games enhance understanding of ICT concepts more effectively than traditional methods. From this, it can be seen that the use of the "ICT Game" as a didactic resource has helped improve the learning of concepts from the subject of Technology with ICT.

Table 6 Paired Samples T-Test – Experimental Group (Pre-test vs. Post-test)

Paired Differences								
		Mean	Std. Deviation	Std. Error	95% Interval Difference Lower	Confidence of the Upper	df	Sig.(2-tailed)
Pair Total (Pre-test) - Total (Post-test)		-11,78	13,17	,87	-13,49	-10,07	228	,000

The results of the dependent samples t-test show a significant difference between the pre-test and post-test scores in the experimental group. The mean difference between the two tests is -11.78, indicating a significant increase in student scores after the computer game intervention. The standard deviation of 13.17 indicates that there is moderate variation in student scores, but the increase is uniform. The standard error of the mean is .87, a low value indicating a high precision in estimating the mean. The 95% confidence interval for the mean difference is from -13.49 to -10.07, indicating that the difference is statistically significant and not the result of chance. The t-value of -13.54 is very high in absolute terms, confirming that there is a large difference between the pre-test and post-test scores. Given that the p-value is .000, this indicates that the difference is statistically significant. The significant improvement in student results after using the "ICT Game" shows that this learning platform has had a positive impact on student knowledge acquisition and performance.

The data show that the experimental group, which used the "ICT Game" during the learning process, had a significant improvement in test scores from 53.47 points before the test to 65.25 points after the test, with an increase of 11.78 points. Meanwhile, the control group, which followed the traditional method, experienced a smaller increase, from 57.97 to 60.74 points, only 2.77 points more. The decrease in the standard deviation in the experimental group (from 19.71 to 17.83) also shows that the results became more equal and more stable among students. This proves that the use of computer games has had a positive impact not only on increasing knowledge but also on improving student involvement in a more balanced way. Compared to traditional methods, this innovative method turns out to be significantly more effective in improving academic performance.

Table 7. Independent Samples T-Test – Comparison Between Control and Experimental Groups (Post-test Scores)

Independent Samples Test									
		Levene's Test for Equality of Variance	t-test for Equality of Means					95% Interval Difference Lower	Confidence of the Upper
		F	Sig.	the	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	
Total (Pre-test)	Equal variances assumed	,223	,637	2,498	456	,013	4,4978	1,8004	,9597 8,0359
	Equal variances are not assumed.			2,498	455,011	,013	4,4978	1,8004	,9597 8,0360
Total (Post-test)	Equal variances assumed	,626	,429	-2,665	456	,008	-4,5109	1,6929	-7,8379 -1,1840
	Equal variances are not assumed.			-2,665	455,583	,008	-4,5109	1,6929	-7,8379 -1,1840

This test was conducted to compare whether the differences in the scores of students in the control and experimental groups, before and after using the computer games, are statistically significant. Levene's test showed that the groups had similar variances both before and after the test ($p > .05$), allowing the use of the t-test for equal variances. Before the test, the control group had a significantly higher mean than the experimental group, with a difference of 4.50 points ($t = 2.498$, $p = .013$), suggesting an initial advantage. However, after using the computer game, the experimental group significantly improved its performance and outperformed the control group with a higher mean of 4.51 points ($t = -2.665$, $p = .008$). The independent samples t-test revealed a statistically significant difference between the experimental and control groups ($t(456) = -2.67$, $p = 0.008$). The calculated Cohen's $d = 0.25$, indicating a small-to-moderate effect size of the game-based intervention on academic performance.

The observed difference between the groups implies that game-based learning can be more effective in promoting academic achievement in the Technology with ICT course. This finding aligns with previous research emphasizing the motivational and cognitive benefits of digital learning tools.

Finally, the results confirm that the use of computer games has had a significant and positive impact on improving student results, making it an effective method to increase academic success in the subject of Technology with ICT.

4.2. Results from the questionnaire

The results collected from the questionnaires with 229 students of the experimental group were analyzed to assess the impact of the "ICT Game" on the motivation of students during the learning process in the subject of Technology with ICT. The questionnaires were used as the main instruments to collect quantitative data and to measure the perceptions, attitudes, and evaluations of students regarding their experience of using the game in the learning process.

Motivation played a key role in the learning process, directly influencing student engagement and performance. In this study, student motivation was analyzed through three main dimensions. Intrinsic motivation was when students participated in the "ICT Game" due to personal interest and the satisfaction they experienced during the learning process. Extrinsic motivation was achieved when students were motivated by external factors, such as assessments, and parental or teacher approval. Whereas, amotivation was presented as a lack of motivation, where students do not see any significant connection between computer games and the learning process. To better understand the impact of using computer games in learning, the mean values and standard deviations of each motivation component were summarized.

Table 8. Motivation results

	N	Descriptive Statistics			
		Minimum	Maximum	Mean	Std. Deviation
Internal motivation	228	2	5	3.98	,560
External motivation	229	1	5	3.62	,777
Amotivation	228	1	5	3.65	,777
Valid N (listwise)	227				

The mean value of intrinsic motivation ($\bar{x}=3.98$, $\delta=.56$) indicates that most students report a high level of interest and satisfaction when using computer games in the learning process. The relatively low standard deviation indicates that most students share a similar motivation in this aspect. This result reinforces the idea that computer games offer an attractive and effective way to learn Technology with ICT concepts.

The mean value of extrinsic motivation ($\bar{x}=3.92$, $\delta=.777$) indicates that students are also motivated by external factors, such as higher grades, parental and teacher appreciation, or competition with peers. However, the higher standard deviation indicates a wider distribution of opinions, implying that not all students perceive the extrinsic benefits of games in the learning process equally.

Interesting is the finding on amotivation ($\bar{x}=3.65$, $\delta=.223$), which shows that some students feel undecided or do not see any direct connection between computer games and learning. Although the mean value indicates a presence of amotivation, the very low standard deviation suggests that these responses are more homogeneous and share similar trends. This may be an indication that some students have not yet fully mastered this learning method or need more guidance from teachers to understand its importance.

In the context of using computer games in learning, it is important to understand how students perceive these tools and whether they affect their motivation and engagement. This section analyzes students' perceptions of the use of computer games in the subject of Technology with ICT. Through the collected data, it is examined whether students consider computer games as a useful tool for learning, and how much these perceptions affect their attitude and involvement during lessons.

Table 9 Student perceptions about computer games

		Frequency	Percentage	Valid Percentage	Cumulative Percentage
Valid	Negative perceptions	4	1.7	1.7	1.7
	Neutral perceptions	62	27.1	27.1	28.8
	Positive perceptions	163	71.2	71.2	100.0
	Total	229	100.0	100.0	

The table above presents the distribution of students' perceptions regarding the integration of computer games in the learning process. The vast majority of students, 163 out of 229 (71.2%), expressed positive perceptions about the use of computer games in learning. This indicates that most students consider games to be an effective learning tool, making the learning process more engaging, interactive, and motivating. This result is consistent with the hypothesis that computer games can positively influence students' engagement and motivation to learn ICT concepts. A portion of students, 62 out of 229 (27.1%), expressed neutral perceptions. This suggests that these students may not have a clear opinion about the effectiveness of computer games in learning or do not see them as particularly useful or harmful. The reason for this may be related to their previous experience with games in learning, their learning style, or the lack of a noticeable impact on their results. Only 4 out of 229 students (1.7%) reported negative perceptions, suggesting that a very small number of students do not value the use of computer games in the learning process. This may be related to technological difficulties, a preference for traditional teaching methods, or a lack of interest in interactive forms of learning. The average value of perceptions is 2.69, which indicates a high tendency towards positive perceptions, being closer to the maximum value (3, which represents positive perceptions). This means that most students consider computer games to be a useful and effective tool for learning, increasing their engagement and motivation. The standard deviation (.498) is relatively low, indicating that most students have similar attitudes towards the integration of games in learning, with little dispersion of opposing opinions. This indicates that the results are consistent and that positive perceptions are not random but dominant across the entire student group. The results show that the use of computer games in learning is largely welcomed by students, with a large majority having positive perceptions. Only a small percentage are skeptical or opposed

to this method. These findings support the idea that integrating games into learning not only increases motivation but is also perceived as an effective tool for knowledge acquisition. For students with neutral or negative perceptions, it may be necessary to explore additional strategies to engage them more and to show how games are integrated into the learning process.

5. Discussion

To evaluate the effectiveness of the computer game, students' performance was assessed both before and after the intervention. The findings revealed that those in the experimental group, who engaged with the game as part of their learning, achieved an average improvement of 11.78 points, whereas the control group demonstrated a more modest gain of 2.77 points. This outcome highlights the substantial influence that educational games can have on student achievement, supporting prior research in the field. Additionally, the study examined the role of the game in enhancing students' technical competencies. Participants who used the "ICT Game" demonstrated a greater ability to grasp and apply key concepts related to hardware and software, compared to their peers in the control group. These results align with earlier studies indicating that interactive, game-based learning environments foster the development of practical and technical skills among students (Liang Y., Lau, Jiang, & Maddison, 2020).

The final objective of this study was to examine how the "ICT Game" influenced students' motivation to engage actively in the teaching and learning process. Motivation plays a central role in education, as it directly impacts students' involvement and academic achievement (Ryan & Deci, 2020). To evaluate the game's effect on motivational factors, data were collected through questionnaires and student interviews, focusing on levels of engagement, perceived satisfaction, and commitment throughout the learning experience.

In this study, students who played the "ICT Game" showed greater interest in the subject of Technology with ICT, compared to the control group. Computer games have been shown to increase student motivation through elements of interactivity and entertainment, making the learning process more engaging (Wang, Chen, Hwang, & Guan, 2022). Furthermore, they stated that the game helped them understand complex concepts more easily, allowing them to learn more actively. This effect is consistent with the theory of digital game learning, according to which when learning occurs in an engaging and interactive environment, it becomes more effective and enjoyable. (Gee, 2020) Furthermore, a study by Clark, Tanner-Smith, Killingsworth, and Bellamy (2020) showed that educational games help reduce students' stress and anxiety, thereby improving their motivation and attitude toward learning (Clark, Tanner-Smith, Killingsworth, & Bellamy, 2020).

The test results indicate that students in the experimental group experienced an average increase of 11.78 points after using the computer game, whereas the control group showed an average increase of only 2.77 points. This difference is statistically significant ($p < .05$), indicating that the integration of computer games has a positive effect on knowledge acquisition. The findings are consistent with other studies that have demonstrated that the use of technology in the learning process increases motivation and learning outcomes (Guo, Saab, Post, & Admiraal, 2020). Hattie, Hodis, and Kang (2020) argue that one of the key factors of academic success is the level of student involvement in the learning process, which increases in the presence of interactive technology-based elements (Hattie, Hodis, & Kang, 2020).

These results are consistent with the theory of experiential learning (Kolb, 1984), which posits that learners understand concepts more effectively when they are actively engaged. Similar findings were reported by Gee (2007) and Prensky (2001), who emphasize the motivational value of game-based learning environments. Through a comparative analysis of students' perceptions, it was observed that computer games provided a more engaging and interactive learning environment. Compared to the traditional method, where students showed lower interest, the experimental group

demonstrated a high level of engagement and satisfaction during the learning process. According to Gonzalez et al. (2020), the use of game-based methods not only improves academic performance but also enhances the level of student satisfaction in learning (Gonzalez et al., 2020).

6. Conclusion

This study provides clear evidence that integrating computer games into teaching the subject of Technology with ICT has a positive and statistically significant effect on student learning outcomes and motivation. Students in the experimental group achieved higher post-test scores than those in the control group, with the most substantial gains observed in complex topics such as integrated circuits and software. These results suggest that interactive and simulation-based learning environments help students better understand and apply technological concepts.

Moreover, students reported greater interest and engagement during the learning process when using the ICT Game. Both intrinsic and extrinsic motivation levels were elevated, indicating that computer games make learning more enjoyable and purpose-driven. These motivational effects are particularly important for 21st-century learners, who respond positively to active and visual forms of instruction.

In light of these findings, game-based learning should not be viewed merely as an innovative approach but as an effective and necessary strategy in modern classrooms. Schools and educational policymakers should consider the structured integration of educational games into curricula and ensure that teachers are adequately trained to implement them effectively.

6.1. Recommendations

The findings of this study suggest that educational computer games should be systematically integrated into the school curriculum, particularly in subjects requiring conceptual understanding and engagement. It is important that these games are carefully developed or adapted to align with learning objectives. To ensure successful implementation, all students must have equal access to the necessary technological equipment, and teachers should receive targeted training on how to effectively use games in instruction. In parallel, schools should regularly monitor and evaluate the impact of such tools on student outcomes to ensure continued effectiveness. Finally, further research is recommended to examine the long-term effects of educational games on learning, knowledge retention, and motivation.

6.2. Research limitations

This study, although it has provided important results on the impact of computer games on students' motivation and academic achievement in the subject of Technology with ICT, has several limitations that should be considered. First, the sample selection was done with a non-probability and purposive method, including only grade IX students from 12 schools in Kosovo, which may limit the generalizability of the results to a wider population. The purposive non-probability sampling limits the generalizability of the findings beyond the selected schools and grade levels. Future studies should employ random sampling to enhance external validity. Second, the research focused only on a short period and for a specific subject, not including other aspects of learning or long-term periods. Also, the measurement of the impact was based mainly on self-reported tests and questionnaires, which may be subjective and influenced by external factors. Furthermore, the willingness and involvement of teachers and students in the use of computer games may have influenced the observed effects. To address these limitations, future studies could include larger samples, longer observation periods, and different measurement instruments to more comprehensively assess the effects of computer games on the learning process.

6.3. Practical implications from the study

The results of the study show that students are more motivated and engaged when they use computer games in the learning process. The use of computer games helps them develop critical thinking skills, such as problem-solving, decision-making, and collaboration in group work. In this regard, computer games can help develop autonomy in learning, making students more independent and more aware of their learning process. For this reason, schools need to encourage the use of computer games as a complementary way to promote active learning.

Declarations

Author Contributions. S.O.: Literature review, conceptualization. K.S.: methodology, S.O.: data analysis. K.S.: review-editing and writing, S.O.: original manuscript preparation. All authors have read and approved the published version of the article.

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