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# The Impact of Using Educational and Digital Games on Middle School Students Science Achievement

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# The Impact of Using Educational and Digital Games on Middle School Students Science Achievement

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## Abstract

Game-based learning has attracted great interest in science education as an effective way to increase student achievement. Most studies in this field have focused on digital or non-digital games. In the literature, some studies generally compare educational games with traditional teaching methods. More studies need to be conducted to compare the effects of digital and non-digital games on achievement. For this reason, the study's primary purpose is to examine the impact of different types of games, namely educational and digital games, and their combinations on students' academic achievement and views on the learning process. In this context, the researcher used three different methods to be applied to three experimental groups and one control group. The research was carried out on 77 5th-grade students studying in a public school in Turkey. Both quantitative and qualitative research methods were used in the quasi-experimental design. Data were obtained through the 'Human and Environment Unit Achievement Test' and semi-structured interviews. The results showed that students in the educational and digital games sections were significantly better at science achievement than students in the textbook-oriented section. No significant difference was found between the digital game-based and educational game-based students in terms of achievement. The academic achievement of the group in which these two game types were used together was higher than the others. In addition, most students were satisfied with the using educational and digital games in science lessons and found the games fun and motivating.

## Introduction

Due to technological advances and rapid development, researchers are looking for new ways to stimulate students' learning and meet the increasing educational demands. (Liu et al., 2020) In modern times, it is seen that classroom activities and academic environments have shown significant changes compared to traditional educational methods (Yıldız, 2022). The teacher-centered method means that the teacher presents content knowledge, experiments are only demonstrated, and there is limited interaction between students (Dimitrios et al., 2013; Eilks et al., 2013; Nzeyimana & Ndihokubwayo, 2019). Traditional teaching methods and some applications are insufficient to meet today's student needs (Kalogiannakis, M et al. 2021).

Accordingly, student-centered education has emerged, and education is based on the student's active participation in the classroom. With the change and updating of educational environments, the process of adapting games that previously seemed meaningless, known only as children's entertainment, to educational environments has also begun (Jurakulovna et al., 2022). According to Dominguez et al. (2013) and Crocco et al. (2016), educational researchers have used games with great interest. Studies in the last two decades have focussed on the theory of game-based learning and why games are a powerful teaching tool. Among these important studies are Prensky (2003), Gee (2003), Oblinger (2004), and Squire et al. (2003).

In the Literature, it is argued that the use of games for instructional purposes enables students to enjoy learning, feeds their self-confidence, imagination, and creative thinking, and guides them to the correct information by providing instant feedback (Alıcı, 2016; Gürpınar, 2017). These can be considered as factors that strengthen student success. In addition, educational games, a learner-centered technique, enable students to have fun, make the lessons more enjoyable and efficient, direct all attention to the subject, and trigger motivation. (Boghian et al., 2019; Plass et al., 2015; Vlachopoulos D, Marki A.2017) This brings effective learning and success (Talan et al., 2020). There are related studies that show that the educational use of games positively affects learning and is effective in increasing achievement (Brezovszky B et al., 2018; Chen, Tseng, et al., 2018; Chian-Wen, 2014; Liao et al., 2010; Tokaç et al., 2019).

However, few studies have compared the effects of game-based learning on students' learning and achievement between digital and non-digital games. (Whang & Zeng, 2021) Research on the impact of non-digital or traditional classroom games is either old-fashioned or limited (Talan et al., 2020). This fact has been echoed in the Literature on the use of educational games, and it is noted that there are reviews examining various essential aspects of games that promote learning. However, they are pretty old (Talan et al., 2020). This is a sign that research into educational games is declining in favor of research into the educational potential of digital games (Yu et al., 2020).

Game-based learning can transform science teaching and learning (Hamari et al., 2016; Khan et al., 2017; Cardinot & Fairfield, 2019). The literature also contains some research findings that show that non-digital games can provide more benefits than digital games (Edwards, 2014; Ernest et al., 2014; Talan et al., 2020; Yang&Chen, 2023; von Gillern & Alaswad, 2016). Several studies have reported the positive effects of using educational games in science education (Lester et al., 2013; Li et al., 2016; Lin et al., 2013; Sung & Hwang, 2013; Wang & Zheng, 2021). Educational games have been demonstrated to impact students' problem-solving abilities positively (Lester et al., 2013; Li et al., 2016), motivation to learn science (Yıldız et al., 2017), and achievement in science (Sung & Hwang, 2013; Wang & Zheng, 2021).

In recent years, there has been a proliferation of literature reviews and meta-analysis studies on the use of different types of educational games in science education (Arztman et al., 2022; Cheng et al., 2015; Chen et al., 2022; Kalogiannakis et al., 2021; Riopel et al., 2019; Tsai & Tsai, 2020; Wang et al., 2022). However, more research is needed to determine which types of games are most effective in increasing students' science achievement. Therefore, this study aimed to go beyond using a single game type and investigate the effects of educational and digital game types used together and separately on students' achievement in science education and students' views

on the process.

## Theoretical Framework

### Game-Based Learning (GBL)

De Freitas defined educational games as 'games for learning'. These games create 'creative, interactive and captivating environments' where learners can engage in 'role plays,' showcase their skills, and engage in various types of learning individually or in co-operation with a team. Mayer (2020) states that GBL occurs when there is a change in the student's skills or academic knowledge as a result of playing games. Such knowledge and skill development are enhanced through game activities that create problem-solving opportunities and challenges, providing students with a sense of winning (Qian & Clark, 2016).

The definition of game-based learning can be ambiguous due to the variety of genres and subject areas in which it is applied. Game-based learning (GBL) combines course outcomes and games to enhance students' learning experiences (Jayasinghe & Dharmaratne, 2013; Roodt & Ryklief, 2019). GBLs are structured materials that provide fun learning, develop thinking skills, and encourage learning through games (Azizan et al., 2021). Educational games are a type of GBL used in education and focus on developing games with specific educational purposes in mind (Anastasiadis et al., 2018; Games & Carvalho, 2022). Dimitra et al. (2020) identified seven main types of GBL approaches applied in education: (i) memory games, (ii) simulation games, (iii) interactive games, (iv) quiz games, (v) puzzles, (vi) strategy games, and (vii) reality testing games.

Currently, GBL is a popular, innovative method widely applied in various disciplines. In contrast to more traditional teaching approaches, the primary method of GBL is to introduce various game elements into subject areas to encourage student engagement and increase participants' motivation. Game-based learning (GBL) combines educational theories, course curricula, and digital games to enhance the learning experience (Jayasinghe & Dharmaratne, 2013; Roodt & Ryklief, 2019).

The scope of GBL is vast and encompasses non-technological and technological integration of games within the educational and training activity. The concept of GBL is fun learning by doing/playing and specially designed, structured game learning materials that can promote the development of thinking skills and self-directed learning among students (Azizan et al., 2021). Educational games are the most common type of GBL used in education, focusing on the development of games with specific educational purposes in mind (Anastasiadis et al., 2018; Games & Carvalho, 2022), leading to increased enthusiasm for play and academic performance (Zhonggen, 2019). Educational games not only improve students' academic achievement and conceptual understanding but also increase their motivation to learn and have fun while making sense of the learned content (Arnold et al., 2021; Baek et al., 2015; Balakrishnan N., 2021; Byusa et al., 2020; Oliveira et al., 2021; Roodt & Ryklief, 2019; Partovi & Razavi, 2019).

### Digital Game-Based Learning (DGBL)

*Definition of Digital Games*

Digital game-based learning is using digital games as educational appliances to achieve desired learning outcomes (Prensky, 2001). Prensky (2003) emphasizes that today's generation is interested in video games because of their natural learning experiences. Various terms are associated with digital games in the Literature (Garris et al., 2002), leading to a broad understanding of what constitutes a digital game. These terms include computer games, digital games, electronic games, mobile games, and video games. To briefly describe digital games as "systems subject to certain rules" in which players achieve variable results or scores by making efforts (Clark et al.,2016). According to Prensky (2006), a game can be defined as digital based on six characteristics leading to grammatical engagement. These items; These are listed as:

- The rules of the game
- The aims of the game
- Conclusion and feedback
- The factor of conflict/ competition/ challenge
- Interaction factor
- The representation of a story or plot.

According to Whitton (2010), there needs to be a well-accepted definition of digital games in the academic Literature. Researchers from various disciplines have different perspectives on this subject. Whitton (2010) investigated the characteristics of digital games taken part in the Literature, focusing mainly on the qualities related to their use in training contexts, and these qualities are summarized in Table 1:

Table 1. Expressions Describing Game Characteristics

| **Characteristics** | **Definition** |
|---|---|
| Competition | It is to be superior to others to achieve a result. |
| Challenge | Tasks require effort and are difficult to solve. |
| Exploring | There is an environment that is searchable and special to the subject. |
| Imagination | There is an imaginary environment, characters, or story. |
| Objectives | There are aims and objectives, which are stated clearly. |
| Interaction | There is an action that can change the course or situation and create feedback. |
| Results | There are measurable results in the game process (for example, scoring) |
| Participant | The other individuals participate. |
| Rules | Artificial restrictions limit the activity. |
| Security | The activity has no consequences in the real world. |

*"Whitton, N. (2010). Learning with digital games: A practical guide to engaging students in higher education. New York: Routledge."*

Digital-based educational games are computer-based programs designed to create an entertaining learning environment by simulating real-world scenarios (Kapp, 2012). They are much more effective than non-digital game-based learning. (Zhonggen, 2019). The digital game is a computer-based program designed for entertainment and learning purposes by simulating real-world scenarios (Kapp, 2012). It is more effective than non-serious game-based learning (Zhonggen, 2019).

**Benefits of GBL and DGBL**

Game-based learning is an emerging field of research with significant potential. Many previous studies have shown that learning motivation and efficiency can be increased through educational games. The benefits of digital and educational games, as discussed in the Literature, are presented in Table 2 below.

Table 2. Summarizing the Benefits of GBL and DGBL as Reflected in the Literature

| **Benefits of Games** |
|---|
| The challenges created by games are conducive to learning (Hamari et al., 2016). |
| Motivates GBL for the improvement of critical thinking (Noroozi et al., 2020) |
| GBL has the potential to promote critical thinking, which is in line with problem-based learning and theories of social conflict (Noroozi et al., 2020). |
| It develops 21st-century general skills such as decision-making, critical thinking, problem-solving, collaboration, and creativity (Anastasiadis et al., 2018; Qian & Clark, 2016; Klopfer & Thompson, 2020). |
| It has a positive impact on student motivation by engaging them in action. (Breien and Wasson, 2021; Hamzeh et al., 2017; Huizenga et al., 2017,). |
| It facilitates learning with increased student participation (de Freitas, 2018; Plass et al., 2015) |
| It can facilitate both cognition and affective and motivational learning (Ke, 2016; Wouters et al., 2013). |
| Educational games effectively improve students' academic performance (Chen, Tseng, et al., 2018; Chian-Wen, 2014; Liao et al., 2010; Tokaç et al., 2019). |
| Games allow students to gain various conflicting information and perspectives on controversial issues. (Noroozi et al., 2016) |
| It positively impacts learning outcomes in science and engineering education and STEM. (Chang et al., 2020; Gao, F. et al. 2020; Gui, Y. et al. 2023; Wang, LH. et al. 2020) |

**Summary of Findings in the Literature**

The theoretical background is summarized in Table 3 to clarify existing knowledge and to analyze and support the findings of this study.

Table 3. Information on Some Studies in the Literature on the Effects of Educational and Digital Games on Education, lesson and Academic Success of Student

| **Title** | **Authors/ Year** | **Purpose of Study** | **Method** | **Game name/ type** | **Results** |
|---|---|---|---|---|---|
| EDUTainment: Effectiveness of Game-based Activities in Teaching | Lasala N. Jr (2023) | This study sought to determine the effectiveness of the developed game-based | The quasi-experimental study used a mixed-method | The Conquest: Non-digital game Eco-Challenge: | The results of this study support the suitability of using game-based activities as |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| Ecosystem Topics | | activities (GBAs)in terms of conceptual understanding and the nature of student engagement. | approach. | Game board Eco-dama: Dama Board Eco-Warrior: Board game | pedagogical and learning tools. They can improve students' understanding of concepts and their engagement in lessons and the learning process. |
| Effects of game-based learning Supports on students' math performance and perceived game flow | Pan, Y., Ke, F. (2023) | The aim is to investigate the effects of three types of game-based learning support, such as modeling, on secondary school students' mathematics achievement and perceived game flow. | Pretest–posttest experimental design | ERebuild: 3D game | The findings showed that students' overall math performance was significantly higher than before the game. |
| The Impact of In-Classroom Non-Digital Game-Based Learning Activities on Students Transitioning to Higher Education | Balakrishna C. (2023) | This study explores the impact of in-classroom, non-digital game-based learning techniques on academic performance, classroom engagement, Moreover, peer interaction among first-year university students studying | The mixed methods approach was used in this study, which involves using both quantitative and qualitative approaches. | Collaboration-based gameplay<br><br>Role-play game<br><br>Challenge-based gameplay<br><br>Construction-based gameplay | In the group component, the average score of the experimental group participants was 86, while the control group participants' average score was 71. Collaborative and interactive in-class game-based learning activities enabled the experimental group participants |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| | | computing qualification. | | | to perform better in the course. |
| The Affordances of Minecraft Education as a Game-Based Learning Tool for Atomic Structure in Junior High School Science Education | Nkadimeng, M., Ankiewicz, P. (2022). | This article aimed to explore the advantages of Minecraft Edu for learning atomic structure in secondary school by exploring students' experiences using Minecraft Edu as a learning tool. The main research question was: What are the benefits of Minecraft Edu for learning atomic structure in secondary school? | Qualitative | Minecraft Edu | Findings showed that students were motivated and interested in critical thinking while collaborating, and the abstractness of the atomic structure was alleviated. While not all features of Minecraft Edu encourage active and deep learning of abstract concepts, it does include some advantages to make the atomic structure less abstract for students. |
| The effect of digital learning on the academic achievement and motivation of natural sciences learners: a case study of a South African ındependent school | Ramaila, S., Mpinga, N. P. (2022). | The study aimed to examine the effect of digital learning on academic achievement and motivation among grade 9 Natural Sciences learners. | Mixed method approach as part of a quasi-experimental design | Kahoot and Edpuzzle | Significant differences were observed between pre-test and post-test scores due to using digital resources. Digital resources positively impacted both academic achievement and learner |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| | | | | | motivation. Theoretical implications for technology-enhanced teaching and learning were discussed. |
| The influence of digital educational games on preschool Children's creative thinking | Xiong, Z., Liu, Q., & Huang, X. (2022) | It aimed to examine the effectiveness of an educational digital game called Thinking Paradise on the creative thinking of preschool children. | Quantitative approach | Thinking Paradise | The results showed that all indicators of creative thinking were significantly supported in children playing the educational digital game and could effectively improve their creative thinking. |
| Educational computer game for earthquake | Yılmaz İnce, E., Sancak, M.E. (2022). | This study aims to examine the effectiveness of an educational digital game created using the UNITY program for earthquake education. | Design based approach | Unity Game Engine | The research suggests that the digital game developed could be effective in teaching earthquakes. Different features can be added to the game to make it more effective. |
| Pre-Service Teachers' Experiences in the Development of Educational Science Board Games | Botes, W. (2022) | This study investigated how science teacher candidates experienced the development of educational science board | A qualitative case study considered a focus-group discussion and photo-voice methodology | Science 360: board game Caught in the Web: board game | Findings from the study revealed how their participation in the development of educational sciences board games had an |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| | | games. It is based on a conceptual understanding of game-based education that allows for integrating board game mechanics, board game aesthetics, and board game thought. | as data collection. | | impact on their personal skill development, professional teacher development, development of pedagogical content knowledge, and development of applicable evaluation methodology related to the teaching of the subject. |
| "Student, parent, and teacher perceptions towards digital educational games: How they differ and influence each other." | Xie, J., et. al. (2021). | This research aims to examine the perceptions of students, parents, and teachers towards educational digital games, to what extent they affect each other, and how they differ. | Mixed-method approach | Electricity and circuits | The research revealed that students, parents, and teachers had a specific digital game experience but limited knowledge about educational digital games. Students' perceptions of educational digital games are more favorable than those of parents and teachers. |
| Using game-based learning to support Learning Science: A Study with middle | Wang, M., & Zheng, X. (2021). | This study implements an experiment to compare the effects of digital | Experimental pre-post test | Lazors Game: digital game<br><br>Laser Maze: Non-digital | Results show that students in GBL groups performed significantly better in the |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| school students | | and non-digital game approaches. | | game | learning content than those in the traditional lecture group. |
| Game On: Exploring the Effectiveness of Game-based Learning | Hartt M., et. al. (2020) | This study investigates the effectiveness of game-based techniques in improving students' perceptions of learning, participation, and teamwork. | Qualitative analysis of the semi-structured interviews. | Lifetime: board game | The study's results demonstrate the potential of game-based learning in higher education. Students generally preferred the gamified course and showed more participation. It has been reported that enjoyment, peer interaction, and idea-sharing skills are more effective in gamified lessons. |
| "Digital game-based learning in a Shanghai primary-school mathematics class: A case study." | Deng, L., et. al. (2020). | This study aimed to examine the perceptions of teachers and students regarding digital game-based teaching in the 2nd-grade mathematics course. | | Digital game | The research data showed that students' interest and motivation in learning increased when digital games were used once a day for six days. |
| CheMakers: playing a collaborative board game to understand organic chemistry | Zhang, Z., et. al. (2020) | In this study, a board game was developed to develop students' higher-order thinking skills and | Qualitative Survey | Chemakers: board game | Surveys before and after the trial showed that CheMakers did not increase students' interest |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| | | as a teaching tool to support the subject of organic chemistry. This board game explores the importance of analyzing chemical mechanisms. | | | in organic chemistry.<br><br>The findings suggest that although game-based learning may increase students' confidence in the subject, more is needed to make them more interested. Students find games engaging and fun but also unique, competitive, and collaborative. |
| Learning how to recycle waste using a game | Gaggi, O., et. al.(2020). | In this paper, we have presented and discussed PadovaGoGreen, a serious game developed to teach people how to match the various types of waste with the corresponding trash can to increase waste recycling effectiveness. | Case Study | PadovaGoGreen, :serious game | The severe game proves its effectiveness in achieving the educational goal and allows users to improve their waste separation skills. |
| Junkbox is a waste management | Gizzi, V., et. al (2019) | It is a game for children aged 3-5. It teaches them to | Case Study | Junbox: EducationalGame | In line with the data obtained from the research, |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| educational game for preschool kids. | | separate recyclable waste and put it in the correct bin. | | | it is stated that the children who played the game enjoyed it and that the purpose of the research was achieved with the game. The game developed will help in waste separation and in getting more information on the subject. |
| Considering students' epistemic beliefs to facilitate their argumentative discourse and attitudinal change with a digital dialogue game | Noroozi, O. (2018) | The primary purpose of this study is to investigate how students participate in argumentative discourse through a digital dialogue game. The second aim is to shed light on the effects of students' epistemic beliefs on their argumentative discourse in the digital dialogue game, and the third aim is to investigate the role of students' epistemic beliefs | | Inter Loc: Digital Dialogue Game | The results showed that the digital dialogue game could guide students toward an interactive and argumentative discourse style. Students' epistemic beliefs are an essential factor in attitude change. The game supported critical reasoning and discussion by increasing students' willingness to discuss. |

| Title | Authors/ Year | Purpose of Study | Method | Game name/ type | Results |
|---|---|---|---|---|---|
| | | in their attitude changes. | | | |
| The Effects of a Digital Dialogue Game on Higher Education Students' Argumentation-Based Learning | Noroozi O. (2016) | This study explored how undergraduate students engage in argumentation discourse activities designed to intensify the debate. | A pre-test, post-test design | Digital: Dialogue game | The results show that the Digital Dialogue Game can facilitate discussion-based learning. The Digital Dialogue Game was also rated positively regarding student satisfaction and learning experience. |

Studies in the Literature have shown that the benefits of educational and digital games in an educational context are relatively compatible, and similar results have been reported. However, no study in the Literature examines the success of three different types of games in science education. The contributions that can be made with this study, which aims to determine the effect of educational and digital games on academic performance in science courses, are presented below.

- Contribute to the Literature on educational and digital games.
- Will be able to determine whether types of games affect academic performance in the science course.

## Method

### Research Design

The mixed method was employed in this study, which aimed to ascertain the impact of the educational and digital game method employed in the science course on students' academic performance in Humans and Environment and their evaluation of the process (Teddlie & Tashakkori, 2009). The mixed method, the process is executed by concurrently collecting and evaluating qualitative and quantitative data (Punch, 2005). This study employed the sequential explanatory method, a type of mixed method. In this method, quantitative data is collected and analyzed first, followed by the collection and analysis of qualitative data (Creswell & Plano Clark, 2011).

### Participants

The study was conducted with a group of 77 5th-grade students from a public school in Turkey who had an Internet connection. The students were around 10-11 years old and enrolled in four different 5th-grade science

classes taught by the same teacher. Each of the four 5th-grade classes was randomly assigned to one of the groups. Table 4 shows how they were distributed among the four groups.

Table 4. Distribution of Participants by Groups

| Groups | Group Definition | Number of Students |
|---|---|---|
| Experimental Group I | Digital Games | 21 |
| Experimental Group II | Educational Games | 20 |
| Experimental Group III | Educational and Digital Games' Combination | 18 |
| Control Group | Traditional Lecture | 18 |

**Data Collection Tool**

*Academic Test*

We used a questionnaire developed by Ekinci (2019) to measure students' achievement. The achievement test comprises 25 questions and measures secondary school students' science class achievement. For the reliability analysis of this test, which consisted of 25 items, the KR20 value was calculated using the TAP (Test Analysis Program). As a result of the analysis, it was determined that the reliability of the achievement test consisting of 25 multiple-choice question items was 100 (KR20 = 0.83). Since this calculated value is considerably higher than the lower value of 0.70 determined for achievement tests, it can be said that the test is reliable.

*Interview*

The second data collection tool employed in this research is the semi-structured interview form, designed to ascertain the students' perceptions regarding the efficacy of educational and digital games in the classroom. The researchers developed the interview form and subsequently reviewed it by two academics with expertise in science education, who provided feedback on the initial draft of the questions. This led to the creation of the first version of the interview questions. These interview questions were then applied to students who did not participate in the study. The questions that were not understood were edited with the feedback received from these students, and the final version of the questions was created with the guidance of the experts.

The interview questions prepared by the researcher to collect the qualitative data for the research are listed below:

1. Have you ever learned educational games?
2. What do you think about using educational/digital games in the lesson?

**Implementation**

The study employed an experimental design. Students in the four groups were exposed to different teaching approaches (see Fig. 1). The efficacy of three distinct teaching methods, implemented in three experimental groups and one control group, was evaluated in terms of students' academic achievement. The study spanned five weeks, with four lessons per week. The research period was limited to 20 sessions.

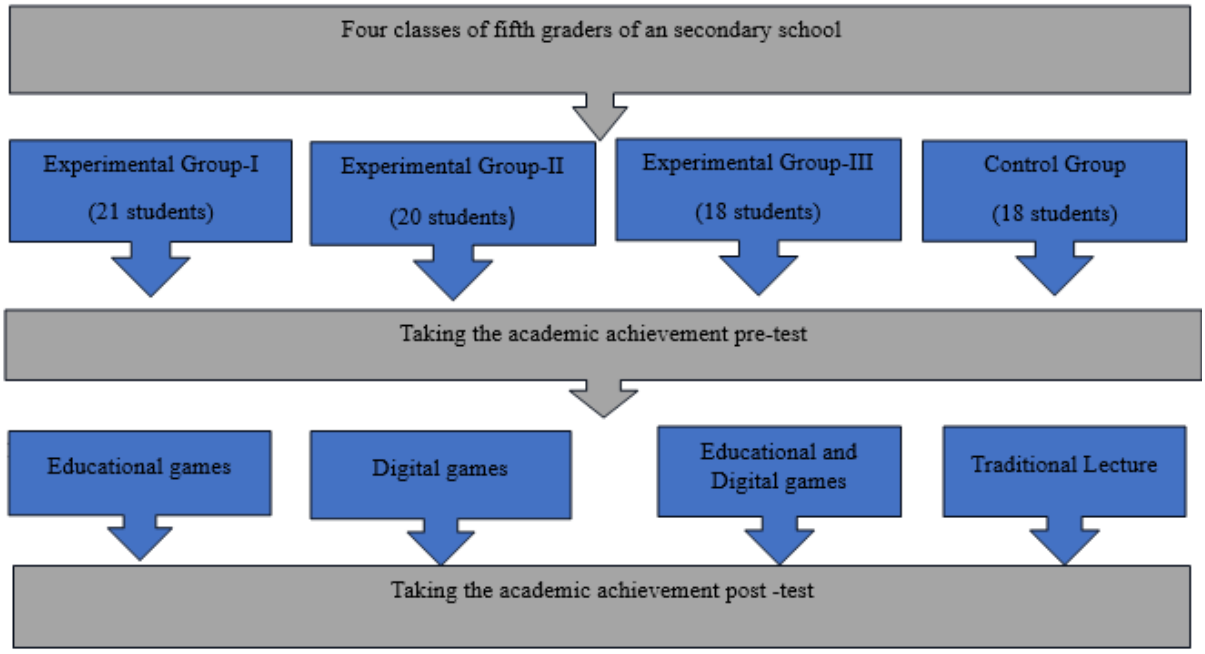


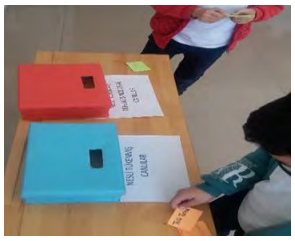

Figure 1. Experimental Design for the Learning Activities

Table 5. Information on the Game with Acquirements

| **Weeks** | **Educational Games Group-II** | **Educational &Digital Games Group-III** | **Digital Games Group-I** | **Acquirements** |
|---|---|---|---|---|
| **1st Week** | Animal Farm | Catch a mole Animal Farm | Catch a mole | The importance of biodiversity for natural life. |
| **2nd Week** | Scienceboard | Scienceboard Space attack | Space attack | The importance of biodiversity for natural life. |
| **3th Week** | Gameboard | Gameboard Space Sale | Space Sale | The factors that threaten biodiversity |
| **4nd Week** | Sciencebox | Çevko-Recycle Science box | Recyclebus | The importance of the interaction between humans and the environment |
| **5nd Week** | Taboo | Taboo Big Risk! | Falling! | The importance of the interaction between humans and the environment |

**Gameboard**

**Gameboard**



**Sciencebox**

**Sciencebox**

**Science-race**

**Science-race**

Figure 2. Educational Game Examples

**Catch a Mole**


**Space Sale**


**Space attack**

**Çevko**

**Çevko-Recycle**


**Falling!**

Figure 3. Digital Games Examples

Students in all groups started with the academic test as a pretest. Students of group I used digital games, while students of group II used educational games. Students of group III used a combination of educational games and digital games. Group IV was the control group and used the traditional lecture method. All four classes were taught by the same teacher. At the end of the study, the same academic test was given as a post-test. Game-play instructions and photographs taken while playing are given in the figures (Figure 2 and 3) regarding the activities for the educational and digital games experimental group.

**Data Analysis**

*Quantitative Data Analysis*

First, the data from the academic test were analyzed using an ANOVA that compared the pretest scores of the four groups. The homogeneity of variances test (Levene test) was checked before each ANOVA test—other assumptions (normality, independent observations, and sample independence). Then, paired-sample t-tests were conducted to compare the pretesting and post-test scores within the four groups to determine whether there were significant changes in academic achievement. Finally, an ANCOVA was used to compare all classes' post-test scores, taking the relevant pretesting scores as covariates. ANCOVA assumptions (normality, homogeneity, homogeneity of regression slopes, linearity, and independent observations) were checked before each ANCOVA test. All the statistical analyses were made using SPSS V22.0. All statistically significant results are reported at .05 level.

*Qualitative Data Analysis*

Data from semi-structured interviews with students in the experimental groups were analyzed using descriptive analysis, frequencies, and percentages, which are qualitative analysis techniques. Themes were created to explain the data in general with codes and to collect these codes under specific categories. To ensure the reliability of the research, the student interviews were coded under the supervision of an expert science educator.

## Results

**Comparison of the Pre-Test Scores**

All classes' pretesting scores were compared in a univariate analysis of variance (ANOVA). Two main assumptions were checked before using an ANOVA. One of them is that the distribution of each sample is normal, and the other is homogeneity of variances, which was tested using the Levene test.

Table 6 Descriptive Statistics and the ANOVA Result of Students' Academic Achievement Pretesting

| Groups | N | Mean+Sd | Levene | F | p |
|---|---|---|---|---|---|
| Group-I Digital Games | 21 | 10.33±3.37 | 2.678 (0.053) | 0.432 | 0.731 |
| Group-II Educational Games | 20 | 11.15±3.17 | | | |
| Group-III Educational and Digital Games | 18 | 10.72±5.26 | | | |
| Group-IV Control Group | 18 | 9.78±3.44 | | | |

The ANOVA results showed no differences among the conditions on the pretest [F(3, 74) = 0,432; p >0.05].

**Comparison of the Pre- Post-test Scores**

Separate paired sample t-tests showed that each class significantly increased its mean score on the academic test. Table 7 shows the paired samples' t-test results for each condition.

Table 7. Paired Samples t-test Results for the Academic Test by Condition

| | | Pre-test | | Post-test | | | |
|---|---|---|---|---|---|---|---|
| | N | M | Sd | M | Sd | t | Sig. |
| Group-I | 21 | 10.33 | 3.37 | 15.86 | 2.89 | -10.455 | 0.000* |
| Group-II | 20 | 11.15 | 3.17 | 15.25 | 3.85 | -10.006 | 0.000* |
| Group-III | 18 | 10.72 | 5.26 | 18.72 | 3.30 | -8.097 | 0.000* |
| Group-IV | 18 | 9.78 | 3.44 | 12.94 | 3.57 | -7.210 | 0.000* |

According to the paired samples t-test results shown in Table 7, there is a significant difference in favor of the post-test in the Achievement test scores of Group-I, Group-II, and Group-III students before and after the implementation of educational and digital game-based activities (t=-10455;-10,006;-8,097;-7,210, p< .05). In other words, the academic achievement levels of experimental group students before and after the practices are different.

**Comparison of the Post-test Scores**

ANCOVA analysis was used to eliminate the effect of pre-test results on post-test results. ANCOVA results are given in Table 8.

Table 8. ANCOVA Results of the Post-test Points Corrected by the Pre-test Scores

| Source | Sum of Square | df | Mean Square | F | p | Eta square |
|---|---|---|---|---|---|---|
| Corrected Model | 731.465 | 4 | 182.866 | 35.293 | <0.001 | 0.662 |
| İntercept | 728.783 | 1 | 728.783 | 140.656 | <0.001 | 0.661 |
| Pre Test | 425.823 | 1 | 425.823 | 82.184 | <0.001 | 0.533 |
| Group | 260.469 | 3 | 86.823 | 16.757 | <0.001 | 0.411 |
| Error | 373.054 | 72 | 5.181 | - | - | - |
| Total | 20056.000 | 77 | - | - | - | - |
| Corrected total | 1104.519 | 76 | | - | - | - |

Levene's test analyzed whether the error variances were homogeneous between the groups. According to the result of Levene's test, it was concluded that the error variances were homogeneous between the groups (p=0.565>0.05). Whether the standardized residuals satisfy the assumption of normal distribution was examined by the Kolmogorov-Smirnov test, and the errors satisfy the assumption of normal distribution (p=0.194>0.05). When the

results given in Table 8 were analyzed, the difference between the group averages was statistically significant (F=16.757, p<0.001). The effect of pre-test scores on post-test scores was significant (F=82.184, p<0.001).

The finding revealed that the classes differed on the post-test scores [F(3, 74) = 16,757; p = .0001, partial η 2 = 0.411].In other words, the post-test scores were significantly different due to the different teaching methods. Furthermore, post hoc analysis was performed to examine specific differences in achievement between the groups (see Table 9). A Tukey's HSD post hoc test revealed that Group III's scores were significantly higher than those of Group II and Group I.

Table 9. Post-hoc Comparisons for the Academic Achievement Test

| | Group | Standard Deviation | | Sig. (2- tailed) |
|---|---|---|---|---|
| Digital Games (Group I) | Educational | 1.118 | 0.713 | 0.729 |
| | Combination | -2.622 | 0.732 | <0.004 |
| | Control | 2.565 | 0.732 | <0.004 |
| Educational Games (Group II) | Digital | -1.118 | 0.713 | 0.729 |
| | Combination | -3.740 | 0.740 | <0.001 |
| | Control | 1.447 | 0.746 | <0.004 |
| Educational and Digital Games' combination (Group III) | Digital | 2.622 | 0.732 | <0.004 |
| | Educational | 3.740 | 0.740 | <0.001 |
| | Control | 5.187 | 0.762 | <0.001 |
| Control Group | Digital | -2.565 | 0.732 | <0.004 |
| | Educational | -1.447 | 0.746 | <0.004 |
| | Combination | -5.187 | 0.762 | <0.001 |

**Interview Results**

Regarding the research question, what are the students' remarks on the process of classes with educational games? Initially, "Have you ever learned with educational games?" was asked, and 20 students expressed that they had never had any lessons through games. The frequency levels of the students' answers are presented in Table 10.

Table 10. Answers to the Student's "Have you ever used educational games in your lessons before" Question

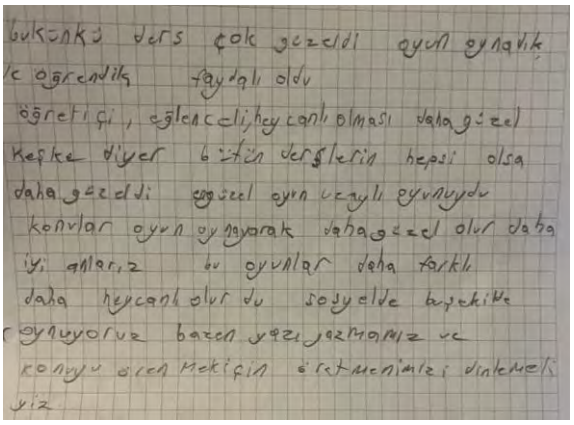
| "Have you ever learned with educational games?" | Educational Games | Digital Games | F | Percentage % |
|---|---|---|---|---|
| Yes | 4 | 2 | 6 | 30 |
| No | 6 | 8 | 14 | 70 |

70% of students said they had not previously used educational or digital games in their lessons. 30% of the students stated that they had previously received education supported by educational games. While only 4 of these students stated that they had experienced educational games, two said they played educational and digital games. Later,

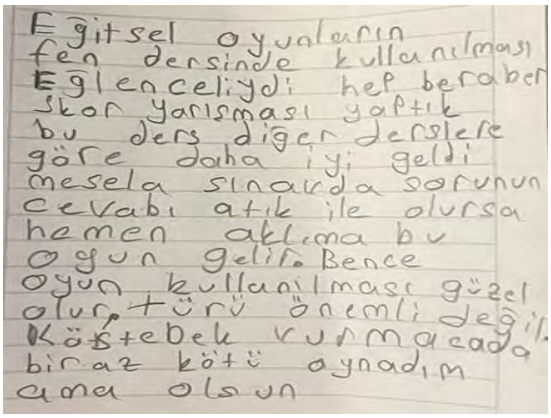
the students were asked, "What do you think about using educational/digital games in the lesson?" The answers are listed in Table 11.

Table 11. The Frequency of Students' Answers to the Question, “What do you think about using educational/digital games in the lesson?”

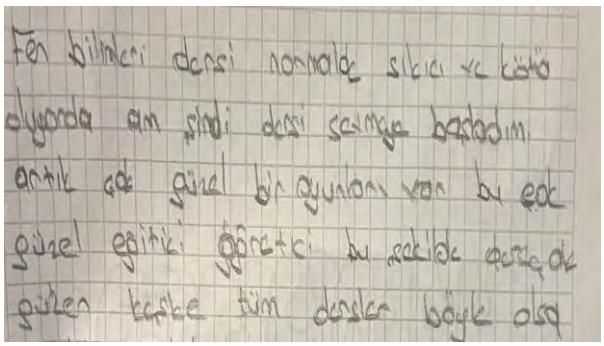
| Theme | Category | Educational Game | Digital Game | Total (f) | Percentage (%) |
|---|---|---|---|---|---|
| Cognitive | Make it easier to understand | 7 | 5 | 12 | 60 |
| | Repetition | 4 | 3 | 7 | 35 |
| | Reinforcement of the topic | 5 | 2 | 7 | 35 |
| | Permanent Learning | 6 | 4 | 10 | 50 |
| | Ease of remembering | 8 | 5 | 13 | 65 |
| Sentimental | Excited | 8 | 10 | 18 | 90 |
| | Motivation | 6 | 5 | 11 | 55 |
| | Fun | 8 | 8 | 16 | 80 |
| | Eager/ Interest | 5 | 4 | 9 | 45 |



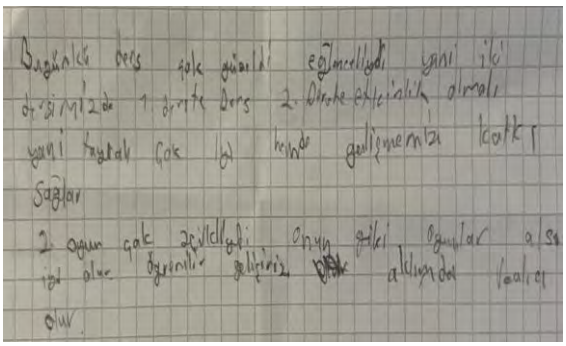

Student 2




Student 6




Student 10




Student 11

Figure 4. Examples of Student Views

The answers to the question “What do you think about using educational/digital games in the lesson?” were categorized under two themes: cognitive aspects and sentimental. It was determined that the students who

expressed make it easier to understand (60%), Repetition (35%), Permanent Learning (50%), ease of remembering (65%), and Reinforcement (35%) through cognitive aspects. In terms of sentimental aspects, it was determined that the students who expressed educational games made the lesson process exciting (90%), motivating (55%), fun (80%), and interesting (45%).

> Student S1 stated, "I had much fun and was looking forward to the next lesson. "When it was my turn, I wanted to play as soon as possible; I was so happy."
>
> Student T7 stated, "I had difficulties in some subjects in science class, but I learned more easily with games."
>
> S 12 student said, "It was easier to learn by playing games. I was stressed initially, but I thought it was more enjoyable."
>
> Student S18 stated the following: “I got excited when I competed with my friends; the lesson was more enjoyable that way. Sometimes science class can be tedious, but I liked it better this way.

## Discussion

This study aimed to investigate the impact of different types of games on the academic achievement of secondary school students. The results showed that the digital and non-digital game-based group outperformed the traditional lecture group. Several empirical studies have found that students in game-based learning classrooms show better learning performance than students in traditional learning classrooms (Arztmann et al., 2023; McLaren et al., 2017; Riopel et. 2019; Tsai ve Tsai, 2020; Wang et al., 2022). It was observed that the students trained through game-based learning were more successful than those in the control group trained through traditional methods. Therefore, it is believed that using games to teach can be more beneficial in different educational settings (Cavus et al., 2011; Giannakos, 2013; Mayo, 2009; Meluso et al., 2012).

Students who utilize GBL demonstrate enhanced learning outcomes compared to those who do not. The effect of game-based learning on student achievement is similar to previous studies (Baran et al., 2018; Kaya & Elgun, 2015; Keçeci et al., 2021; Mc Laren et al., 2017; Wang et al., 2018; Yıldız et al., 2016). Consequently, the integration of GBL may have a favorable impact on student's academic performance (Chen, PY. et al. 2022).

According to Morrison et al. (2019), students need opportunities to use and transfer their acquired knowledge, skills, and practical experience. The possible explanation for the lower success of students in the control group is that traditional teaching methods need to give students more opportunities to actively apply the knowledge they have learned, which reduces their ability to learn and supports their development. From this perspective, games, regardless of the type of game, have a positive effect on student achievement.

Another result of the study is that there is no significant difference in students' science learning between digital and non-digital play groups. The results show that digital and non-digital games have similar positive effects on students' science learning. In the study conducted by Talan et al. (2020), it was seen that the highest overall effect size in terms of game types played was in non-digital games. Some research findings in the Literature report that non-digital games may provide more benefits than digital games (Edwards, 2014; Ernest et al., 2014; Talan et. al, 2020; Yang&Chen, 2023; von Gillern & Alaswad, 2016).

The results of this study show that the students who participated in the experimental group (Group -III), where educational and digital games were used together, were more successful. The students in this group are believed to be more successful than the other experimental groups in terms of academic achievement due to the use of educational and digital games. Another reason for the students' higher academic achievement in the experimental group (experimental group-III), in which educational and digital games were integrated, can be attributed to Vygotsky's (social constructivism) theory and Bandura's social learning theory.

The theory (Bandura, 1986) emphasizes that students can learn most of their emotional, cognitive, social, and psychomotor learning skills more effectively through observation. It is also stated that the student's interaction with his friends and teacher during observation contributes to developing cognitive functions (Bandura, 1986). Play is believed to influence students' learning greatly (Russ, 2003; Zabelina & Robinson, 2010). Children can express themselves through play and gain experiences to structure their knowledge.

Based on these learning approaches, it can be said that the students who participated in the course conducted with a combination of digital and non-digital educational games were more successful than the students in other groups in gaining experience through observation, practice, communication, and information. In this context, combining digital and non-digital educational games in science education can lead to more effective learning results. We can attribute the reasons why the students in the experimental group, where digital and non-digital educational games were used together, had higher academic achievement scores than the other groups to the fact that they interact with each other, observe the process, and are in constant communication.

According to the types of games played, the highest overall average score belongs to the group of games (Experimental Group-III) in which combinations of digital and non-digital games are used together. It was concluded that combining digital and non-digital games may be more effective in students' development and learning, as these games offer more opportunities for peer-to-peer interaction, a more comprehensive range of activities, greater flexibility in content, and the opportunity to learn in different environments. An assessment of the related Literature shows that studies have been conducted to examine the effects of educational and digital games on students' motivation, engagement, self-efficacy, and cognitive develop in science education rather than comparing the effects of different game types on achievement (Chen et al., 2019; Hung et al., 2014; Domínguez et al., 2013; Li & Tsai, 2013; Nietfeld et al., 2014; Wang & Zheng, 2021).

A review of the relevant literature reveals a need for more research comparing the effects of using these three games on students' science achievement. De Freitas (2007), it is clear that the lack of empirical data supporting game-based learning is one of the main obstacles to adopting games in education. This situation has prevented understanding how to integrate games into the educational environment and how to use them most effectively (Hartt, 2020). This renders the current study's findings of significant importance in this context.

**Interview**

As part of the qualitative part of the study, semi-structured interviews were conducted with the students in the

experimental groups. The results showed that most students were satisfied with using educational and digital games in science class. It was noted during the interviews that the students in the two groups included in the gaming experiment had similar thoughts. When the interviews with the experimental group students who were educated with digital games were examined, it was received that “make it easier to understand," "fun," and "excitement" had high frequencies. In the interviews conducted with the experimental group of students who were educated with educational game activities, the codes of "Ease of remembering," "fun," and "motivation" came to the fore. In addition, all these content codes are consistent in both experimental groups and support the game-based learning approach applied in this study. Interviews with students showed that they enjoyed science lessons with educational and digital game methods and wanted to use these game types in other lessons. Game-based learning increases course success, reduces anxiety, and provides a fun learning environment (Lim et al., 2006). The results of this study align with those of previous studies in the field, which have consistently demonstrated the positive impact of digital and non-digital features of games compared to traditional teaching (Alrehaili & Al Osman,2019; Chen et al., 2019; Chen,2020; Partovi et al., 2019; Su & Cheng,2015)

## Conclusions

The results of this study demonstrated that both educational games and digital games had a positive effect on students' thoughts about science classes. There was no significant difference between the students' thoughts in the experimental group, but they had similar views. The study's findings concluded that educational and digital games positively affected the students' success in the 5$^{th}$-grade science class. Student interviews further supported and clarified this finding. The current study suggests several recommendations for researchers, educators, and future developers. This study demonstrated that educational and digital games improved pupil achievement in the "Human and environment" subject. Future research can analyze the effect of educational games on students' performance in various units. Moreover, if larger sample sizes and more extended implementation periods are used, it might be able to generalize this beneficial effect. Due to the advantages of educational and digital games, scientists and educational game developers must continue developing and producing new digital games that support science teaching. Consequently, developing more educational and digital games for teaching science can improve the quality of science education.

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