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The Effects of Digital Game-Based Learning in Technology-Oriented Course: A Case Study in the Biochemistry Department

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Article Info	Abstract
<p><i>Article History</i></p> <p>Published: 01 January 2024</p> <p>Received: 08 January 2023</p> <p>Accepted: 28 August 2023</p> <hr/> <p><i>Keywords</i></p> <p>Digital game Educational technology Digital game based learning</p>	<p>This study was done to find out what students thought about the variables of perceived control, perceived learning, perceived benefit, interest, motivation, affective components, attitude, behavioral components, and learning experience when using digital games in information and communication technologies courses. As a case study, the study was created. 30 students from the biochemistry department made up the study's research group. The tool for gathering data was a semi-structured interview form. Data analysis was done using the content analysis method. When the study's results were discussed, students claimed that playing digital games improved their perceptions of their level of control, interest in the subject, motivation, perceived value of the course, learning experiences, and learning facilitation. Students also mentioned that they felt a variety of positive emotions while using digital games, that they wanted to play them constantly and willingly, and that their attitudes had improved. To increase and enhance students' interest in the course, motivation, positive attitudes and emotions, desire, and learning experiences, digital games can be used in technology-focused courses.</p>

Introduction

The importance of the digital gaming sector has increased recently on a global scale. The number of gamers worldwide provides insight into the significance placed on the digital gaming industry. The number of current game users worldwide increased by 5.3% in 2020 compared to the previous year, reaching 2.7 billion. This information comes from the Newzoo 2020G Global Games Market Report. According to the same report, gaming streaming usage increased 69% in the first quarter of 2022 compared to the same period in 2020, and Twitch, a platform for streaming live sports and video games, recorded 229 million hours of streaming in that same period (Digital Games Report, 2020). On a particular day, data from Steam (<https://store.steampowered.com>), one of the digital gaming websites, revealed that there were 22,395,491 concurrent active users. According to Counter-Strike: Global Offensive's 30-day statistics (found at <https://store.steampowered.com/app/730> CounterStrike Global Offensive/), 541 million hours were spent playing the game by 995 thousand players (Savaş, Güler, Kemal, Çoban & Güzel, 2021). This information on digital games shows that they have a significant global impact and tremendous potential. The audience that digital games have an impact on and their potential have been discovered to be quite remarkable in the fields of education and other fields. The use of games for learning has become increasingly popular among academics and practitioners in the field of education, particularly those working in the area of educational technologies (Tüzün, Akıncı, Yıldırım, & Sırakaya, 2016).

Academics are very interested in the widespread and quick development of digital games in the field of education (Mayer, 2019). The possibility of using digital games as a tool for learning and teaching or as a method of learning in the field of education has raised interest in research in this area (Whitton, 2010). Due to this interest, there have been an increasing number of studies in the literature on digital game-based learning that are based on games with various features. In fact, digital game-based learning has received a lot of attention in recent years and has established itself as a significant topic of study in the literature (Chen, Zou, Cheng & Xie, 2020; Koparan, 2021).

Information and communication technologies (ICT) are seen as both a cause and an effect for innovations and changes in the field of education, even though they are one of the most striking symbols of globalization and the innovation movement in education (Clegg, Hudson & Steel, 2003; Power, 2007; Peeraer & Van Petegem, 2015). In actuality, the use of ICT in the field of education is very effective in a variety of areas, including producing, changing, and sharing knowledge, facilitating quick and simple access to information, and creating content that is appropriate for needs and individual differences (Erdoğan, 2020). ICT in education has many advantages,

according to studies in the literature (Fullan & Langworthy, 2013). ICT can be used for creative learning outside of the classroom and in the context of a skills-based approach (Peeraer & Van Petegem, 2011a).

The use of mobile technologies, virtual worlds, and cloud computing in education, which support a progression beyond the use of personal computers, can help students develop their knowledge and skills to become independent learners (Peeraer & Van Petegem, 2012). ICT used in education can assist students in taking ownership, allowing them to make mistakes, questioning authority, and making data-driven decisions (Tubin, 2006). It is critical in this setting for students to acquire a solid understanding of contemporary information and communication technologies as well as the knowledge and skills necessary to use them. To ensure that students learn effectively and acquire a variety of knowledge and skills, many different techniques are employed. In fact, methods that encourage students to pursue individual education for an active learning process and distance methods from traditionalism are expected to be included in today's educational systems (Cuncka & Savicka, 2012). Learning through digital games has a significant place among them.

Digital game-based learning can be used to facilitate interaction, overcome lack of engagement, deep thinking, positive behavioral changes, and content-based learning in addition to amusing students (Phaire, 2007; Perrotta, et al., 2013; Lester, et al., 2014). Learning materials are combined with competition, feedback, and rewards in digital game-based learning to create a fun and educational environment (Chen & Chang, 2020; Tan, Chen & Lee, 2020; Liu, Wang & Lee, 2021). According to various studies' findings, incorporating competition, feedback, and rewards into digital game-based learning can significantly improve learning (Yang, Chung, & Chen, 2022).

Digital game competition has been used to get students to concentrate more on the game, just-in-time feedback has been used to increase learning gains and retention, and incentives have been used to get students to put in extra effort to learn (Wei, Kao, Lu, & Liu, 2018; Park, Kim, Kim, & Mun, 2019; Reynolds & Kao, 2021). By allowing the games to be played repeatedly, the integrity of these components with the learning material ensures that learners actively participate in the games, making their knowledge more permanent, and creates a fun environment, increasing both participation and motivation (Hung, Yang, Hwang, Chu & Wang, 2018; Lee, 2019). Additionally, by engaging in learning-by-doing activities, students are able to structure their new knowledge with their prior knowledge and experiences and perform more successfully for learning thanks to this integrity (Pitarch, 2018). The types of digital games with the features of knowledge transfer (cognitive learning outcomes), skill acquisition (skill-based learning outcomes), and behavior/attitude change (affective learning outcomes) are used to achieve the stated situations with game-based learning (Stewart et al., 2013). Effectively utilizing various digital game types makes it quick and simple to accomplish a variety of goals and objectives. According to research published in the literature, effective planning and design of games used in digital game-based learning can improve student performance in terms of engagement, motivation, attitude, and concentration (Sung & Hwang, 2018; Tapingkae, Panjaburee, Hwang & Srisawasdi, 2020; Taub, Sawyer, Smith, Rowe, Azevedo & Lester, 2020; Cai, Mao, Wang, He, Chen & Fan, 2022); this can (Hsiao, Chang, Lin, Chang & Chen, 2014; Dindar, 2018; Pratama & Setyaningrum, 2018).

Research on digital game-based learning has shown that it can be more effective than conventional methods in a variety of subject areas, including the teaching of mathematics, the acquisition of foreign languages, the study of science, and the provision of healthcare (Wouters & van Oostendorp, 2013; Clark, Tanner-smith & Killingsworth, 2016; Tokac, Novak & Thompson, 2019; Gentry et al., 2019; Ghoman et al., 2019). Considering the results of the studies on the games used in digital game-based learning, the effects of digital games in shaping the emotions and behaviors of students in the educational environment and processes can be evaluated in the context of different variables. These may include perceived control, perceived usefulness, affective and behavioral components. Perceived control refers to the emotional and reactive behaviors that students develop while playing digital games. Self-learning skills related to tasks in games and having control abilities while playing games can be evaluated in this context. Perceived benefit refers to behaviors that result from students' beliefs about the benefits of games.

The affective components are the feelings of fear, hesitation and irritability before and during the play. Students' willingness or unwillingness to play games are also behavioral components (Sarigöz, Bolat & Alkan, 2018). Making positive contributions to students' perceived control and benefit, affective and behavioral components with the help of digital games can help shape students' emotions and behaviors. In fact, it is aimed to provide emotional and behavioral participation in the games and to satisfy the students by entertaining them (Sarigöz, Bolat & Alkan, 2018). The positive development of students' emotions and behaviors with digital games makes significant contributions to many different variables for lessons. These include attracting students' interest in lessons, changing their behaviors, influencing their motivation (Foster & Shah, 2016) and enabling them to

develop positive attitudes towards lessons (Prensky, 2003; Papastergiou, 2009). These findings are supported by meta-analyses of the literature on digital game-based learning (Clark et al., 2016; Tsai & Tsai, 2020). However, it has been noted that there are only a few qualitative studies that reveal the effects of using digital games on various variables while taking student opinions into consideration. Qualitative research is required in this area. With qualitative research, detailed information about the topic and situation being studied can be obtained from a small number of participants, and this information can be thoroughly explained through content analysis (Hsieh & Shannon, 2005; Elo & Kyngäs, 2008). Examining how the use of digital games affects various student-related variables from the viewpoint of the students is deemed important in this context.

The literature on digital game-based learning reveals the positive effects of this method on various variables and fields. However, it is understood from the literature that the underlying reasons that cause and underlie the positive effects of digital games used in digital game-based learning are not well known and researched. Considering this situation, this study was conducted to determine how these positive effects emerge in students and students' experiences of using digital games. In this respect, the study will make important contributions to the literature. This study was conducted to reveal the role of digital game-based learning in the information and communication technologies course within the scope of a qualitative research in line with student views. The research questions to be analyzed in line with the purpose of the study are as follows.

- What are students' views on digital games in terms of perceived control?
- What are students' views on the effects of digital games in terms of perceived learning?
- What are students' views on digital games in terms of perceived benefit?
- What are students' views on the effects of digital games in terms of their interest in the course?
- What are the opinions of students about the effects of digital games in terms of their motivation towards the course?
- What are students' views on digital games in terms of affective components?
- What are the opinions of students about the effects of digital games in terms of their attitudes towards the course?
- What are students' views on digital games in terms of behavioral components?
- What are students' views on the effects of digital games in terms of learning experiences?

Method

Research Model

The study was designed with a case study, one of the designs based on qualitative research approaches. Case studies are research studies in which the causes, processes or results that are thought to be the source of a particular situation are examined and described in detail in line with the research purpose (Creswell & Creswell, 2018). In the study, the research approach was determined first. Then, the process was organized in accordance with the qualitative research approach and the design of the case study was planned. In the next stage, the research group and data collection tools were organized and the research group was determined (Arıcı, Yılmaz & Yılmaz, 2021). The research group was determined by convenience sampling method. A semi-structured interview form was prepared as a data collection tool and its validity and reliability were tested. For this purpose, opinions were taken from experts in the field for the interview form and pilot interviews were conducted with the students with the interview form. In the last stage, the research was carried out. In the study, biochemistry department students were enabled to use digital games in information and communication technologies courses and extracurricular activities. Then, the opinions of the students about digital games were revealed. The students' views were analyzed from their perspectives in terms of perceived learning, interest, attitude, motivation, learning experience, affective components, perceived benefit, perceived control and behavioral components.

Study Group

The participants in the research group of the study were randomly selected from the biochemistry department students among the departments in which the researcher taught the information and communication technologies course with the convenience sampling method. Convenience sampling method was preferred in this study because it allows data collection easily, quickly and without much cost (Karasar, 2014). A total of 30 first-year students, 23 female and 7 male, participated in the study voluntarily. Participants were given detailed

information about the study process. Students participated in the study on a voluntary basis. Permissions were obtained from the institution and ethics committee where the study was conducted. All of the students who actively attended the classes participated in the study.

Data Collection Tools

In the study, a semi-structured interview form was developed to obtain the opinions of the students. The questions in the interview form were adapted from the studies of Sarıgöz, Bolat, and Alkan (2018) and Arıcı, Yılmaz, and Yılmaz (2021) and prepared by the researcher. For the questions in the interview form, the opinions of experts in the field were taken and arrangements were made in line with these opinions. Two of these experts were experts in computer and instructional technologies, and the other two were experts in educational sciences and measurement and evaluation. Pilot interviews were conducted with the interview form. The data obtained from these interviews were taken into consideration and the form was finalized. The questions in the interview form prepared for the students are given below.

- How do you evaluate digital games in terms of perceived control?
- How do you evaluate the effects of digital games on your perceived learning?
- Do you think digital games are useful?
- How do you evaluate the effects of digital games on your interest in the course?
- How do you evaluate the effects of digital games on your motivation towards the course?
- What are your affective feelings towards digital games?
- How do you evaluate the effects of digital games on your attitude towards the course?
- How do you evaluate your behavioral tendencies towards digital games?
- How do you evaluate your learning experiences with digital games?

Data Analysis

The study's data analysis process used the content analysis methodology. The connections and relationships between the themes and codes related to the subject are revealed in the content analysis method, allowing for a detailed and in-depth analysis of the subject (Creswell, 2013). After the course process was completed, individual interviews were held with the students. Interviews were held once with each student participating in the study. The interviews, which were made with the permission of the students, were recorded with a voice recorder. The data recorded with the interviews were converted into text with software. In order to avoid data loss regarding the answers given by the students to the questions, the students were provided to check their answers. Students had the opportunity to review their answers and correct omitted or incorrectly worded sections. In this way, reliability is ensured. The interviews had no set time limit. Short breaks were taken when students became uninterested or uncooperative. The interviews with the students were carefully conducted in a setting conducive to casual conversation. This worked well to build trust.

A comprehensive approach was used to identify the subject-related themes and codes in the content analysis method used to examine the study data (Strauss & Corbin, 1990). The researcher went over each interview form where student opinions were collected multiple times at various times. In this process, opinions of different experts were taken. Repeated phrases in the interview forms, ideas with overlapping characteristics and connections to one another directly or indirectly, and content analysis units were identified (Arc, Yılmaz, & Yılmaz, 2021). Themes and codes make up these units. Tables are used to display the themes and codes that were developed for each research question.

Process

The study used 10 weeks of digital games designed for "Information and Communication Technology Concepts," "Using Computer and Managing Files," "Word Processing Software," "Spreadsheet Software," "Presentation Preparation Software," and "Internet and Web Usage" on the "learningapps.org" and "wordwall.net" websites. Five different templates were used in the design of digital games. 10 different games were designed using these templates. The templates are arranged according to the content of the course topics. Word puzzle, word stack, word hunt, matching and labeled diagram are the templates used. Some images of the games used in the implementation process of the study are shown in Figure 1.

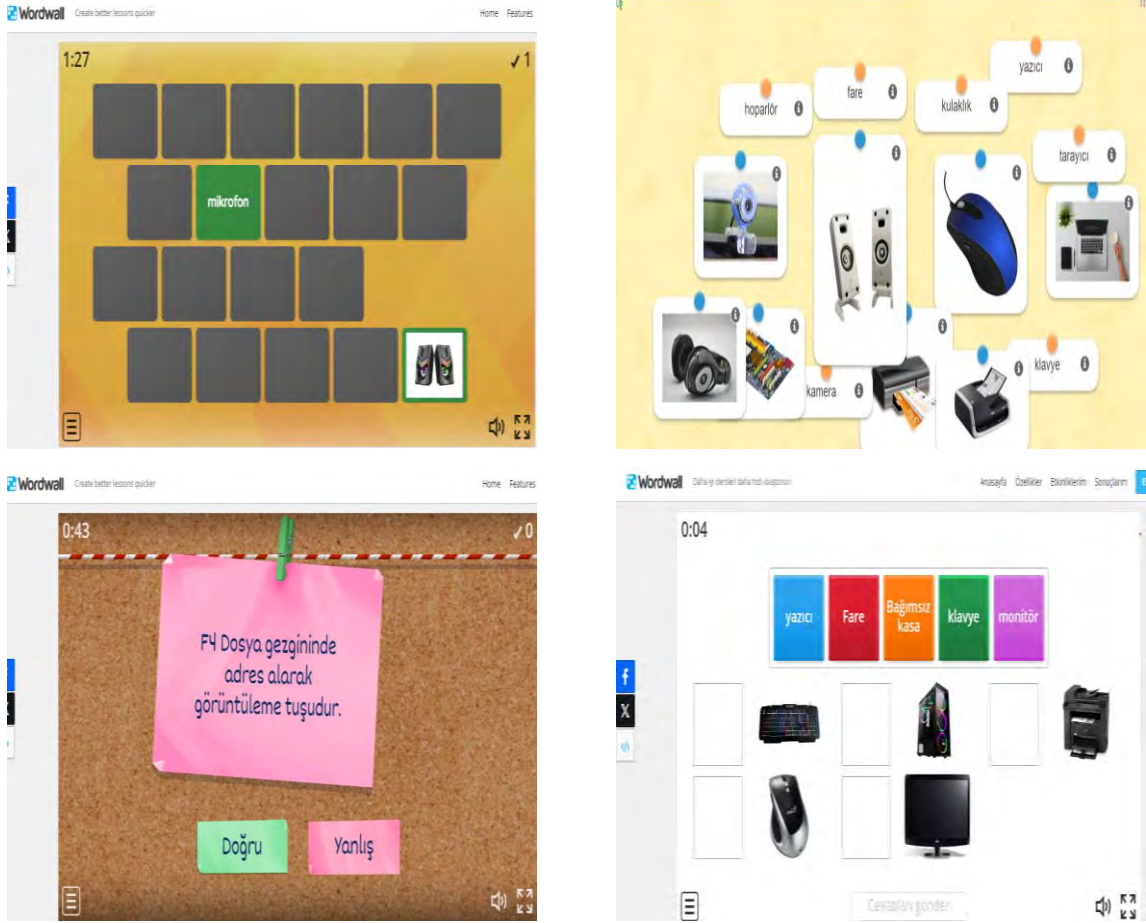


Figure 1. Some images of the games used in the implementation process of the study

Students played digital games in different parts of the lessons under the control of the researcher. Some visuals of the implementation process are presented in Figure 2. Students were permitted to use the digital games for both in-class and extracurricular purposes while the study was being implemented. In order to check whether the students play digital games in extracurricular activities, information about the games was obtained from the students at the beginning of the lessons. At the same time, the students were given the opportunity to replay the games they gave information under the control of the researcher. The students were interviewed at the conclusion of the procedure. The researcher conducted each and every interview.

Role of the Researcher

The researcher's course on information and communication technologies was taught in the biochemistry department, where the study was done. The researcher meticulously carried out and kept track of all of the digital game-based activities during the development and implementation phases of the course. At every stage of the study, the researcher played a part. The use of digital games in the classroom was viewed favorably by the researcher.

Validity and Reliability

In order to guarantee the study's internal validity, external validity, and reliability, Merriam's (2010) suggestions were taken into account. Internal validity was ensured through long-term observation, peer review, participant data verification, researcher expression of views and opinions at the start of the study, and participant involvement throughout the entire process. At the beginning of the implementation process, the researcher shared his thoughts and views with the students and encouraged all students to actively participate in the process. The researcher made his observations impartially in the long term throughout the implementation process. At the end of the application process, the data on the views on digital games were checked by the

researcher and students. Rich descriptions were made and the special characteristics of the circumstance were stated for external validity. For credibility, the researcher clearly described his or her position and role in the study and provided thorough explanations of each stage of its development in accordance with a predetermined system (Yin, 2013). In the study, the consistency was ensured by taking the opinions of different experts in determining the themes and codes.

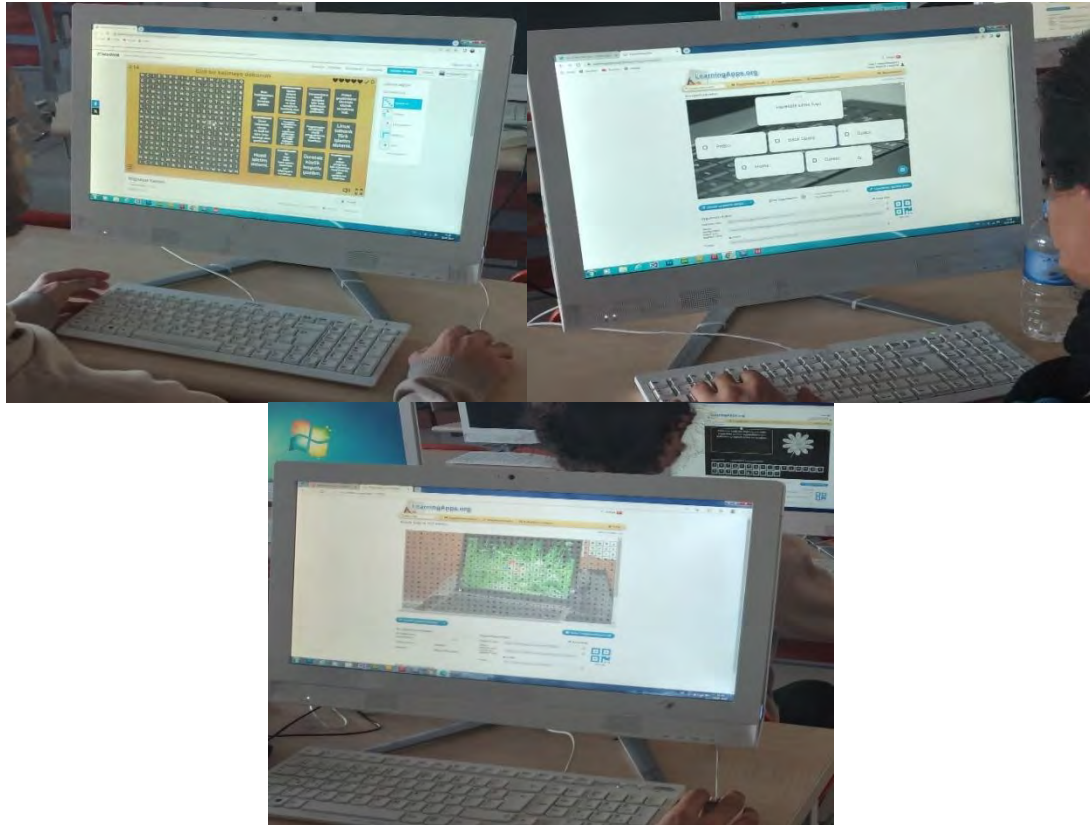


Figure 2. Some visuals of the implementation process

Findings

The findings obtained from student opinions are presented by classifying them in terms of perceived control, perceived learning, perceived benefit, interest, motivation, affective components, attitude, behavioral components and learning experience.

Perceived Control

Student responses to the question "How do you evaluate digital games in terms of perceived control?" were analyzed. Themes and codes were created within the scope of the related data. These are given in Table 1.

Table 1. Digital games in terms of perceived control

Theme	Codes	f
Perceived control	I was able to use the games easily	27
	I was able to use the games the way I wanted	27
	I learned many things about games on my own	26
	I had difficulties using the games	3
	Some games seemed complicated to me	2

According to Table 1, students stated that they could use digital games easily ($f = 27$) and as they wanted ($f = 27$) and that they could learn many things about the games by themselves ($f = 26$). On the other hand, some students stated that they had difficulties in using the games ($f = 3$) and that some games were complex ($f = 2$). Student opinions on this issue are given below:

"I had no difficulty in using the games, I used them the way I wanted. When I examined the structure of the games, I was able to learn many things on my own." (S:5)

"Some games were very easy to use, but some games had a very complex structure and I had a hard time using them." (S:11)

Perceived Learning

The answers given by the students to the question "How do you evaluate the effects of digital games on your perceived learning?" were analyzed. Themes and codes were created according to the data obtained and presented in Table 2.

Table 2. Effects of digital games on perceived learning

Theme	Codes	f
Perceived learning	Making learning fun	28
	Facilitating learning	28
	Accelerating learning	28
	Making learning more effective	27
	Making learning more permanent	27

According to Table 2, students stated that digital games make learning more fun ($f = 28$), easier ($f = 28$) and faster ($f = 28$). In addition, students stated that games make learning more effective ($f = 27$) and permanent ($f = 27$). Examples of student opinions revealing this situation are given below:

"Digital games made computer-related subjects understandable for me. I can play games in a fun way and learn something easily and quickly." (S:25)

"I have never learned computer-related subjects in such a fun way. I learned many subjects that seemed very complicated and difficult to me easily and quickly." (S:15)

Perceived Benefit

The answers given to the question "Do you think digital games are useful?" were analyzed and Themes and Codes were created according to the answers given. These are given in Table 3.

Table 3. Digital games in terms of perceived usefulness

Theme	Codes	f
Benefit	Offer different ways to learn	28
	Enriching learning experiences	26
	Improving performance for learning	27

When Table 3 is examined, students stated that digital games helped them in providing different ways for learning ($f = 28$) and enriching learning experiences ($f = 26$). In addition, students stated that the games increased their performance towards learning ($f = 27$). Student opinions regarding this are presented below:

"I learned many things in different ways in digital games. It enriched my learning experiences and thus made it easier for me to learn" (S:30)

"I think that the games we play are very useful for learning. I think that this is how my performance in the lessons increases." (S:27)

Interest

The answers to the question "How do you evaluate the effects of digital games on your interest in the course?" were analyzed. Theme and Codes created with the data obtained from the answers given by the students are presented in Table 4.

Table 4. Effects of digital games on interest in the course

Theme	Codes	f
Interest	Having fun in lessons	28
	Enjoying lessons	28
	Increasing curiosity towards lessons	27
	Ensuring that lessons are followed carefully	27

When Table 4 is analyzed, students stated that they had fun in the lessons thanks to digital games (f = 28). While this situation made the lessons enjoyable (f = 28), it increased students' curiosity about the lessons (f = 27) and enabled them to follow their lessons carefully (f = 27). Some of the student opinions on this issue are given below:

"Digital games make the lessons very fun. I look forward to the next lesson. These lessons are very enjoyable." (S:5)

"Computer lessons are very enjoyable and these lessons make me very curious. I follow the lessons very carefully and I want to learn everything about computers."(S:1)

Motivation

The answers given to the question "How do you evaluate the effects of digital games on your motivation towards the course?" were analyzed and Themes and Codes were created and presented in Table 5. Table 5 shows that students claimed that using digital games increased their positive attitudes (f = 28), self-confidence (f = 28), and self-efficacy (f = 27) toward the course. By giving them control over the lesson, students claimed they improved their performance (f = 26; f = 27). Below are some student opinions in this regard:

"Before this course began, I found computer-related subjects to be very challenging and complex, but thanks to these games, my positive thoughts about this course have significantly increased, my self-confidence has increased, and I started to see myself as competent in this course," the student said. (S:26)

"I learned many subjects quickly, and my performance significantly improved compared to the first time. I feel competent in subjects that I know little to nothing about the computer. I learn the course subjects effectively by playing the games whenever and wherever I want, so I am in control." (S:17)

Table 5. effects of digital games on motivation towards the course

Theme	Codes	f
Motivation	Increasing positive thoughts towards the lesson	28
	Boosting self-confidence	28
	Supporting self-efficacy	27
	Ensuring control of the course	27
	Improving performance	26

Affective Components

The answers to the question "What are your affective feelings towards digital games?" were analyzed. Themes and Codes were created in the context of the data obtained through the analysis and presented in Table 6.

Table 6. Affective feelings towards digital games

Theme	Codes	f
Affective components	I did like games	27
	I enjoyed playing the games	27
	I was happy playing the games	26
	I was wondering while playing games	26
	I got excited playing the games	25
	I didn't like games	3
	I did't enjoy the games	3
	I got angry while playing games	2

According to Table 6, students stated that they had positive emotions towards digital game use such as liking ($f = 27$), enjoying ($f = 27$), being happy ($f = 26$), being curious ($f = 26$), and being excited ($f = 25$). On the other hand, some students stated that they had negative emotions towards digital games such as disliking ($f = 3$), disliking ($f = 3$) and getting angry ($f = 2$). Student opinions in this context are given below:

"I liked the games very much, I had a lot of fun while playing them. They helped me learn while repeating the lesson, which made me very happy." (S:22)

"I was very curious about the new games. Each game excited me a little more. But the fact that I was not successful in some games made me angry and I did not like those games." (S:26)

"I don't like computer games very much and I don't like them, they seem very complicated to me and this complexity makes me angry." (S:27).

Attitude

The answers to the question "How do you evaluate the effects of digital games on your attitude towards the course?" were analyzed. Themes and Codes were created according to the answers given. These are given in Table 7.

Table 7. Effects of digital games on attitude towards the course

Theme	Codes	f
Attitude	Attending classes willingly	28
	Getting rid of prejudices about lessons	27
	Liking the lessons	27
	Be happy in the lessons	26

According to Table 7, students stated that thanks to digital games, they participated in the lessons willingly ($f = 28$) and got rid of their prejudices about the lessons ($f = 27$). This situation enabled students to love their lessons ($f = 27$) and feel happy in these lessons ($f = 26$). Student opinions on this issue are presented below:

"I attend computer lessons very willingly. I had a lot of prejudices against this course, but I got rid of them all." (S:6)

"At first, I thought that the computer course was very difficult, but I realized that it was not. Now I like the computer course very much and I see it as a very happy course." (S:7).

Behavioral Components

The answers to the question "How do you evaluate your behavioral tendencies towards digital games?" were analyzed and Themes and Codes were created. These are given in Table 8. When Table 8 is analyzed, students stated that they play digital games continuously ($f = 28$) and that they are willing to play digital games ($f = 28$) and that they can learn different subjects through digital games ($f = 27$). On the other hand, some students stated that they were not willing to play digital games ($f = 2$) and that they could play digital games when told ($f = 2$). Student opinions in this context are presented below:

"I am very eager to play digital games and I play these games constantly. Thanks to these games, I can learn many different subjects." (S:3)

"I am not very eager to play games on the computer. I play the games because the lecturer tells me to." (S:4).

Table 8. Behavioral tendencies towards digital games

Theme	Codes	f
Behavioral Components	I play digital games all the time	28
	I am very eager to play digital games	28
	I can learn different subjects with digital games	27
	I am not very keen to play digital games	2
	I play digital games when told to	2

Learning Experience

The answers to the question "How do you evaluate your learning experiences with digital games?" were analyzed. Themes and Codes were created within the scope of the data and presented in Table 9.

Table 9. Learning experiences towards digital games

Theme	Codes	f
Experiences of using digital games	Fun	28
	Remarkable	28
	Easy to use	27
	Having content compatible with the course subjects	27
	Supporting individual learning	26

When Table 9 is analyzed, students stated that digital games are fun ($f = 28$), attention-grabbing ($f = 28$), easy to use ($f = 27$) and their content is compatible with the course subjects ($f = 27$). In addition, students stated that these games support individual learning ($f = 26$). Student opinions on this subject are given below:

"Digital games were quite remarkable and fun for me. The games were very easy to use. The subjects that were explained to us in the lesson were all in these games." (S:19)

"By using these games, I was able to learn the subjects I did not understand in the lesson by studying them individually. This happened very quickly and effectively." (S:20).

Discussion & Conclusion

Within the framework of a qualitative study, the opinions of students who use digital games in ICT classes were revealed. These opinions covered perceived control, perceived learning, perceived benefit, interest, motivation, affective components, attitude, behavioral components, and learning experience variables. The opinions of the biochemistry department students were discussed in this context

Perceived Control

The students said they could use the games easily and however they wanted when the study's findings were analyzed. Students acknowledged that they had picked up a lot of knowledge about the games on their own as well. This might be as a result of the simple and clear structures of digital games. The fact that students can play the games repeatedly whenever they want to overcome learning challenges and that they can repeatedly practice the subjects may also have had an impact on this situation. Additionally, this might also be because of how interactive digital games are. In fact, interactive technologies significantly raise users' perceived levels of control (Hu & Wise, 2020). There are similar study results even though there aren't many in the literature (Hu & Wise, 2020; Gu, Chen, Lin, Lin, Wu, Jiang, Chun, & Wei, 2022). Control is entirely given to the students when using digital games. Students had an optimistic view of their own potential and capabilities. Students felt they had more control over video games. The students' high level of perceived control over the digital games they were playing allowed them to have a high level of control over those games (Overmars & Poels, 2015). Better teaching outcomes were influenced by raising the sense of control over the teaching process (Gu et al., 2022). Some students, however, claimed that they found some of the games to be too complex for them and that they had trouble using them. Students may have perceived digital games to be challenging and complex due to the fact that cognitive load on users' working memory increases in digital game-based learning environments (Norman, 2011). In fact, learning becomes challenging when working memory is strained (Hariharasudan, Rahiman, Nawaz & Panakaje, 2021). As a result, it can be concluded that digital games make significant contributions to the enhancement of students' perceptions of their level of control.

Perceived Learning

The use of digital games in the ICT course, according to students' perceptions of their learning, made learning enjoyable. Digital games that have enjoyable environments, high-quality graphics, sound effects, and other aesthetic features can make learning enjoyable (Prensky, 2003). Students claimed that playing digital games made learning simple, quick, effective, and more lasting. Digital games with clearly defined objectives and tasks

to complete (Koparan, 2021) can guarantee the realization of the aforementioned learning-related situations. This situation may have been improved by incorporating learning materials with various components such as competition, feedback, and reward in digital game-based learning (Chen & Chang, 2020; Tan, Chen & Lee, 2020; Liu, Wang & Lee, 2021). Additionally, by encouraging active participation in the games, the competition, feedback, and rewards offered in accordance with the lesson plan may have ensured that the information is more permanent (Hung, Yang, Hwang, Chu, and Wang, 2018; Lee, 2019). Digital games have been shown in the literature to positively impact learning and a number of learning-related variables (Perrotta et al., 2013; Lester et al., 2014; Pitarch, 2018; Azevedo & Lester, 2020; Koparan, 2021; Cai et al., 2022). The positive effects that students reported for their learning may have been brought on by the use of a remarkable technology that had never been used before in their lessons. The novelty effect could also be to blame for this (Jeno, Vandvik, Eliassen & Grytnes, 2019). In light of these findings, it is clear that the use of digital games in game-based learning in ICT courses helps students perceive learning by positively influencing their learning.

Perceived Benefit

According to the study's findings, students said that playing digital games gave them access to new learning opportunities, enhanced their educational experiences, and improved their performance in academic settings. These findings appear to be directly related to how useful people believe digital games to be. Students successfully overcame their challenges by utilizing the variety of learning opportunities provided by digital games. In fact, students who play digital games have a variety of learning options by doing research (Hsiao, 2007). By utilizing the various features and functions of digital games, students showed significant improvements in their learning. This can be explained by the fact that online games can cater to the various expectations and needs of students while also varying their educational opportunities. Digital games' suitability for individualized instruction and a range of learning preferences might have had an impact. This might also be because digital games are simple to use and offer immediate feedback. According to the National Council for Teachers of Mathematics (NCTM), 2000, games can assist students in continuing their learning processes independently, coming up with alternate solutions for various problem situations, and receiving immediate feedback. By fulfilling the fundamental needs of a learning environment, games can give students interesting learning opportunities (Kiili, 2005). Additionally, games can improve and enrich students' educational experiences, making them more enjoyable and captivating (Anastasiadis, Lampropoulos & Siakas, 2018). In light of the study's findings, digital games were able to improve students' learning outcomes and performance by offering a variety of learning opportunities.

Interest

Students claimed that they had fun and enjoyed the lessons as a result of the use of digital games, according to the study's findings. The characteristics of digital games that make lessons less monotonous and boring can be used to explain this outcome. Additionally, it can be asserted that the inclusion of enjoyable elements in digital games and the provision of enjoyable experiences (Abdul Jabbar & Felicia, 2015; Kim & Lee, 2015) contribute significantly to students' enjoyment of the lessons. Digital games, according to the students, piqued their interest in the lessons and made them easier to carefully follow. Students' curiosity was piqued by the games that were created with unique features for each lesson. Students were able to better concentrate on the lessons because of the much more engaging learning environment created by digital games (Cai et al., 2022). The students' interest in video games and ability to closely follow instructions were both greatly influenced by their curiosity about these mediums. Similar study findings have been reported elsewhere (Sáez-López, Miller, Vázquez-Cano, and Domnguez-Garrido, 2015; Akn and Atc, 2015; Chang, Liang, Chou, and Lin, 2017; Anastasiadis, Lampropoulos, and Siakas, 2018), and they may be found in this context. It is safe to conclude that the games used in digital game-based learning increase students' interest in the subject.

Motivation

Students claimed that playing digital games increased their positive attitudes and sense of confidence toward the lessons, taking into account their opinions on motivation. This situation might have been impacted by the fact that students view digital games as a fun and enjoyable environment. This situation may also be impacted by the fact that students had quick and efficient learning experiences with digital games. Students' confidence may rise as a result of playing successful video games. Additionally, students reported that playing video games improved their performance, self-efficacy, and control over their education. This situation may have been

influenced by students' use of digital games to meet their own standards and objectives. Students were able to perceive themselves as competent in this regard and as possessing the necessary skills. Students took individual responsibility for the lessons in this way, assisted by the use of digital games, and improved their performance in terms of learning. All of the aforementioned circumstances can be said to be motivated by motivation. According to recent research, game-based learning significantly boosts motivation (Koparan, 2021). The findings of studies demonstrating the beneficial effects of digital games on motivation and variables related to motivation can be found in the literature (Bhandari, Hallowell & Correll, 2019; Grivokostopoulou, Kovas, & Perikos, 2019; Yang et al., 2020; Hwang & Chang, 2020; Chang, Kao, Hwang & Lin, 2020; Tapingkae et al., 2020). As a result, in learning environments supported by game-based learning, students' motivation and performance toward learning rise (Hsu, Chen, & Cao, 2017).

Affective Components

The study's findings indicated that liking, enjoying, being happy, curious, and excited were among the positive emotions experienced by students when using digital games. The development of these feelings may have been influenced by the fact that students find digital games entertaining and interesting, and that they enjoy playing them. Due to the fact that students use digital games as a new technology in their lessons, an innovation effect can be mentioned. According to Bendicho, Mora, Aorbe-Daz, and Rivero-Rodriguez (2017) and Jenó et al. (2019), the novelty effect may be to blame for this. Additionally, this situation may have been influenced by the fact that digital games assist students in learning new information, skills, and technological concepts and applications. Students' positive attitudes toward digital games grew as they enjoyed the feeling of success while playing these games. The students' curiosity and excitement were significantly piqued by the content, organization, and variety of the games created separately for each course subject. Similar study findings have been published in the past (Cheng & Su, 2012; Akın & Atıcı, 2015; Koparan, 2021; Cai et al., 2022). On the other hand, some students expressed that they experienced negative emotions while playing games, such as dislike for digital games and dislike for games in general. Use of digital games over an extended period of time might have had an impact. After extended use, favorable effects associated with newly adopted technologies may disappear (Arc, Yılmaz, & Yılmaz, 2021). This might also be a result of students' resistance to playing video games. In actuality, digital games might not be particularly engaging for all students and might divert their attention (Ke, 2008). It could be argued that this makes students feel unfavorably about playing video games.

Attitude

The study's findings demonstrated that students willingly engaged in the lessons using digital games and overcame their prejudices. This suggests that the games used in digital game-based learning help students have positive experiences and fulfill their expectations. According to opinions in this context, students adopt a positive attitude toward educational settings where video games are used. This situation may have been impacted by the fact that digital games efficiently allow interaction between the participant and the content (Anderson et al., 2010). A positive attitude toward the lessons was greatly influenced by the students' involvement in the game action, interactions, and challenges (Calleja, 2011; Barzilai & Blau, 2014). By encouraging enthusiastic participation in the lessons and facilitating the quick and easy acquisition of new knowledge and skills, the use of digital games helped students overcome their negative perceptions of the lessons. The use of digital games in the classroom, according to the students, made their lessons enjoyable. The students may have enjoyed themselves by having a good time in class, developed a positive attitude toward the lessons, and let go of their prejudices as a result. Students' active participation has been facilitated by the fact that digital games significantly increase interaction by appealing to multiple sensory organs, making them love their lessons and feel content in the classroom. The use of digital games by students to improve their academic performance also contributed to the appearance of these results. Literature (Sáez-López et al., 2015; Akın & Atıcı, 2015; Kruger, 2016; Sung & Hwang, 2018; Tapingkae et al., 2020; Taub et al., 2020; Yang, Chang, Hwang & Zou, 2020) contains studies with similar findings. As a result, a sizable majority of students adopted a favorable perspective on video games.

Behavioral Components

The study's findings revealed that a sizable majority of students played digital games regularly and were willing to do so. Students claimed that playing digital games allowed them to learn various subjects. The students'

enthusiastic attitude toward playing video games can be used to explain this. By taking part in and interacting with the game action, students were able to cultivate a positive attitude toward video games (Calleja, 2011; Barzilai & Blau, 2014). This situation might be impacted by the behavioral effects that online games have on students (Plass, Homer, & Kinzer, 2015). This situation may also be affected by the fact that students use digital games for enjoyment while also learning and developing new knowledge, skills, and behaviors. Digital games can foster a positive learning environment by incorporating a variety of educational resources (Chen & Chang, 2020; Tan, Chen & Lee, 2020; Liu, Wang & Lee, 2021). Digital games can also amuse students while bringing about positive behavioral changes in them (Phaire, 2007). On the other hand, some of the students claimed that they only participated in the games because someone else told them to. Students who held this opinion may have developed negative attitudes toward video games, which is what led to the situation. In fact, when it comes to occupying some students, some may find that playing digital games is boring (Koparan, 2021). According to the study's findings, students grew to enjoy playing video games and did so voluntarily and continuously. Additionally, this circumstance improved students' perceptions of using video games to teach them various subjects.

Learning Experience

According to the study's findings, students reported having played digital games that were entertaining, captivating, and simple to use. Due to their aesthetic appeal, entertaining features, and enjoyable settings, digital games may be very engaging for students (Prensky, 2003). The students' active and high level of participation in the lessons was significantly impacted by this. Students found the lessons more engaging thanks to digital games. Students were able to understand and learn concepts that were thought to be complex and difficult through the use of digital games. Additionally, playing online games helped students learn new information and skills more quickly. When used in this setting, digital games may have helped students learn while having fun, interacting with one another during class, overcoming a lack of commitment, and changing their behavior for the better (Phaire, 2007). Studies with comparable results have been published (Ebner & Holzinger, 2007; Akin & Atci, 2015; Abdul Jabbar & Felicia, 2015; Kim & Lee, 2015; Marsh, 2022) in the literature. Students claimed that digital games support individual learning and have content that is related to the course topics. The findings of studies demonstrating how games benefit individualized learning are in this direction (Hsu, Chu & Wang, 2013; Young & Wang, 2014; Lan, 2015; Hwang & et al., 2017). Digital games that are compatible with the course material can be played repeatedly, which helps students learn the material in the courses effectively. Digital games that were created with students' learning needs in mind were able to significantly support individual learning at the same time. This might have been because digital games allowed students to move at their own pace and repeat lessons they needed to learn in a way and quantity that suited them. In fact, when prepared by taking into account the unique needs and interests of students, digital games can be very effective in fostering the most suitable learning environment (Magerko, Heeter, Fitzgerald & Medler, 2008). Given this situation and the study's findings, it is clear that digital games used in game-based learning significantly enhance the learning experiences of students.

Recommendations

Considering the results of the study, the following suggestions can be made.

- The limited number of studies in the literature that examine the effects of digital games used in digital game-based learning on different variables based on qualitative research approaches can be increased.
- The study was conducted with associate degree students in the biochemistry department. Future studies can be conducted with different study groups.
- Games used in digital game-based learning support active participation by creating fun, enjoyable and highly interactive learning environments. Digital games used in digital game-based learning can be used in technology-oriented courses to improve students' learning experiences.
- Since digital games used in digital game-based learning have significant positive contributions to different variables related to students, more effective learning environments can be created using this method.
- It was understood that digital games used in digital game-based learning are interesting and motivating. In this respect, digital games can be utilized in different courses.

- It was revealed that students got rid of their prejudices about the course with digital games. In this context, digital games can be used in technology-oriented and different courses to eliminate student prejudices.
- It was understood that students developed positive attitudes towards lessons thanks to digital games. Considering this situation, digital games can be used to change students' attitudes towards different courses.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the author.

References

- Abdul Jabbar, A. I., & Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of Educational Research*, 85(4), 740–779. <https://doi.org/10.3102/0034654315577210>.
- Akın, F. A. & Atıcı, B. (2015). The effect of game-based learning environments on student success and opinions. *Turkish Journal of Educational Studies*, 2(2), 75-102.
- Anastasiadis, T., Lampropoulos, G., & Siakas, K. (2018). Digital game-based learning and serious games in education. *International Journal of Advances in Scientific Research and Engineering*, 4(12), 139-144. <https://doi.org/10.31695/IJASRE.2018.33016>.
- Anderson, E. F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., & De Freitas, S. (2010). Developing serious games for cultural heritage: a state-of-the-art review. *Virtual Reality*, 14(4), 255-275. <https://doi.org-10.1007/s10055-010-0177-3>.
- Arcı, F., Yılmaz, R. M., & Yılmaz, M. (2021). Affordances of augmented reality technology for science education: Views of secondary school students and science teachers. *Human Behavior and Emerging Technologies*, 3(5), 1153-1171. <https://doi.org/10.1002/hbe2.310>.
- Barzilai, S., & Blau, I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences. *Computers & Education*, 70, 65-79. <https://doi.org/10.1016/j.compedu.2013.08.003>.
- Bendicho, P. F., Mora, C. E., Añorbe-Díaz, B., & Rivero-Rodríguez, P. (2017). Effect on academic procrastination after introducing augmented reality. *Eurasia Journal of Mathematics, Science and Technology Education*, 13, 319–330. <https://doi.org/10.12973/eurasia.2017.00618a>.
- Bhandari, S., Hallowell, M. R., & Correll, J. (2019). Making construction safety training interesting: A field-based quasi-experiment to test the relationship between emotional arousal and situational interest among adult learners. *Safety Science*, 117, 58–70. <https://doi.org/10.1016/j.ssci.2019.03.028>.
- Cai, Z., Mao, P., Wang, D., He, J., Chen, X., & Fan, X. (2022). Effects of scaffolding in digital game-based learning on student's achievement: a Three-level meta-analysis. *Educational Psychology Review*, 34, 1-38. <https://doi.org/10.1007/s10648-021-09655-0>.
- Calleja G., (2011). *In-game: from immersion to incorporation*. MIT Press, Cambridge, MA, London, UK.
- Chang, C. C., Liang, C., Chou, P. N., & Lin, G. Y. (2017). Is game-based learning better in flow experience and various types of cognitive load than non-gamebased learning? Perspective from multimedia and media richness. *Computers in Human Behavior*, 71, 218-227. <https://doi.org/10.1016/j.chb.2017.01.031>.
- Chang, C. Y., Kao, C. H., Hwang, G. J., & Lin, F. H. (2020). From experiencing to critical thinking: A contextual game-based learning approach to improving nursing students' performance in electrocardiogram training. *Educational Technology Research & Development*, 68, 1225–1245. <https://doi.org/10.1007/s11423-019-09723-x>.
- Chen, S. Y., & Chang, Y. M. (2020). The impacts of real competition and virtual competition in digital game-based learning. *Computers in Human Behavior*, 104, 106171. <https://doi.org/10.1016/j.chb.2019.106171>.
- Chen, X., Zou, D., Cheng, G. & Xie, H. (2020). Detecting latent topics and trends in educational technologies over four decades using structural topic modeling: A retrospective of all volumes of Computers & Education. *Computers & Education*, 151, 103855. <https://doi.org/10.1016/j.compedu.2020.103855>.
- Cheng, C. H., & Su, C. H. (2012). A Game-based learning system for improving student's learning effectiveness in system analysis course. *Procedia-Social and Behavioral Sciences*, 31, 669-675. <https://doi.org/10.1016/j.sbspro.2011.12.122>.

- Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research*, 86(1), 79–122. <https://doi.org/10.3102/0034654315582065>.
- Clegg, S., Hudson, A., & Steel, J. (2003). The emperor's new clothes: Globalisation and elearning in higher education. *British Journal of Sociology of Education*, 24(1), 39–53. <https://doi.org/10.1080/01425690301914>.
- Creswell, J.W. (2013). *Research design: Qualitative, quantitative, and mixed-methods approaches*. Boston: Sage Publications.
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Thousand Oaks, CA: Sage.
- Cunskaa, A., & Savicka, I. (2012). Use of ICT teaching-learning methods make school math blossom. *Procedia-Social and Behavioral Sciences*, 69, 1481-1488. <https://doi.org/10.1016/j.sbspro.2012.12.089>.
- Digital Games Report, (2020). *Digital games information platform [Information Technologies and Communications Authority]*. Access address: <https://www.guvenlioyna.org.tr/dosya/jVFeB.pdf>.
- Dindar, M. (2018). An empirical study on gender, video game play, academic success and complex problem solving skills. *Computers & Education*, 125, 39–52. <https://doi.org/10.1016/j.compedu.2018.05.018>.
- Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & Education*, 49(3), 873-890. <https://doi.org/10.1016/j.compedu.2005.11.026>.
- Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, 62, 107–115. <https://doi.org/10.1111/j.1365-2648.2007.04569.x>.
- Erdoğan, Y. K. (2020). *Investigation of pedagogical agent and feedback types by academic success, flow experience and cognitive load in a game based learning environment*. (Doctoral dissertation). Retrieved from Council of Higher Education Thesis Center. (624421)
- Foster, A., & Shah, M. (2016). Knew me and new me: Facilitating student identity exploration and learning through game integration. *International Journal of Gaming and Computer-Mediated Simulations*, 8(3), 39-58. <https://doi.org/10.4018/IJGCMS.2016070103>.
- Fullan, M., & Langworthy, M. (2013). *Towards a new end: New pedagogies for deep learning*. Seattle, WA: Collaborative Impact. Access address: http://www.newpedagogies.info/wp-content/uploads/2014/01/New_Pedagogies_for_Deep%20Learning_Whitepaper.pdf.
- Gentry, S. V., Gauthier, A., L'Estrade Ehrstrom, B., Wortley, D., Lilienthal, A., Car, L. T., ... Car, J. (2019). Serious gaming and gamification education in health professions: Systematic review. *Journal of Medical Internet Research*, 21(3), 1–20. <https://doi.org/10.2196/12994>.
- Ghoman, S. K., Patel, S. D., Cutumisu, M., Hauff, P. V., Jeffery, T., Brown, M. R. G., & Schmölzer, G. M. (2019). Serious games, a game changer in teaching neonatal resuscitation? A review. *Archives of Disease in Childhood. Fetal and Neonatal Edition*, 1–10. <http://dx.doi.org/10.1136/archdischild-2019-317011>.
- Grivokostopoulou, F., Kovas, K., & Perikos, I. (2019). Examining the impact of a gamified entrepreneurship education framework in higher education. *Sustainability*, 11, 5623. <https://doi.org/10.3390/su11205623>.
- Gu, C., Chen, J., Lin, J., Lin, S., Wu, W., Jiang, Q., Chun, Y., & Wei, W. (2022). The impact of eye-tracking games as a training case on students' learning interest and continuous learning intention in game design courses: Taking flappy bird as an example. *Learning and Motivation*, 78, 101808. <https://doi.org/10.1016/j.lmot.2022.101808>.
- Hamari, J., Shernof, D. J., Rowe, E., Collier, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, 54, 170–179. <https://doi.org/10.1016/j.chb.2015.07.045>.
- Hariharasudan, A., Rahiman, H. U., Nawaz, N., & Panakaje, N. (2021). Strategic influence of business english in management education. *Polish Journal of Management Studies*, 23(2), 180. <https://doi.org/10.17512/pjms.2021.23.2.11>.
- Hong, K. S., & Songan, P. (2011). ICT in the changing landscape of higher education in Southeast Asia. *Australasian Journal of Educational Technology*, 27(8), 1276-1290. <https://doi.org/10.14742/ajet.893>.
- Hsiao, H. C. (2007, March). A brief review of digital games and learning. In *2007 First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning (DIGITEL'07)*, pp. 124-129.
- Hsiao, H.-S., Chang, C.-S., Lin, C.-Y., Chang, C.-C., & Chen, J.-C. (2014). The influence of collaborative learning games within different devices on student's learning performance and behaviours. *Australasian Journal of Educational Technology*, 30(6), 652–669. <https://doi.org/10.14742/ajet.347>.
- Hsieh, H. F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15, 1277–1288. <https://doi.org/10.1177/1049732305276687>.

- Hsu, C. Y., Chu, F. C., & Wang, H. Y. (2013, June). Embedding collaboration into a game with a self-explanation design for science learning. *In Proc. 21st Int. Conf. Comput. Educ. Indonesia, Asia-Pacific Soc. Comput. Educ.*, pp. 116-121.
- Hsu, C., Chen, C., & Cao, D. (2017, July). Effect of design factors of game-based English vocabulary learning APP on learning performance. *In 6th ILAI International Congress on Advanced Applied Informatics*, pp. 661-666.
- Hu, X., & Wise, K. (2020). Perceived control or haptic sensation? Exploring the effect of image interactivity on consumer responses to online product displays. *Journal of Interactive Advertising*, 20(1), 60-75. <https://doi.org/10.1080/15252019.2019.1707729>.
- Hung, H. T., Yang, J. C., Hwang, G. J., Chu, H. C., & Wang, C. C. (2018). Ascoping review of research on digital game-based language learning. *Computers & Education*, 126, 89-104. <https://doi.org/10.1016/j.compedu.2018.07.001>.
- Hwang, G. J., & Chang, C. Y. (2020). Facilitating decision-making performances in nursing treatments: A contextual digital game-based flipped learning approach. *Interactive Learning Environments*, 1-16. <https://doi.org/10.1080/10494820.2020.1765391>.
- Hwang, G. J., Hsu, T. C., Lai, C. L., & Hsueh, C. J. (2017). Interaction of problem-based gaming and learning anxiety in language students' English listening performance and progressive behavioral patterns. *Computers & Education*, 106, 26-42. <https://doi.org/10.1016/j.compedu.2016.11.010>.
- Jeno, L. M., Vandvik, V., Eliassen, S., & Grytnes, J. A. (2019). Testing the novelty effect of an m-learning tool on internalization and achievement: A self-determination theory approach. *Computers and Education*, 128, 398-413. <https://doi.org/10.1016/j.compedu.2018.10.008>.
- Karasar, N. (2014). *Scientific research method*. Ankara: Nobel Publishing.
- Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay?. *Computers & Education*, 51(4), 1609-1620. <https://doi.org/10.1016/j.compedu.2008.03.003>.
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education*, 8(1), 13-24. <https://doi.org/10.1016/j.iheduc.2004.12.001>.
- Kim, J. T., & Lee, W. H. (2015). Dynamical model for gamification of learning (DMGL). *Multimedia Tools and Applications*, 74(19), 8483-8493. <https://doi.org/10.1007/s11042-013-1612-8>.
- Koparan, T. (2021). Investigation of reflections from the digital game-based learning environment in higher education. *Journal of Higher Education and Science*, 11(3), 503-515. <https://doi.org/10.5961/jhes.2021.470>.
- Kruger, M. (2016). *A comparative study of student performance when using minecraft as a learning tool*. (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global.(1881841972).
- Lan, Y. J. (2015). Contextual EFL learning in a 3D virtual environment. *Language Learning & Technology*, 19(2), 16-31.
- Lee, S. M. (2019). Her story or their own stories? Digital game-based learning, student creativity, and creative writing. *ReCALL*, 31(3), 238-254. <https://doi.org/10.1017/S0958344019000028>.
- Lester, J.C., Spires, H.A., Nietfeld, J.L., Minogue, J., Mott, B.W. & Lobeni, E.V. (2014). Designing game-based learning environments for elementary science education: A narrative centered learning perspective. *Journal of Information Science*, 264, 4-18. <https://doi.org/10.1016/j.ins.2013.09.005>.
- Liu, Y. C., Wang, W. T., & Lee, T. L. (2021). An integrated view of information feedback, game quality, and autonomous motivation for evaluating game-based learning effectiveness. *Journal of Educational Computing Research*, 59(1), 3-40. <https://doi.org/10.1177/0735633120952044>.
- Magerko, B., Heeter, C., Fitzgerald, J., & Medler, B. (2008). Intelligent adaptation of digital game-based learning [Paper presentation]. *Proceedings of the 2008 Conference, on Future Play: Research, Play, Share*, 200-203.
- Marsh, A., J., (2022). *Improving differentiated digital game-based learning*. (Doctoral dissertation). Retrieved from Doctor of Education in Secondary Education Dissertations. (35)
- Mayer, R. E. (2019). Computer games in education. *Annual Review of Psychology*, 70(1), 531-549. <https://doi.org/10.1146/annurev-psych-010418-102744>.
- Merriam, S. B. (2010). Qualitative case studies. In P. Peterson, E. Baker, & B. McGaw (Eds.), *International encyclopedia of education* (3rd ed., pp. 456-462). Elsevier Ltd. <https://doi.org/10.1016/B978-0-08-044894-7.01532-3>.
- National Council for Teachers of Mathematics (NCTM) (2015). *Strategic use of technology in teaching and learning mathematics a position of the National Council of Teachers of Mathematics*. Reston, VA: NCTM.
- Newzoo Global Games Market Report (2021). <https://newzoo.com/insights/trend-reports/newzoo-global-games-market-report-2021-free-version>.
- Norman, K. L. (2011). Assessing the components of skill necessary for playing video games. *Human-Computer Interaction Technical Report*, 1, 11-24.

- Overmars, S., & Poels, K. (2015). Online product experiences: The effect of simulating stroking gestures on product understanding and the critical role of user control. *Computers in Human Behavior*, 51, 272-284. <https://doi.org/10.1016/j.chb.2015.04.033>
- Papastergiou, M. (2009). Exploring the potential of computer and video games for health and physical education: A literature review. *Computers & Education*, 53(3), 603-622. <https://doi.org/10.1016/j.compedu.2009.04.001>.
- Park, J., Kim, S., Kim, A., & Mun, Y. Y. (2019). Learning to be better at the game: Performance vs. completion contingent reward for game-based learning. *Computers & Education*, 139, 1-15. <https://doi.org/10.1016/j.compedu.2019.04.016>.
- Peeraer, J., & Van Petegem, P. (2011a). Information and communication technology in teacher education in an emerging developing country: Vietnam's baseline situation at the start of 'the year of ICT'. *Computers & Education*, 56(4), 974-982. <https://doi.org/10.1016/j.compedu.2010.11.015>.
- Peeraer, J., & Van Petegem, P. (2012). Measuring integration of information and communication technology in education: An item response modeling approach. *Computers & Education*, 58(4), 1247-1259. <https://doi.org/10.1016/j.compedu.2011.12.015>.
- Peeraer, J., & Van Petegem, P. (2015). Integration or transformation? Looking in the future of information and communication technology in education in Vietnam. *Evaluation and Program Planning*, 48, 47-56. <https://doi.org/10.1016/j.evalprogplan.2014.09.005>
- Perrotta, C., Featherstone, G., Aston, H. & Houghton, E. (2013). *Game-based learning: Latest evidence and future directions*. Berkshire, UK: National Foundation for Educational Research
- Phaire, C. B. (2007). Video games and mathematics education: Studying commercial sports video games to identify the potential for learning and thinking about mathematics. In *Proceedings of the Ninth International Conference Mathematics Education in a Global Community* (pp. 1993-1995).
- Pitarch, R. C. (2018). An approach to digital game-based learning: Video-games principles and applications in foreign language learning. *Journal of Language Teaching and Research*, 9(6), 1147-1159. <http://doi.org/10.17507/jltr.0906.04>.
- Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational Psychologist*, 50(4), 258-283. <https://doi.org/10.1080/00461520.2015.1122533>.
- Power, C. (2007). Educational research, policy and practice in an era of globalisation. *Educational Research for Policy and Practice*, 6(2), 87-100. <https://doi.org/10.1007/s10671-007-9016-z>.
- Pratama, L. D., & Setyaningrum, W. (2018). GBL in math problem solving: Is it effective? *International Journal of Interactive Mobile Technologies*, 12(6), 101-111. <https://doi.org/10.3991/ijim.v12i6.8658>.
- Prensky, M. (2003). Digital game-based learning. *Computer Entertainment*, 1(1), 21. <https://doi.org/10.1145/950566.950596>.
- Reynolds, B. L., & Kao, C. W. (2021). The effects of digital game-based instruction, teacher instruction, and direct focused written corrective feedback on the grammatical accuracy of English articles. *Computer Assisted Language Learning*, 34(4), 462-482. <https://doi.org/10.1080/09588221.2019.1617747>.
- Sáez-López, JM, Miller, J., Vázquez-Cano, E., & Domínguez Garrido, MC (2015). Exploring application, attitudes and integration of video games: MinecraftEdu in middle school. *Educational Technology & Society*, 18(3), 114-128.
- Sarıgöz, O., Bolat, Y., & Alkan, S. (2018). Digital educational game usage scale: Adapting to Turkish, validity and reliability study. *World Journal of Education*, 8(5), 130-138. <https://doi.org/10.5430/wje.v8n5p130>.
- Savaş, S., Güler, O., Kemal, K., Çoban, G., & Güzel, M. S. (2021). Digital games in education and learning through games. *International Journal of Active Learning*, 6(2), 117-140. <https://doi.org/ijal.1014960>.
- Stewart, J., Bleumers, L., Van Looy, J., Mariën, I., All, A., Schurmans, D., ... & Misuraca, G. (2013). *The potential of digital games for empowerment and social inclusion of groups at risk of social and economic exclusion: evidence and opportunity for policy*. Joint Research Centre, European Commission.
- Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage Publications, Inc. <https://doi.org/10.4135/9781452230153>.
- Sung, H., & Hwang, G. (2018). Facilitating effective digital game-based learning behaviors and learning performances of students based on a collaborative knowledge construction strategy. *Interactive Learning Environments*, 26(1), 118-134. <https://doi.org/10.1080/10494820.2017.1283334>.
- Tan, C. C., Chen, C. M., & Lee, H. M. (2020). Effectiveness of a digital pen-based learning system with a reward mechanism to improve learners' metacognitive strategies in listening. *Computer Assisted Language Learning*, 33(7), 785-810. <https://doi.org/10.1080/09588221.2019.1591459>.
- Tapingkae, P., Panjaburee, P., Hwang, G. J., & Srisawasdi, N. (2020). Effects of a formative assessment-based contextual gaming approach on students' digital citizenship behaviours, learning motivations, and perceptions. *Computers & Education*, 159, 103998. <https://doi.org/10.1016/j.compedu.2020.103998>.

- Taub, M., Sawyer, R., Smith, A., Rowe, J., Azevedo, R., & Lester, J. (2020). The agency effect: The impact of student agency on learning, emotions, and problem-solving behaviors in a game-based learning environment. *Computers & Education*, 147, 103781. <https://doi.org/10.1016/j.compedu.2019.103781>.
- Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning*, 35(3), 407–420. <https://doi.org/10.1111/jcal.12347>.
- Tsai, Y. L., & Tsai, C. C. (2020). A meta-analysis of research on digital game-based science learning. *Journal of Computer Assisted Learning*, 36, 280–294. <https://doi.org/10.1111/jcal.12430>.
- Tubin, D. (2006). Typology of ICT implementation and technology applications. *Computers in the Schools*, 23(1/2), 85–98. https://doi.org/10.1300/J025v23n01_08.
- Tüzün, H., Akıncı A., Yıldırım D. & Sırakaya M. (2016). Computer games and learning. In K. Çağıltay ve Y. Göktaş (Eds.), *Fundamentals of instructional technologies: Theories, research, trends* (pp. 597-614). Ankara: Pegem.
- Wei, C. W., Kao, H. Y., Lu, H. H., & Liu, Y. C. (2018). The effects of competitive gaming scenarios and personalized assistance strategies on English vocabulary learning. *Educational Technology & Society*, 21(3), 146–158.
- Whitton, N. (2010). *Learning with digital games: A practical guide to engaging students in Higher Education*. New York, NY: Routledge.
- Wouters, P., & van Oostendorp, H. (2013). A meta-analytic review of the role of instructional support in gamebased learning. *Computers & Education*, 60, 412–425. <https://doi.org/10.1016/j.compedu.2012.07.018>.
- Yang, J. C., Chung, C. J., & Chen, M. S. (2022). Effects of performance goal orientations on learning performance and in-game performance in digital game-based learning. *Journal of Computer Assisted Learning*, 38(2), 422-439. <https://doi.org/10.1111/jcal.12622>.
- Yang, Q. F., Chang, S. C., Hwang, G. J., & Zou, D. (2020). Balancing cognitive complexity and gaming level: Effects of a cognitive complexity-based competition game on EFL students' English vocabulary learning performance, anxiety and behaviors. *Computers & Education*, 148, 103808. <https://doi.org/10.1016/j.compedu.2020.103808>.
- Yin, R. K. (2013). Validity and generalization in future case study evaluations. *Evaluation*, 19(3), 321–332. <https://doi.org/10.1177/1356389013497081>.
- Young, S. S. C., & Wang, Y. H. (2014). The game embedded CALL system to facilitate English vocabulary acquisition and pronunciation. *Journal of Educational Technology & Society*, 17(3), 239–251.

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