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Exploring the Impact of Digital Game Design Instruction on Candidate Science Teachers' Perceptions of Digital Games in Science Education

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This study aims to explore the integration of the digital game strategy into teaching by providing candidate science teachers with training in game design and examining how this process influences their related perspectives. It was conducted within a qualitative research framework, the participants were selected using criterion-based approach and the RPG Maker program that does not require coding skills was utilized. The game design training spanned six weeks, encompassing program introduction and hands-on activities. Data collection tools included a digital game-based learning questionnaire, case scenario forms, and a 5E model lesson plan form. The collected data were analyzed using content analysis, and findings were presented in tabular format. The findings revealed that some candidate science teachers initially held negative views on using digital games in teaching; however, their attitudes shifted positively following the training process. Moreover, a significant portion of participants who had no specific opinion on the use of digital games prior to the training developed positive perspectives afterward. This shift was primarily attributed to the recognition that digital game-based teaching could foster a student centered learning environment and encourage more active participation from both teachers and students. During the training, digital games were rarely utilized in the engagement, exploration, and explanation phases. Nonetheless, following the training, participants demonstrated increased preferences for incorporating digital games in these phases. The study concluded that the digital game design training positively influenced candidate science teachers' perceptions of digital game usage in science education and effectively challenged some of their initial biases.

Introduction

The development of technological tools in our age has also caused an innovative effect in the field of education. Educators and teachers prefer to use digital tools in order to interact with their students and enrich their learning experiences (Mishra & Koehler, 2006). This

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situation has also brought about a transformation in the field of education and technology as an important tool for transferring information has also become a tool that allows students to develop skills such as critical thinking and problem solving (Meng et al., 2025; Topuz & Göktaş, 2015).In addition, considering that new generations are growing up in more technologically advanced environments (Karamustafaoğlu & Kılıç, 2020), it becomes obvious that educational environments should be equipped with technological tools in order to make them feel like in their natural environment and contribute to their development (Chang et al., 2025; Patton & Knochel, 2017; Timur et al., 2020).

A significant portion of the technological tools that can be used in education are gathered under the umbrella of Web 2.0. Web 2.0 symbolizes a paradigm that provides individuals with the opportunity to interact with each other, not only consume content but also produce content, and share the products they produce. Web 2.0 tools were developed so that users could interact online and increase their content creation skills, and in this context, they have deeply affected the field of education by offering various opportunities to students and teachers (Daud et al., 2012; Gün, 2015; Urooj et al., 2023). Since they provide teachers with the opportunity to create different learning environments, Web 2.0 tools support professional development and contribute to the formation of a contemporary, student-centered, and active participation-based contexts by challenging traditional paradigms in education (Bünül, 2019; Su et al., 2010; Yang et al., 2014).

The training of candidate science teachers to use student-centered strategies will equip future teachers with problem-solving, critical thinking, and digital literacy skills, and will also provide them with the opportunity to better manage interactive classroom environments (Voogt & McKenney, 2017). This will provide teacher candidates with the opportunity to create more diverse learning environments for students and increase their skills in integrating technology into their lessons (Akkaya, 2019; Hixon & So, 2009; Tondeur et al., 2025). Regular developments in information and communication technologies require teachers to use digital tools effectively in the classroom and provide students with the skills of our age (Niess, 2011). For this reason, the curriculum of education faculties should adapt to the changes in technology in daily life and should be constantly updated (Funan, 2024; Swerzenski, 2021; Yanpar-Yelken et al., 2007).

In order to increase success in education and to provide schools with access to technology that can support current curriculum, UNESCO and the People's Republic of China have jointly organized economic programs (Teo et al., 2018). In our country, just like in China, various investments have been made and projects have been carried out in order to improve the technological infrastructure of schools. One of the most comprehensive of these projects is undoubtedly the FATİH project (Yılmaz, 2020). Within the scope of this project, large investments have been made in schools in our country, smart boards have been placed in schools and tablets have been distributed to students. However, research findings are not adequate regarding whether the FATİH project has been successful at the desired level (Bozkuş & Karacabey, 2019). One of the possible reasons for this situation is that teachers are not sufficiently prepared for this project technologically and do not have the competence to use current technologies in the classroom effectively. It is obvious that it is necessary to start from the basics in order to prepare teachers for such technology enriched learning environments and with this perspective, in this research, a digital game development process has been planned with a Web 2.0 tool that can be used synchronously with technological devices in the classroom.

A review of the relevant literature indicates that studies examining pre-service teachers' views on digital game-based learning strategies are prominent. In this context, while Akgül and Kılıç (2020), İşçi and Yeşiltaş (2020), and Uluay (2017) introduced the Kodu game engine to pre-service teachers, Uzunboylu et al. (2020) focused on their experiences using Kahoot. Similarly, Hsu and Chiou (2019) and Wells and Fotaris (2017) serve as examples of studies examining pre-service teachers' perceptions of the subject. In addition to investigating candidates' views, Sardone and Scherer (2009) explored their guidance roles within the classroom, while Hu and Sperling (2022) analyzed through interviews, at which stage of the lesson digital games should be utilized. While tools such as Kodu and Kahoot are generally widespread in applied studies, it is observed that studies conducted with RPG Maker are limited. Based on the premise that different game engines offer distinct educational experiences, RPG Maker was preferred in this research due to the extensive design possibilities it offers. Furthermore, since this study addresses teacher roles and game integration processes, it serves a synthesizing function within the literature.

Digital games are tools that can easily attract students' attention, concretize abstract topics with the support of visual materials, and provide an effective learning environment with the use of the right tools in the right subjects (Karamustafaoğlu & Kılıç, 2020). Considering the abundance of abstract concepts in science classes in particular, the strengths of digital games can also be used as an important opportunity by teachers against this difficulty. For this reason, in this study it was planned to work with candidate science teachers and aimed to provide them with experience in designing and integrating digital games into learning environments. For such an experience, the RPG Maker digital game platform was preferred since it does not require coding skills that teacher candidates are not expected to have. In this context, the aim of this research was to provide digital game production training to science teacher candidates, to enable them to produce digital games, and to discover how their views on this subject are affected by the intervention. In accordance with this aim the research questions were as follows:

(1) How were candidate science teachers' perceptions regarding the use of digital games in science education evolved with their digital game design teaching experience?
(2) How were candidate science teachers' perceptions regarding the roles of teachers and students in digital game-based science education evolved with their digital game design teaching experience?
(3) How were candidate science teachers' digital game-based science teaching perspectives evolved with their digital game design teaching experience?

Method

Research design

The research was planned as a case study (Creswell, 2013) since the aim of the study was to investigate the views of candidate science teachers regarding digital games in science education in their natural context. The participants, data collection tools, intervention, data analysis process and validity, reliability issues are presented below.

Participants

The study group of the research was determined as 3rd grade students (5 males, 36 females) studying in the Department of Science Education at a public university. The study was carried out in the "Science Education I" course in the 2023-2024 Fall semester. The study group was determined by the criterion-based sampling method that based on the examination of situations that coincide with predetermined criteria (Creswell, 2013).

The first sampling criterion was the accessibility principle. The study was conducted at major public university, where the researcher was studying, in order to provide ease of transportation. The second sampling criterion that was taken into consideration was the researcher's ability to control the environmental conditions. The study was conducted in a computer laboratory in accordance with its context and objectives, the entire process was planned from beginning to end with the relevant course instructor, and thus the environmental conditions were kept under control. The context of the course in which the study would be conducted was the third sampling criterion. The scope of the "Science Teaching I" course in which the study was conducted aimed to transfer modern strategies to science teacher candidates and was in accordance with the content of the study. The last sampling criterion was being volunteer. A volunteering form was distributed to all teacher candidates participating in the study before the study and it was documented that they were volunteers.

Data collection tools

In the study, the Digital Game-Based Learning Questionnaire (DGBLQ), the Sample Case Form (SCF) and the 5E Model Lesson Plan Form (5ELPF) were used in order to determine how the opinions of science teacher candidates were affected by the digital game-based teaching intervention.

Digital game-based learning questionnaire (DGBLQ)

DGBLQ was used to reveal the participants' opinions about the digital game-based teaching strategy and its initial form (consisting of 12 open-ended questions) was developed by the researchers with taking into consideration all the sub-problems of the research. It presented to a science education expert and a measurement and evaluation expert in order to ensure that the questions were valid, clear and understandable. According to the experts' advice, one question was removed and two intersecting questions were combined and DGBLQ was made ready for the intervention process with 10 questions. A sample question from DGBLQ is presented below:

- Do you think digital games should become a part of science education? Why?

Sample case form (SCF)

SCF was used to examine the reactions and behaviors of the participants to various situations related to the use of digital games and to reveal their understanding of the role of the teacher in such a process. The initial draft of SCF (consisting of 12 sample cases) was developed by the researchers with taking into consideration the second sub-problem of the research. It presented to a science education expert and a measurement and evaluation expert to ensure that the sample case fictions were valid, clear and understandable. According to the experts' advice, the two cases were combined and the SCF was given its final form with 10 sample cases. A sample case scenario from SCF is presented below:

- Student: Teacher, when I tell my family that we're using digital games to learn at school, they get angry at me. They say, "Are we sending you to school to play games?"

5E Model lesson plan form (5ELPF)

5ELPF was used to discover the teaching approaches of candidate science teachers in digital game-based science education and to seek answers to the third sub-problem of the study. Therefore, rather than testing candidates'ability to develop 5E plans, it was aimed to determine at which stages they would prefer to use digital games in learning environments. The reason for preferring the 5E model was the participants' experience regarding this model.

Data analysis

In this study, the content analysis method was used in the analysis process of the data obtained from DGBLQ, SCF and 5ELPF. Content analysis is a method of classifying the message contained in verbal and written materials in an objective and systematic way in terms of meaning, converting them into numbers and making inferences (Hermann, 2008). The analysis process was performed by following the stages of data editing, pre-reading, code generation from data, code organization, and code grouping under certain themes respectively (Creswell, 2013). In the data editing phase, diverse data were labelled individually on a participant basis (e.g. for the first candidate science teacher as CST1). In the pre-reading phase, the data of each candidate were reviewed in their own context to obtain the narratives related to the research questions and brief explanatory notes were taken for these narratives. Then, the whole data were reviewed in detail in order to perform comparative evaluations both individually and with other participants to generate codes representing the content of these narratives with the help of brief notes taken in the pre-reading phase. Lastly, the list of generated codes was reviewed to combine the overlapping or repetitive ones, and the analysis process was completed by grouping the relevant codes under certain themes.

Intervention

The intervention process of the research was carried out in the computer laboratory with candidates taking the "Science Education I" course. The workflow diagram of the intervention process is presented in Figure 1 below.

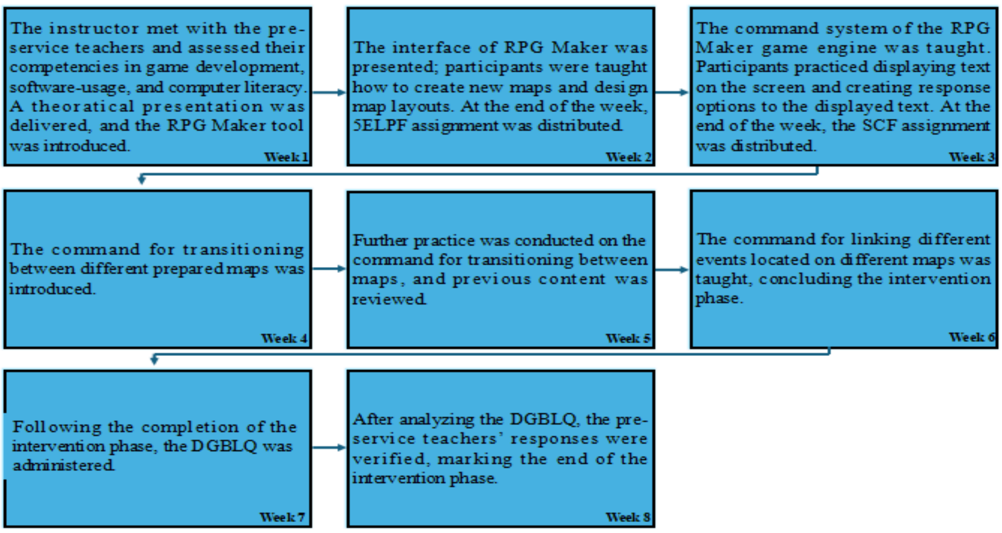

Figure 1.Workflow Diagram of Digital Game Design Instruction

To design the intervention process of the research in a healthier way, the game development experiences and software, computer usage competencies of candidates were evaluated by discussion in class in the first week. It was determined that all the teacher candidates had basic level of computer usage competency. In line with the feedback obtained, the intervention process was shaped and organized in accordance with the general knowledge levels of the participants. To increase the efficiency of the research, an informative presentation was made to the teacher candidates about the benefits of using digital games in the classroom, the importance of digital games in accordance with the needs of the age, and the skills that digital game design will provide to the teacher candidates. In this context, the RPG Maker game engine was introduced and brief information was provided about the program's definition, function and reasons for preference, and procurement and installation methods. After the presentation, a discussion was held with the teacher candidates about the use of digital games in science education and it was observed that their motivation to learn the game designing process was high. The first week was completed after the teacher candidates downloaded the RPG Maker program.

In the second week of the intervention, the basic features of the RPG Maker program were introduced to the candidate science teachers. The program interface, tools and icons were explained; basic functions such as creating, editing, painting and using the "event" buttons were demonstrated. The training was carried out by answering the candidate science teachers' questions and expecting them to complete each stage. At the end of the week, the candidate science teachers gained basic map design skills. They were given homework to design maps related to science topics, and the 5ELPF was distributed to them for the third sub-problem of the research. They were asked to choose a science topic and plan a one-hour science lesson. In the plans, the use of digital games was left optional.

In the third week of the intervention, the 5E lesson plans and game maps prepared by teacher candidates were examined, and creative designs were encouraged by giving examples. Then, the “event” system, which allows adding content to maps in the RPG Maker game engine, was introduced. Basic commands such as “Show Text”, “Show Choices” and “Erase Event” were taught to candidate science teachers, and each candidate was individually supported in learning the commands. At the end of the week, the candidate science teachers were asked to design their first games by adding dialogues and texts to the game maps with these commands. In addition, the SCF was distributed for the second sub-problem of the research and they were asked to fill it out. In this way, the intervention and data collection process of the third week was completed.

In the fourth week, teacher candidates' answers for SCF were collected and feedback was given on their homework regarding their initial game designs. Then, systems for adding new maps to the game and switching between maps were taught. Using the "Transfer Player" command, the teacher candidates designed more than one map, added conversational content to these maps, and learned to establish connections between maps. At the end of the week, they were given the homework of designing a game that included at least three maps, where the maps were connected to each other, and included the learned commands.

The fifth week started with the examination of the game designs developed by teacher candidates. It was seen that the candidates understood how to use the program to a large extent, but some candidates had problems with the "Transfer Player" command. Therefore, this command was repeated and continued with one-on-one support. At the end of the week, the "Control Switches" command, which connects events between maps, was introduced and practices were carried out regarding this command. The training was completed by giving homework to the teacher candidates regarding the "Transfer Player" command.

The sixth week began with examining the digital games of the teacher candidates and teaching the details of the "Control Switches" command. It was emphasized that this command provided the opportunity to establish complex connections between games and develop creative systems. At the end of the intervention, the candidates learned basic game development skills and reached a level where they could apply them. Throughout the process, individual problems were solved patiently and the teacher candidates were thanked for their contributions. The candidates stated that they gained a new skill during this process.

In the seventh week, the DGBLQ was distributed to teacher candidates and they were asked to answer questions sincerely. All the candidates answered the questions individually and independently of external influences. The data collection process was completed one week later by re-discussing the answers of ten participants individually in order to have idea about the validity of data analysis process. Thus, the interventionand data collection processes ended in a total of eight weeks.

Validity and reliability

The validity issue of this research was examined on internal and external dimensions with several techniques as stated by Creswell (2013). Firstly, the researchers established a long-term and close interaction with the participants in the field. The intervention and data collection process was completed in eight weeks and the researchers established sincere communication with the participants in their natural environment. Secondly, comprehensive data were collected for the same purpose by using different data collection tools in order to provide triangulation. Thirdly, researchers advanced the process by taking into consideration the opinions of experts and science teacher candidates. The intervention process was shaped in line with the suggestions received from science education experts and feedback received from candidates. Fourthly, after all the data were analyzed, the analysis results of ten participants were discussed with them to confirm the accuracy of analysis process. Lastly, the research process with its all phases was presented transparently in detail.

The reliability issue of the study was assessed by using the inter-coder agreement technique. Two independent researchers coded the responses of the candidates and the similarity of the coding results was calculated. The initial agreement rate was found to be approximately 82% and this result was evaluated to be acceptable since it is above 75% (Mulaik et al., 1989). Then, the researchers discussed the differences that emerged in the initial analysis process and reached a consensus.

Findings

In this section, research findings are presented in the context of the sub-problems of the study.

Perceptions regarding the use of digital games in science education

The first sub-problem of the research was about the evolution of candidate science teachers' perceptions regarding the use of digital games in science education. For this, initially, candidates' opinions about the advantages, disadvantages and suitability of the use of digital games in science teaching were examined with the first and last questions of DGBLQ. The answers were analysed holistically and the codes, themes generated in this context were presented in Table 1.

Table 1. The Use of Digital Games in Science Education

Theme	Code	f	%
Advantages	Engaging/Attractive	38	33,04
	Promotes Permanent Learning	28	24,34
	Promotes Active Learning	12	10,43
	Concretizes Abstract Concepts	7	6,08
	Enables Assessment	4	3,47
Disadvantages	Not Suitable for Every Topic	14	12,17
	May Lead to Digital Addiction	7	6,08
	Time Consuming to Develop Games	3	2,60
	Requires Digital Competence	2	1,73

The participants' views on the use of digital games were divided into two as advantages and disadvantages. They put forward five different reasons to justify their positive opinions. The most striking reason was being engaging/attractive (f=38), and the others were promoting permanent (f=28) and active learning (f=12), concretizing abstract topics (f=7) and being useful in evaluation (f=4) respectively. Sample quotes from participants' responses in this regard were presented below.

> In the age of ever-evolving technology, students are very interested in computers and tablets. Using games with lesson content in line with students' interests can be efficient in terms of learning (CST28).
> Digital games will increase learning retention. Students can memorize science topics. I believe this problem will be eliminated with digital games, and rote memorization can be eliminated (CST2).
> Using digital games in science classes allows students to be involved in the process and actively participate, allowing them to better grasp the subject and concepts (CST21).

The candidates put forward a holistic and meaningful perspective with the positive elements that digital games will attract students' attention with the visual richness they contain, will overcome rote-learning approaches and ensure permanence in learning, will facilitate active participation with the application and interaction environment they offer, and will support the learning of abstract science concepts. On the other hand, some of the candidates also drew attention to various potential disadvantages, arguing that the context would be inappropriate due to the intensive processing and drawing required for some science topics, that it risked reinforcing students' potential digital addiction, and that it would be a time-consuming and labor-intensive process for teachers. In this sense, it can be said that these candidates envisioned a more limited use.

With the second question of DGBLQ, the participants were asked to evaluate if digital game design teaching that they experienced affected their views on the use of digital games in science education. The codes developed and the themes generated in this context were presented in Table 2.

Table 2. Declared Changes in Views on the Use of Digital Games

Theme	Code	f	%
Positively Changed Views	Lack of Prior Knowledge	21	42
	Breaking Down Prejudices	14	28
Stable Views	Belief in Already Existing Benefits	14	28
	Concerns About Screen Time	1	2

An important portion of the participants declared that their opinions were changed after instruction. These participants put forward two different reasons to justify their opinion change as eliminating the lack of prior knowledge (f=21) and breaking down prejudices (f=14) regarding the use of digital games in education. In addition, it was seen that some participants (f=14) maintained their positive initial views across the intervention, and just oneparticipant did not change his/her negative concern regarding the screen time. Sample quotes from participants' responses in this regard were presented below.

> I hadn't seen digital game design used in education before. I thought it wouldn't be easy to manage. However, as I learned the steps and saw that it could be integrated with the Science course, I realized that using and implementing digital games would be appropriate (CST5).
> I used to think that using digital games simultaneously during the lesson would be a waste of time. Now, I think we can direct the course as we want and focus the students' attention in this direction, making the lesson more comfortable (CST39).
> Teaching digital game design didn't change my views... I think students should be kept away from screens. If not, students' screen time should be minimized... (CST36).

It was observed that candidates who changed their views on the use of digital games in science education either lacked sufficient prior knowledge on the subject or were acting with certain prejudices. These lack of knowledge or prejudices could be grouped under various headings, including the production process and scope of digital games, their potential benefits in the classroom, the computer and IT skills they required, and the management of their use. However, one of the primary reasons was a lack of experience. The only negative and unchanging reason for the use of digital games remained as the amount of screen time.

Perceptions on the roles of teachers and students in digital game-based science education

The second sub-problem of the research was about the evolution of candidate science teachers' perceptions regarding the roles of teachers and students in digital game-based science education. For this, firstly, at the third week of the intervention with the scenarios in SCF, the opinions of candidate science teachers about the proposed roles of teachers in digital game-based science education were examined. The codes developed by the analysis of candidates' answers were presented in Table 3.

Table 3. Teachers' Roles as Proposed in SCF

Theme	Code	f	%
Teachers' Roles	Guiding	18	43,90
	Leader	13	31,70
	Manager	5	12,19
	Instructor	5	12,19

Candidates had highlighted four different roles for teachers in the digital game-based teaching as guiding (f=18), leader (f=13), manager (f=5) and instructor (f=5). At the end of the intervention, candidates'opinions about the roles of teachers in digital game-based science education were examined again with the third question of DGBLQ.The codes developed by the analysis of answers were presented in Table 4.

Table 4. Teachers' Roles as Proposed in DBGLQ

Theme	Code	f	%
Teachers' Roles	Guiding	23	24,39
	Leader	10	56,09
	Manager	4	9,75
	Instructor	4	9,75

Candidates highlighted four different roles for teachers in digital game-based teaching and the most dominant one among these was guiding (f=23). The other roles were being leader (f=10), manager (f=4) and instructor (f=4) respectively. Teachers' leading role required explaining the whole process to students and directing them, manager role symbolized mastering all digital processes and technical information while managing the classroom, and the instructor role indicated continuing teaching role and focusing on the content of the course. Sample quotes from participants' responses in this regard were presented below.

> The teacher should guide the students about digital games. He/she should explain how the students will play the game and help the students who encounter problems while playing the game to solve the problem...He/she should also maintain control of the class while playing the game (CST12).
> The teacher must be familiar with the platform on which the digital game is prepared. He/she must determine the game's limitations because students may use it for purposes other than its intended purpose... The teacher must comply with both the subject matter and the proficiency in digital tools (CST1).

Candidates argued that teachers should guide students who experience technical difficulties in the learning environment, especially in the context of games; they should know the class well, choose the most effective games and demonstrate leadership skills to take the necessary steps to enrich students' experiences; they should master digital game platforms, manage the entire process successfully and in accordance with its purpose; and while doing all of this, they should not forget their role as teachers, emphasizing that the main goal is learning, not entertainment.

Candidates' responses on the DGBLQ were largely consistent with their proposed roles in the case scenarios of SCF. They reinforced the teacher profile they had developed in the third week of the practice and put more emphasis on the importance of the guiding role of the teacher while slightly decreasing the importance of the leader role at the end of the intervention.

Candidates' opinions about the roles of students in digital game-based science education were examined with the fourth question of DGBLQ.The codes and themes generated by the analysis of answers were presented in Table 5.

Table 5. Students' Roles as Proposed in DBGLQ

Theme	Code	f	%
Participation	Willingness	15	30,6
	Openness to Learning	9	18,3
Readiness	Technological Competence	16	32,6
	Subject Readiness	9	18,3

Candidates' views on student roles were focused on participation and readiness in learning environments. Under the theme of participation, they emphasized willingness (f=15) and pointed out that students should be willing to play the games in line with the objectives of the learning process. They also emphasized that students should be open to learning (f=9) by focusing on the content presented in the context of the game. Candidates also noted that students need to have a certain level of readiness for these roles to be adapted, and they asserted technological competence (f=16) and subject readiness (f=9) under the theme of readiness. By technological competence, they meant the technological infrastructure and knowledge required for students to play digital games, and by subject readiness, they indicated that students must be ready for the course topics to play the games. Sample quotes from participants' responses in this regard were presented below.

> Students should be patient in the classroom. While the game is being played, they should play the game willingly with the help of the information they have understood (CST18).
> Students should be open to self-improvement, innovation, and learning. They should also be open to learning through games in digital game-based science teaching. In the classroom, they should focus on the game and strive to complete and learn tasks completely (CST25).
> The student's role is to try to understand the game being played. They should try to grasp the subject individually. To do this, they need to have knowledge about computers and technological competence (CST33).

With the fifth question of DGBLQ, candidates were asked to express whether their perspectives regarding the roles of teachers and students in digital game-based science education had evolved by the intervention. The codes and themes generated by the analysis of answers were presented in Table 6.

Table 6. Declared Changes in Views on Teacher and Student Roles

Theme	Code	f	%
Evolved Views	Increased Student Activation	21	48,7
	Increased Teacher Activation	5	9,75
	Teacher's Role as a Manager	4	9,75
	Teacher's Role as a Guide	2	4,87
Stable Views	Correct Predictions	9	21,9
	Past Experiences	1	2,43

A great portion of candidates declared that they changed their opinions regarding the roles of teachers and students in digital game-based teaching by the intervention they experienced. In the context of evolving views, increased student activation (f=21) came to the forefront, followed by increased teacher activation (f=5), and teachers' managing (f=4) and guiding (f=2) roles. Candidates asserted that they began to see active participation of students as more important. Similarly, some of the candidates stated that they became more aware of the active role of teachers in game-based science education and their managing, guiding identity in such a process. On the other hand, some of the participants declared that their views did not change by the intervention since either they had corrected predictions or past experiences about the digital game-based science education. Sample quotes from participants' responses in this regard were presented below.

> We can make students more active in the lessons by offering games and having them play. Since the student will feel freer and more original in this way, it will be easier for them to reach the desired level and will be permanent at that level. (CST27).
> I find it beneficial for new-generation teachers to receive training in digital game design. This way, teachers won't have difficulty guiding their students and will have a better command of their classroom (CST28).
> Initially, I thought students wouldn't be able to play games, and the teacher would just explain the topic and move on without much discussion. Now, I think having the teacher play a guide role and delegate the rest to the students is in line with the learning-by-doing approach, and that learning will be easier (CST10).

In Table 5, it was presented that candidates' mentioned willingness, being open to learning, having technological competence and being ready for the subject as required roles for students. In accordance with these defined roles, most of the candidates stated that by the intervention they realized further the importance of active participation of students and teachers in digital game-based science education. The candidates, who stated that the main roles that teachers must undertake should be guidance and leadership, realized the importance of the teacher's active participation in the process and his/her ability to direct and guide the process with the intervention.

Perspectives on digital game-based science teaching

The third sub-problem of the research was about the evolution of candidate science teachers' digital game-based science teaching perspectives. For this, initially, 5ELPF was given to candidate science teachers in the second week of the intervention and the candidates were asked to prepare one-hour lesson plan in accordance with the 5E model. These plans were analyzed and preferred phases for digital games in science classes were reviewed. The codes developed by the analysis of participants' 5E lesson plans were presented in Table 7.

Table 7. Preferred Phases for Digital Games in Science Classes

Theme	Code	f	%
Digital Games in Science Classes	To Elaborate	12	28,57
	No Games	11	26,19
	To Evaluate	11	26,19
	To Explain	5	11,90
	To Explore	3	7,14

A significant portion of the candidates initially planned to include digital games in their science courses, mainly in the elaboration (f=12) and evaluation (f=11) phases, and to a limited extent in the explanation (f=5) and exploration (f=3) phases, while some of them (f=11) did not include digital games in their 5E lesson plans.

After intervention, with the sixth question of DGBLQ, candidate science teachers were asked to explain their general perspectives on science teaching and then to declare which approach (behaviorism, constructivism, etc.) they are closest to. The codes developed under the theme of science teaching perspectives by the analysis of candidates' answers were presented in Table 8.

Table 8. Science Teaching Approaches

Theme	Code	f	%
Science Teaching Perspectives	Constructivism	32	76,1
	Problem-Based Learning	9	21,4
	Collaborative Learning	1	2,38

The majority of the candidates expressed their understanding of science teaching through constructivism(f=32), while some referred to problem-based (f=9) and cooperative learning (f=1). Sample quotes from participants' responses in this regard were presented below.

> Science teaching should not be a lesson where only the teacher is active. If games, experiments and activities are carried out to make the student active while teaching science, more effective and permanent learning will take place as the student discovers and learns on his/her own. The constructivist approach is more suitable for my teaching approach... (CST26).
>
> I am one of those who believe that science education should be more about learning by doing and experiencing. As students connect with real life, they are motivated to learn. It should be more student-centered, not teacher-centered. Students should solve problems themselves and make connections. Therefore, science should be taught through problem-based learning (CST6).

Since these codes were created based on the candidates' ways of expressing their own approaches, they were not made part of a theoretical discussion in an educational sense, but it is known that constructivism also includes problem-based and collaborative learning processes. Therefore, student-centered approach based on active learning was seen to be the common perspective for all the candidates.

Following that direct and explicit question regarding adopted science teaching approaches, with the seventh, eighth and ninth questions of DGBLQ, candidates were asked to choose a science topic and explain which teaching methods, techniques they would prefer to use, what kind of digital game they would design and at which phase of teaching they would plan to use it. The candidates' answers to these questions were analyzed for whether they made a plan consistent with the understanding of science teaching they explained in the sixth question and whether the phases in which they planned to use digital games were different from the stages in the 5E lesson plans they developed in the second week of the application. The codes developed under the theme of digital games in science classes by the analysis of participants' responses were presented in Table 9.

Table 9. Preferred Stages of Digital Game Use in Science Classes

Theme	Code	f	%
Digital Games in Science Classes	To Elaborate	15	35,71
	To Evaluate	15	35,71
	To Explain	8	19,04
	To Explore	3	7,14
	To Engage	1	2,38

When the data in Table 9 is compared with those in Table 7, it is understood that the candidates' tendency to use digital games in the elaboration, evaluation and explanation phases had increased, and it was also seen that a candidate suggested using games in the phase of engage. Sample quotes from participants' responses in this regard were presented below.

> I would begin the lesson with game-based instruction on electrical circuit elements to both measure students' readiness and attract their attention. Then, I would explain the lesson according to the students' readiness. Finally, I would have them build a simple electrical circuit and play another game to both assess and further reinforce students' knowledge (CST14).
>
> I would use digital games in a project-based teaching method for teaching about humans and the environment... I believe that a world actively designed by students will provide more benefits to students. I believe using digital games during the exploration phase of the course is appropriate... It requires being active. For students to be active, they need to engage in the exploration process (CST19).

It was seen that the emphasis on the elaboration and evaluation phases, where candidates plan to use digital games, increased. Similarly, the tendency to use games in the explanation phase also increased, and candidates who had not previously considered using digital games in science classes leaned toward integrating them into the teaching process. In this sense, it can be said that all candidates preferred to include digital games in their planning, albeit with varying degrees of intensity. In addition, when the candidates' plans were examined in terms of their preferred methods and techniques, it was observed that they suggested activities that aligned with the constructivist perspective they outlined in question six, which were based on active student participation, project-based learning and collaborative activities involving drama. This situation demonstrated that they could reflect the teaching approach they were theoretically close to in their planning and were willing to integrate digital games into this practice.

Results, discussion and conclusion

Technological developments have led to significant transformations in educational processes (Marshall et al., 2024; Timur et al., 2020) and this transformation has increased the importance of the training that teachers need to receive, especially in new teaching technologies (Niess, 2011). Because, as in the case of Türkiye, even if schools increase their investments in technological infrastructure such as computers, smart boards and projectors, teachers' capacity to use all this equipment effectively remains limited by their level of mastery of new teaching technologies (İmer & Yürekli, 1996; Uzun & Koparan, 2021). In order to avoid problems in this sense, teachers need to be trained to be open and willing to use new technologies and their integration into teaching processes, starting from their undergraduate education. This research was conducted with this understanding and it was aimed to train candidate science teachers for digital game design process and then to examine how their thoughts on digital games in science education had evolved by such an intervention.

Findings related to the first sub-problem of the research revealed that candidate science teachers mostly posed a positive perspective for the use of digital games in science teaching and asserted that it will attract students' attention, overcome rote-learning, ensure permanence in learning, facilitate active participation and support the learning of abstract science concepts. On the other hand, some of the candidates also drew attention to potential disadvantages or risks of digital games, such as inappropriateness for some science topics, reinforcement of students' potential digital addictions and the additional workload to teachers in designing their digital games. These reservations of candidate science teachers were seen to be consistent with the results of related research. For instance, Kapucu and Çağlak (2018) reported that pre-service teachers struggled to find games aligned with specific learning outcomes and topics, while An et al. (2016) and Kılıçel and Kılıç (2021) pointed to the substantial time required for digital game design and the additional workload this places on teachers. Similarly, Kaimara et al. (2021) drew attention to hardware inadequacies resulting from financial constraints. Regarding the concerns about addiction, Coşkun and Akçay (2018) found that pre-service teachers' high awareness of digital game addiction negatively affects their attitudes toward using digital educational games. Finally, Sajinčič et al. (2022), Wu (2013), and Watson and Yang (2016) noted that pre-service teachers' insufficient technological background could lead to challenges in the pedagogical implementation process. While raising these concerns, it was seen that an important portion of the candidates reached a positive perspective by the intervention and also declared that they had overcome their prejudices and lack of knowledge regarding the use of digital games in science teaching. Just one candidate remained concerned about screen time and risk of digital addiction. The related lack of knowledge or prejudices were about the production process, scope and potential benefits of digital games, the required information technology skills, and the management of digital game-based teaching process. In fact, one of the primary reasons was lack of experience. As a result, it can be asserted that after the intervention, candidates had mostly adopted a positive approach to the integration of digital games in science teaching by providing reasons such as being motivating, entertaining and effective teaching method. They found visually rich digital games to be useful in concretizing abstract concepts and on topics such as systems in our bodies. In addition, teacher candidates believe that digital game-based learning will create a more effective and active learning environment by providing students with opportunities for peer interactions. They qualified digital game-based science teaching as a student-centered and active participation-oriented approach, and differed it from traditional teaching methods. These positive qualifications of candidates were seen to be consistent with results of related research. For instance, while Valverde et al. (2024), Hacer and Topsakal (2021), and Akgül and Kılıç (2020) reported that this approach promotes students' active participation in class; Yıldırım (2016), Akgül and Kılıç (2020), and Hu and Sperling (2022) emphasized its contribution to the concretization of abstract information, thereby ensuring learning retention. Regarding the nature of the learning process, Küçükşen et al. (2024) and Hacer and Topsakal (2021) noted that the game-based approach offers the opportunity for learning through entertainment. In parallel, Sajincic et al. (2022), Valverde et al. (2024), Küçükşen et al. (2024), and İşçi and Yeşiltaş (2020) demonstrated the effect of this on enhancing student motivation. Furthermore, while Medina and Ferrer (2022) and Sajincic et al. (2022) drew attention to the method's support for peer teaching and collaborative learning, İşçi and Yeşiltaş (2020) identified digital games as a significant factor in increasing academic achievement.

Findings related to the second sub-problem of the research revealed that candidates proposed guiding, leadership and managing roles for teachers. They argued that teachers should guide students; demonstrate leadership skills in order to enrich students' learning experiences; master digital game platforms and manage the entire learning process in accordance with its purpose. They also added that while performing these roles, teachers must take into account the main goal as learning, not entertainment. This profile, which was created based on the candidates' responses to sample case scenarios regarding the use of digital games in science teaching in the third week of the intervention, was observed to differ slightly after the training was completed. It was seen that candidates put more emphasis on the importance of the guiding role of the teacher while slightly decreasing the importance of the leader role at the end of the intervention. This result was seen to be consistent with related research results emphasizing guiding role of teachers in digital game-based learning environments (İmer, 1996; Sardone & Scherer, 2009; Zourmpakis et al., 2022). On the other hand, candidates underlined willingness, being open to learning, having technological competence and readiness as the required roles for students in digital game-based science instruction, which is a finding consistent with the existing literature in the field (Abdulmuhsin et al., 2025; Tsai et al., 2025). An important portion of the candidates stated that their views regarding teachers' and students' roles evolved by the intervention and they realized further the importance of active participation of students and teachers in digital game-based science education. The candidates, who stated that the main roles that teachers must undertake should be guidance and leadership, realized the importance of the teacher's active participation in the process in order to direct and guide the learning. This finding aligns with those of Caparoso and Orleans (2024), and Ilić et al. (2024).

Findings related to the third sub-problem of the research revealed that some of candidates initially planned to include digital games in their science courses mainly in the elaboration and evaluation phases, and to a limited extent in the explanation and exploration phases, while some of them did not include digital games in their 5E lesson plans. Candidates who declared to adopt a constructivist and student-centered approach based on active participation, tended to use digital games further in the elaboration, evaluation and explanation phases in their plans after intervention. In addition, candidates who had not previously considered using digital games in science classes leaned toward integrating them into their teaching process. The intervention they experienced enabled them to develop awareness that digital games can be used effectively in all stages of the course. It was seen that all the candidates preferred to include digital games in their planning and suggested activities that aligned with the constructivist perspective based on active student participation. They realized that digital games can effectively be used in attracting attention, assessing performance and elaborating learning of students. These post intervention perspectives of candidate science teachers were seen to be consistent with the results of related research (Fikriyatii et al., 2022; Meletiou & Prodromou, 2016; Uzunboylu et al., 2020).

Recommendations

Training programs or courses can be designed to increase teachers' and teacher candidates' awareness of the positive effects that digital educational games can have on the learning process and to improve their competence in using these games.

Teachers and teacher candidates can be informed about the potential risks of digital educational games, such as digital addiction and the inability to create meaningful context for some science topics, as well as the precautions that can be taken.

Practices can be planned to improve the competencies of teachers and teacher candidates on how to meaningfully integrate digital games into learning environments.

A meta-analysis of scientific studies that have addressed the use of digital games in science education in different contexts can be conducted to holistically evaluate the relevant research results.

To popularize the design and use of digital games in science education and to enrich the materials available to teachers and teacher candidates, digital game-based learning festivals and competitions can be organized.

Declarations

Ethics Statements: The ethical standards that are accepted in this journal were followed in this research.
Conflict of Interest: Authors declare that there is no conflict of interest in this publication.
Informed Consent: All participants have agreed to be involved in this study.

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