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The effect of digital game-based learning on secondary level students' learning of Internet literacy

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Abstract
Since the effectiveness of pedagogies relies heavily on the context they are practiced, scholars strive to revalidate them with different participants representing different disciplines, age, cultures and so on. In this regard, this piece of work was undertaken so as to reveal the impact of a digital game-based learning environment on the achievement of secondary school participants in the topic of Internet literacy in Turkey. To this end, a three dimensional multi-user digital game-based learning environment through Active Worlds game engine was created. The static-group pre-test post-test design was adopted. We recruited 266 students attending 10th-grade at a public high school. The participants were block-randomized to the groups. The control group partook in a lecture-based learning environment for two weeks, whereas the experimental group learned with a digital game-based learning environment. The results ascertained that even though there were significant learning gains in control as well as experimental groups, no substantial significant difference was observed in the achievement across the groups. The results illustrated that the interaction of method and gender had no influence on the achievement. Particularities of the context of the study causing the results and study's far-reaching implications were discussed.

Keywords Secondary school · Internet literacy · Digital game-based learning · Experimental design · Gender · Two-way ANCOVA

1 Introduction

Nowadays, almost all educators think that the Internet must be used in education. However, most students do not have detailed knowledge of how to use the Internet (Harrison, 2017). Therefore, it is necessary to raise students' awareness of the correct and effective use of the Internet in schools and provide them with skills

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in subjects such as Internet use, accessing information on the Internet, evaluating the information accessed, and critical Internet literacy (Demir & Seferoğlu, 2016). Schools should ensure that students understand Internet literacy and the potential risks associated with it (cyberloafing, cyberbullying, Internet addiction, information pollution, etc.) (Hussein & Hussein, 2020). To this end, digital game-based learning (DGBL), which can be expressed as using digital games as a medium and method, can be employed to achieve a predetermined educational acquisition. The interest in DGBL is gradually increasing (Chen et al., 2022). Educational institutions have found the opportunity to apply methods, such as DGBL, in classrooms owing to technological advancements (Turner et al., 2018). It is now seen in the literature that DGBL is associated with interactive learning and higher-order thinking skills (Chen et al., 2022). However, for this method to be applied more efficiently and effectively, context-specific guidelines are required (Tüzün, 2007), considering the game to be used, the level of education, and individual differences in the subject desired to be taught. This study investigated the details of using an educational digital game for the learning of Internet literacy at the high school level, its application effects, and the interaction of these effects with gender with an experimental design.

2 Related literature

There is extensive literature on the effects of DGBL on academic achievement. It is remarkable that different domain studies conducted with experimental and control groups have found no difference between the success achieved in the DGBL environment and the success achieved in the lecture-based learning environment (or traditionally characterized learning environment) (e.g., Abrams, 2008; Bayırtepe & Tüzün, 2007; Chen et al., 2016; Kızılkaya et al., 2006). Contrary to the studies above, McKenzie (2013) stated that face-to-face teaching was more effective in terms of knowledge acquisition than digital game-based online activities. There are also studies in the literature reaching results in favor of DGBL environments in terms of learning. For example, Soflano et al. (2015) revealed that students learned more in the DGBL environment they developed to teach SQL (Structured Query Language) compared to the paper-based learning environment. Ku et al. (2015) indicated that 5th-grade students learned more in the DGBL environment compared to textbooks and lecture-based learning environments in learning idioms. Additionally, in a study conducted with secondary school students, Admiraal et al. (2014) found that students performed better in a DGBL environment compared to the control group. In a study performed with university students, Kablan (2010) revealed that the DGBL method was more effective in terms of learning than the lecture-based learning method. In their study on the academic achievement of high school 10th-grade students in learning English, Yeşilbağ et al. (2020) concluded that educational digital games were more effective than traditional teaching activities. In their study with secondary school students, Zengin and Yılmaz (2021) found that educational digital games were more effective in learning English vocabulary than the current program. The findings obtained by Hashemi (2021) are similar to those of Zengin and Yılmaz. However, Hashemi worked with gifted freshmen. There are many

studies in the literature finding that methods using digital games are more effective in terms of academic achievement compared to methods that do not use digital games (e.g., Bakar et al., 2008; Chung & Chang, 2017; Haruna et al., 2021; Ku et al., 2015; Liu, 2016; Öztürk & Korkmaz, 2020; Suh et al., 2010; Tüzün & Özdinç, 2016). To summarize the literature, Clark et al. (2016) revealed in their meta-analysis study that digital game environments increased learning more than non-digital game environments. In a meta-analysis study involving experimental studies, Karakoç et al. (2022) concluded that DGBL affected achievement. In another meta-analysis study, Lei et al. (2022) again found a significant difference in favor of DGBL. In the study, it was stated that this effect was stronger in Eastern countries and elementary school students. It was also reported that the smallest effect occurred when the intervention period was longer than one week. As a result, despite some contradictory findings, it can be concluded that the literature is in favor of DGBL.

To ensure equality of opportunity in education, new learning technologies must be suitable for everyone. Therefore, gender-related differences in DGBL environments should be revealed (Steiner et al., 2009). Considering the effect of gender on academic achievement in DGBL, Soflano et al. (2015) concluded that male students displayed higher learning performance in DGBL environments. Contrary to this finding, some studies with findings in favor of females draw attention. For example, a study on energy knowledge of 9th-grade students found that females exhibited higher learning performance than males after the DGBL experience (Tsai, 2017). In another study, females outperformed males in terms of engagement and learning in DGBL practices (Khan et al., 2017). Hsieh et al. (2016) found that females showed higher learning performance than males in DGBL environments. However, there are also studies in the literature that did not find a difference in terms of gender. For example, Chung and Chang (2017) reported that gender did not affect academic achievement in DGBL environments. In their study in the field of computer science, Zahedi et al. (2021) revealed that gamification was a gender-free strategy improving the performance of both males and females. Likewise, Haruna et al. (2021) did not find a gender difference in terms of learning outcomes in the serious games and gamification groups. Other studies that did not find a gender difference are also available (e.g., Abrams, 2008; Bayırtepe & Tüzün, 2007). In general, despite some findings in favor of females, it can be said that gender does not influence academic achievement in DGBL environments.

2.1 Justification and aim

As a result of the literature review on the effects of educational digital games on academic achievement, the scarcity of research on using educational digital games for any unit in the Information and Communication Technologies (ICT) course has drawn attention. However, Shulman (2005) revealed that domain-specific pedagogy was indispensable for learning domains with the concept of *signature pedagogy*. Additionally, Kolb (1981) divided academic disciplines into four categories, hard-pure, hard-applied, soft-pure, and soft-applied, and reported significant differences between them. To refer to the rigidity of these differences, academic units are

sometimes called *academic tribes* (e.g., Becher & Trowler, 2001; Trowler, 2014). This means that the DGBL practice may vary according to the learning domain.

It is observed that the majority of the studies in the DGBL literature have been conducted at the university or elementary school level. However, Knowles (1978) stated that the concept of pedagogy was valid only for children and introduced the concept of *andragogy* for adults. According to the concept of andragogy, adults experience different learning processes from children since they have more life experience and know themselves better. This difference limits the generalizability of the findings of university-level studies based on andragogic foundations to the high school context. Furthermore, according to *theory of cognitive development* (Barrouillet, 2015), elementary school students are at the *concrete operational stage* and high school students are at the *formal operational stage*. This stresses the originality of high school level studies on DGBL.

The present study investigated the effect of a 3D digital game on high school students' learning about the Internet. Moreover, the interaction of gender in this effect was also examined since Turkey is a patriarchal society (World Economic Forum, 2020) and stereotyped gender roles are formed in the context of *gender schema theory* (Bem, 1981). These roles may cause differences in the impact of DGBL on achievement. In this respect, answers to the following research questions were sought.

2.1.1 Problem sentence and research questions

Do educational digital games have a statistically significant effect on high school students' knowledge of the Internet?

1) Does the teaching method used have a statistically significant effect on the achievement of learning the Internet unit?
2) Does the interaction of gender and teaching method have a statistically significant effect on students' achievement in learning the Internet unit?

3 Methodology

The static-group pretest-posttest design, which does not involve randomly assigning individuals to experimental groups, was applied in the study (Fraenkel et al., 2019). Instead of individual randomization, block randomization was employed, where individuals are randomly assigned to the experimental group in blocks (in our case classes) to ensure a balance in terms of participants' number and critical traits in the experimental and control groups (Suresh, 2011).

3.1 Research context and participants

Before the study, the a priori sample size estimate required to find the moderate ($f = 0.25$) effects in the two-way ANCOVA analysis was calculated. In this

calculation, when the alpha level was taken as 0.05 and the target statistical power was taken as 0.95, it was concluded that 210 participants were sufficient. To stay on the safe side, data were collected from 266 students. The study was conducted with 10th-grade students attending a public high school in a district of the Central Anatolia Region in Turkey, using the convenience sampling method. During the study, there were 2233 students and 107 teachers in the school, and the only computer laboratory in the school had 20 computers with an Internet connection. During the study, one of the researchers taught twelve out of sixteen 10th-grade classes in this school. To prevent the different teacher variable from impacting the research results, these twelve 10th-grade classes were included in the study. Two classes selected from among these were used for the pilot study. Five classes randomly selected from the remaining 10 classes were assigned to the experimental group, and the remaining five classes were assigned to the control group. The class sizes in the experimental group were 24, 25, 27, 28, and 29, while the class sizes in the control group were 21, 22, 22, 32, and 36. Table 1 shows the distribution of the study group by gender.

While 78.2% of the experimental group had a computer at home, 76.7% of the control group had a computer. Of the experimental and control groups, 69.9% and 63.9%, respectively, had Internet access at home. Additionally, 23.3% of the experimental group used the computer for gaming purposes, while 25.6% of the control group used the computer for the same purpose. As a result, these rates indicate that the sample exhibited small differences in terms of the mentioned characteristics that would not harm the internal validity of the study.

3.2 Design of the DGBL environment

In the current study, Active Worlds (AW) (http://www.activeworlds.com), a 3D multi-user virtual environment, was used. In this virtual environment, users are represented by virtual characters called avatars. This 3D virtual world has four components. First, there is a 3D environment for students to wander around on the left. Second, there is a web browser on the right, providing information and instructions. Third, there is a chat window below that students can use for simultaneous communication. Finally, there are toolbars at the top through which users can customize the game. The researchers developed a virtual world expressed as *www* and used this world (Fig. 1).

This virtual world consists of an Internet cafe, park, library, school, computer shop, data processing center, factory, teleport tower, Computer Can's (Soul's) house,

Table 1 Distribution of study group by gender

Group	Gender				Total	
	Female		Male			
	N	%	N	%	N	%
Experimental	73	55	60	45	133	100
Control	65	49	68	51	133	100
Total	138	N.A.	128	N.A.	266	

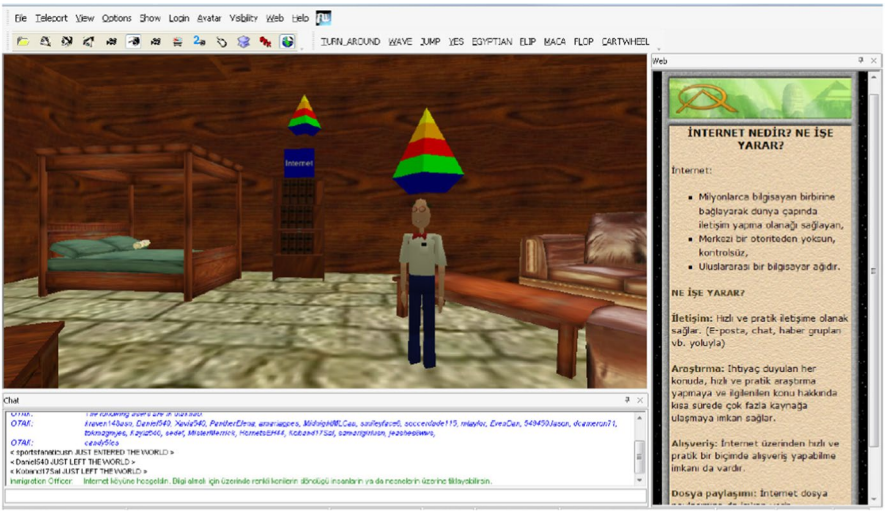

Fig. 1 A view from the house of Mr. Doğa (Nature)

and ethics house. At the entrance to the www world, a non-playable character (NPC) welcomes the users and tells them the story of the game. The brief story of the game is as follows. The players help Mr. Doğa (Nature) to save a village whose natural beauty has been polluted by a factory. Mr. Doğa wants to save the nature of the village using a computer, but he asks the players for help because he does not know how to use a computer.

In the www world, information about the Internet is accessed by interacting with NPCs with colored cones or books on bookshelves. Information is also sometimes presented through signs and objects hanging on the walls. With the guidance of Mr. Doğa, when the player first clicks on the books on the bookshelves, information about the Internet is provided in the web browser of the game. The players find their quest places by looking both at the coordinates on the distributed quest papers and the direction signs in the game and learn the quest content by clicking on the rotating roll-shaped objects containing the quest information. The interaction between game-based and discovery-based learning is intended to influence the level of the Internet literacy as suggested by Barab et al. (2005) and Tüzün et al. (2019).

To facilitate navigation in the game, maps are placed in different places, and the location of the player at that moment is indicated on these maps (Tüzün & Doğan, 2019). There is an NPC at the entrance or inside each building in the game environment, and this NPC tells the player about the information contained in that building. There is also a teleport cabin in the game, which is the last mission and contains boards with brief information about the Internet. To enter this cabin, the players must reach a secret passage in the forest.

Before implementing the game, a pilot test was conducted with all students in two 10th-grade classes randomly selected from the implementation school. There were a total of 71 students (33 males and 38 females) in these two classes. As a result of the pilot test, it was found that it took an average of 42 minutes to

complete the eight quests in the game, slightly more than a 40-minute class hour. As a result of analyzing the quest papers in the pilot test, it was understood that two class hours were insufficient to complete the quests, and it was decided to allocate three class hours for the implementation. In line with the findings of the usability test, the design of the www world was finalized.

3.3 Data sources

In the study, data were collected using three tools: *The information technologies usage status questionnaire*, *quest paper*, and *achievement test on the Internet subject*. Computer and Internet usage experience, frequency, computer and Internet access condition, frequency of playing computer game, and the demographic information of all students participating in the study were collected using the questionnaire developed. During the implementation, quest papers were distributed to the students in the experimental group so that they could easily find their quest places and not forget what their quest was. The coordinates of the quests in the game in the 3D environment were specified on the quest papers, and the students were asked to write down what the quests were and their answers to these quests on the quest paper. Using the quest papers, it was aimed to collect data on how much of the quests the students completed.

The achievement test on the Internet subject, which was prepared by the researchers as a multiple choice of 22 questions, was checked and corrected by five experts in the field (three teachers, two faculty staff) for content validity. And then, we moved to the discriminant validity for which it was applied to second-grade students ($N = 41$) at a high school different from the school of main implementation and second-year university students ($N = 47$) studying in an informatics-related program to determine the item difficulty index. High school second-grade students are a group which does not know this subject, whereas university students are a group that knows this subject. It is expected that the items in the achievement test can distinguish between students knowing and not knowing the subject. Hence, the expected result is that the difficulty indices of the items in the achievement test are low for high school second-grade students and high for university sophomores. As stated by Binbaşıoğlu (1983), the closer the item difficulty index gets to 1, the easier the item is and the closer it gets to 0, the harder the item is. Therefore, items with an item difficulty index of 0.70 and higher were excluded from the test after applying it to the group not knowing the subject. Since the group knowing the subject was expected to answer all the questions, items with an item difficulty index below 0.80 were excluded from the test after applying it to this group. The mean difficulty index of the scale was calculated as 0.79 for the group knowing the subject and as 0.42 for the group not knowing the subject. In this way, discriminant validity of the test was supported. At the end of this process, the test was given its final form consisting of 8 questions. KR-20 internal consistency value of the test was calculated as 0.924, which is excellent according to Nunnally and Bernstein (1994).

3.4 Procedure

Table 2 contains the activities carried out with the groups in the DGBL and the lecture-based learning environment during the implementation process.

In the first week of the implementation, *the information technologies usage status questionnaire* was applied during the first lesson hour, and *the achievement test on the Internet subject* was applied during the second lesson hour. In the second week of the implementation, the game environment was introduced to the classes in the experimental group. In this process, it was ensured that the experimental group students wandered around the 3D environment and understood the properties of the environment. The orientation was carried out in the *www* world. After one class hour, the subject of the Internet was learned by the students in the experimental group in the DGBL environment and by the students in the control group in the lecture-based learning environment. This process also continued in the third week (a total of 3 class hours). In the fourth week of the implementation, the implementation process ended with reapplying *the achievement test on the Internet subject* to the experimental and control groups.

Due to the small number of computers in the laboratory, the students sat at the computer in pairs in the experimental group. During the implementation, one of the authors, who was one of the information technology teachers of the school where the implementation was performed, guided the students and answered their questions about the use of the game environment. Exactly the same information as in the experimental group was presented to the control group, and the question-answer technique was employed. In the practice for using search engines and e-mail, it was ensured that the students in the control group sat at the computers in pairs, just like the students in the experimental group.

3.5 Data analysis

The data set, which was 353 in total, decreased to 266 after absentee students were excluded using list-wise deletion. Pre-test and post-test fulfilled the assumption of multi-variate normality by groups as per critical Z values of 3.29 (Kim, 2013) (See. Table 3). The homogeneity of the variances was checked by Levene's test. The

Table 2 Implementation process

Week	Experimental group	Control group
1	1.1) Information technologies usage status questionnaire 1.2) Achievement pre-test on the Internet subject	1.1) Information technologies usage status questionnaire 1.2) Achievement pre-test on the Internet subject
2	2.1) Orientation 2.2) DGBL environment	2.1) Free computer time 2.2) Lecture-based learning environment
3	3.1) DGBL environment	3.1) Lecture-based learning environment
4	4.1) Achievement post-test on the Internet subject	4.1) Achievement post-test on the Internet subject

Table 3 Normality values of pre-test and post-test by group

Test	Group	Skewness			Kurtosis			Critical value[b]
		Statistics	Std. error	Z value[a]	Statistics	Std. error	Z value	
Pre-test	Control	−.336	.210	−.160	.089	.417	.213	<|3.29|
	Experiment	−.510	.210	−2.429	.251	.417	.602	<|3.29|
Post-test	Control	−.064	.210	−.305	−.693	.417	−.1.662	<|3.29|
	Experiment	.004	.210	.019	−.162	.417	−.388	<|3.29|

[a]Z value = Statistics divided by standard errors

[b]Kim (2013) suggests that if sample size is between 50 and 300, the data are not non-normal as long as all absolute Z values are lower than critical *Z* value of 3.29

pre-test scores of the experimental and control group students were compared by the independent-samples t-test. The paired-samples t-test was used to check whether a significant learning gain occurred at the end of the implementation process in both groups. The effects of the teaching methods used, gender, and the interaction between gender and teaching method on achievement were examined by two-way ANCOVA. The significance level of .05 was taken as a basis in all statistical analyses.

4 Findings

To start with Levene's test for equity of variances, it showed that the groups had equal variances ($F = .029$, $p = 0.865 > 0.05$). This study found that the pre-test scores of the experimental group ($M_{Experiment} = 4.38$) and control group ($M_{Control} = 4.41$) were close to each other and there was no statistically significant difference between them ($t_{264} = 0.132$, $p = 0.895 > 0.05$) (See. Table 4). The absence of a difference between the pre-test results of the experimental and control groups indicates that the groups are similar in terms of prior knowledge of the Internet.

The post-test score of the experimental group ($M_{Post\text{-}test} = 5.17$) was higher than the pre-test score ($M_{Pre\text{-}test} = 4.38$), and this difference was statistically significant ($t_{132} = 6.624$, $p = 0.000 < 0.05$) (See. Table 5). This finding shows a positive change in the learning of the experimental group students as a result of the implementation.

The post-test score of the control group ($M_{Post\text{-}test} = 5.44$) was higher than the pre-test score ($M_{Pre\text{-}test} = 4.41$), and this difference was statistically significant

Table 4 Independent-samples t-test result of pre-tests of groups

Group	Descriptives			Levene's test		Independent-samples t-test		
	N	M	SD	F	p	df	t	p
Experimental	133	4.38	1.39	.029	.865	264	.132	.895
Control	133	4.41	1.40					

Table 5 Paired-samples t-test result of pre-test and post-test of experimental group

Test	N	M	SD	df	t	p
Pre-test	133	4.38	1.39	132	6.624	.000
Post-test	133	5.17	1.30			

($t_{132} = 6.919$, $p = 0.000 < 0.05$) (See. Table 6). This finding demonstrates a positive change in the learning of the control group students as a result of the implementation.

As a result of the implementation, the effect of the teaching method used on achievement was examined after the conclusion that learning took place for both groups was reached. To compare digital game-based and lecture-based learning methods in terms of their effects on achievement, two-way ANCOVA was conducted, in which pre-test scores were used as covariate and teaching method and gender were taken as the main factors. As seen in Tables 7 and 8, the results show that there was no statistically significant difference between the groups' post-test scores ($M_{Experiment} = 5.17$, $M_{Control} = 5.44$) ($F_{(1–261)} = 2.680$, $p = 0.103 > 0.05$).

The post-test scores of the female students in the control group ($M_{Control} = 5.34$) were higher than the post-test scores of the female students in the experimental group ($M_{Experiment} = 5.05$) (See. Table 7). Likewise, the post-test scores of the male students in the control group ($M_{Control} = 5.54$) were higher than the post-test scores of the male students in the experimental group ($M_{Experiment} = 5.30$). However, the interaction effect of the group and gender on the post-test was found to be statistically insignificant ($F_{(1–261)} = 0.718$, $p = 0.398 > 0.05$) (See. Table 8).

Table 6 Paired-samples t-test result of pre-test and post-test of control group

Test	N	M	SD	df	t	p
Pre-test	133	4.41	1.40	132	6.919	.000
Post-test	133	5.44	1.56			

Table 7 Post-test descriptives of groups by gender

Group	Gender	N	M	SD
Control	Female	65	5.34	1.34
	Male	68	5.54	1.75
	Total	133	5.44	1.56
Experimental	Female	73	5.05	1.29
	Male	60	5.30	1.31
	Total	133	5.17	1.30
Total	Female	138	5.19	1.32
	Male	128	5.43	1.56
	Total	266	5.30	1.44

Table 8 Two-way ANCOVA result of post-tests of groups

Source	Type III sum of squares	df	Mean square	F	p
Corrected model	92.395	4	23.099	13.223	.000
Intercept	287.850	1	287.850	164.778	.000
Pre-test	83.862	1	83.862	48.007	.000
Group	4.682	1	4.682	2.680	.103
Gender	1.211	1	1.211	.693	.406
Group * Gender	1.254	1	1.254	.718	.398
Error	455.940	261	1.747		
Total	8033.000	266			
Corrected total	548.335	265			

5 Discussion

This study investigated the difference in terms of academic achievement and achievement-gender interaction between the DGBL environment in which the 3D digital game was used and the lecture-based learning environment in the teaching of the Internet subject of the elective ICT course at the 10th-grade at a high school. A total of 266 students participated in the study, in which a static-group pre-test post-test design was used. As a result, it was concluded that learning took place in both environments. The two-way ANCOVA test found that the DGBL method was equally effective as the lecture-based method and there was no interaction between achievement and gender.

The findings of this study generally contradict the literature. It is possible to summarize the effect of DGBL on academic achievement with the current meta-analysis studies conducted by Clark et al. (2016), Karakoç et al. (2022), and Lei et al. (2022). These three studies reached findings in favor of DGBL. There are five possible reasons for the discrepancy between the current study and the trend in the literature. First, the students' sitting in pairs at the computer due to the inadequacy of the computer laboratory limited their interaction with the game in this study. Applications in the literature are designed in such a way that each person uses a computer. Second, the Internet achievement was measured within the scope of this study, but no other DGBL study addressing this issue was found in the literature. Studies in the literature have been performed in different learning domains, such as SQL (Structured Query Language) (e.g., Soflano et al., 2015), Computer Sciences (e.g., Liu, 2016), geology (e.g., Chen et al., 2016), and language learning (e.g., Suh et al., 2010; Yeşilbağ et al., 2020; Zengin & Yılmaz, 2021). However, the nature of the disciplines (Kolb, 1981) and signature pedagogy differ (Shulman, 2005). Third, very few studies in the literature have been carried out with high school students. Some studies in the literature have been conducted with gifted university students (e.g., Hashemi, 2021), some with secondary school students (e.g., Zengin & Yılmaz, 2021). According to the *theory of cognitive development* (Barrouillet, 2015), it becomes difficult to compare students at different education levels since they exhibit

different cognitive development characteristics. In support of this argument, Lei et al. (2022) reported that the effect of DGBL was higher in studies with elementary school students. Moreover, andragogy is the issue, not pedagogy, in studies with university students (Knowles, 1978). Fourth, there may be cultural differences. Lei et al. (2022) stated that the effect of DGBL was higher in Eastern countries. Chen et al. (2022) found that the highest number of studies on DGBL was conducted in Taiwan. Considering these two findings together, it can be claimed that the positive finding about DGBL in the literature may be restricted. It is possible to reach the same conclusion as a result of the fifth reason. The relatively long-term two-week implementation period in the current study may have caused the results not to differ in the experimental and control groups. Considering the effect of DGBL, Lei et al. (2022) reported that the least effect was in interventions lasting longer than one week. This suggests that there may be a novelty effect in short-term interventions. This situation may have caused inflation in the findings in favor of DGBL in the literature. When it is considered that the current study lasted in 2 weeks, it is even more understandable that no significant difference could be reached. To summarize, the differences in the method and context of this study make it difficult to compare it with other studies in the literature.

Another finding of the study is that there was no statistically significant difference between the academic achievements of the students based on gender. There is extensive literature supporting this finding (e.g., Abrams, 2008; Bayırtepe & Tüzün, 2007; Chung & Chang, 2017; Haruna et al., 2021; Zahedi et al., 2021). On the contrary, there are also contradictory findings indicating that either males (e.g., Soflano et al., 2015) or females (e.g., Khan et al., 2017; Tsai, 2017) display higher achievement. Since the general trend is that there is no difference, it can be stated that the present study is in line with the literature. This can be interpreted as the fact that gender should not be considered an individual difference in DGBL.

6 Concluding remarks

Considering the findings from the study, it can be said that success in DGBL environments can also be achieved in lecture-based learning environments. This requires remembering the discussion of media and method in using technology. Clark (1994) indicated the answer to the question of which learning environment with the same achievement should we choose as preferring the cheapest way. Clark mentioned the cost-effectiveness relationship and argued that it was important to pay attention to economy. Therefore, considering Clark's cost-effectiveness approach and that the DGBL method is more expensive than the lecture-based method, it can be stated that the lecture-based method emerges as a more reasonable teaching method in the research context. However, Kozma (1994) centered the question, "In what ways should we use the capacities of environments to ensure that the environment affects learning?" In this context, for example, the fact that the students sat at the computers in pairs may have caused the full capacity of DGBL not to be used.

Leaving aside the effect of DGBL on academic achievement, it is seen that educational digital games have a lot of benefits (Turner et al., 2018). It is known

that educational digital games are very effective in knowledge acquisition (Basler et al., 2018; Boyle et al., 2016) and enable students to become more independent learners (Tüzün et al., 2009). Furthermore, the DGBL method positively affects lesson engagement (Khan et al., 2017). Educational environments become entertaining if games and education are combined (Cheung & Ng, 2021; Kuzu & Ural, 2008). There is extensive literature support showing that educational digital games motivate learners (e.g., Alkan & Çağıltay, 2007; Chen et al., 2022; Demir et al., 2020; Hashemi, 2021; Hsu et al., 2017; Sun-Lin & Chiou, 2019; Tüzün, 2004; Tüzün et al., 2009). Gamification activities improve the attitude toward the lesson and cooperative learning skills compared to the traditional method (Öztürk & Korkmaz, 2020). Further, having fun is a taken for granted trait in present User Experience (UX) design, but mostly neglected and not measured in comparative DGBL studies.

As a result, even if it is not more effective than the lecture-based environment, it can be recommended to use DGBL environments, especially in the teaching of the Internet subject at the high school level, due to the increase in academic achievement and other benefits mentioned above. As one of the anonymous reviewers remarked, the situation should not be handled as a tug of war between game-based and lecture-based learning; rather, we should look for ways to reconcile the two methods. Furthermore, we urge the future researchers to adopt "one computer per student policy" in order to fully exploit the benefits of game-based learning. As another suggestion, a process of adaptation is required since the Active Worlds environment has its unique ethos. Therefore, before starting the implementation, students should be adequately oriented, and the problems that may arise in practice and from not being able to adapt to the environment should be eliminated. Concerning suggestions for designers, the fact that technical design features are the game features that first attract students' attention reveals the necessity of attaching importance to the sound and graphic dimensions of the design. In particular, the graphic dimension of this finding coincides with the finding of Demir et al.'s (2020) literature review of COTS games that can be used for educational purposes indicating that games are relatively weak in terms of visual quality. As we conclude the study (game over), we encourage future researchers to consider these issues while researching (replaying) this phenomenon in different contexts and domains.

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Data availability The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval All aspects of this study, including the informed consent process, were reviewed and improved by an Institutional Review Board.

Competing interests All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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