Original Article

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Investigating the Effect of Online Gamification on Electrocardiogram Interpretation and Self-Directed Learning in Nursing Students

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Introduction: Knowing and interpreting the Electrocardiogram correctly and taking care based on it is one of the most important ways to save the patient's life. Therefore, this study aimed to investigate the effect of online gamification on the ability to interpret Electrocardiograms and Self-Directed Learning in nursing students.

Methods: The present study was carried out quasi-experimentally on 44 nursing students (22 participants for each group) in the fifth semester in Ilam city in 2023 using a convenience sampling method by four permutations balanced block randomization to control and intervention groups. During four sessions in four weeks, the participants in the intervention group received Electrocardiogram interpretation as training on the Storyline platform and playing games in the Socrative software. The control group received the same content in the form of education from the same lecturer. ECG Interpretation Learning Test, Self-Directed Learning, Mini-Mental Status Examination, and demographic questionnaires were filled out before the intervention (pre-test). Then, Electrocardiogram Interpretation Learning Test and Self-Directed Learning questionnaires were completed two weeks after the end of the intervention (post-test), and the data were analyzed in the standard error of 0.05 using Shapiro-Wilk, independent t-test, paired t-test, chi-square, and multiple linear regression tests in SPSS V.16.

Results: The mean and standard deviation of the participants' age was 21.35±1.02, and 59% of the samples were male. Before the intervention, no significant difference was observed between the two groups, but after the intervention, the mean and standard deviation of the ECG interpretation scores in the intervention group increased significantly (14.1±2.94) compared to the control group (8.8±1.36) (P=0.007). Also, Self-Directed Learning in the intervention group (168±10.42) compared to the control group (125±4.3) showed a statistically significant difference (P=0.003).

Conclusion: Using online gamification as a new educational method in nursing students improves the ability to interpret Electrocardiograms and Self-Directed Learning. It is suggested that this method should be used to teach lessons that are more useful and important at the hospital.

Keywords: Gamification, Electrocardiogram, Self-directed learning, Nursing

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Introduction

Cardiac disorders are one of the most common diseases known to adults and can threaten their lives (1). The complications of these disorders in people are different according to their severity. The most important complications caused by heart disorders include blood circulation and conductive tissue disorders. According to the results of studies, cardiovascular diseases are the first cause of death in the whole world, and especially in Iran, heart diseases are the third cause of death after cancers and accidents (2).

Electrocardiogram (ECG) monitoring should be started to detect cardiac irregularities as soon as possible (3). Nurses are on the front line of patient care; they should have sufficient knowledge and skills in the field of diagnosis and interpretation of ECG to prevent fatal complications of these disorders (4). In most nursing education centers in Iran, nursing students are taught cardiopulmonary resuscitation and common heart disorders in the course of nursing special care in the second or third year of the university (5). For this reason, one of the main reasons for not acquiring enough knowledge and skills and the amount of rereading the learned content is traditional teaching methods and not using modern and advanced learning methods (6, 7). The results of the recent studies showed that students and graduates of medical and nursing fields faced problems in interpreting ECG (8, 9). Various methods have been used to interpret the ECG so far, including lectures, peer training, mentoring, and posters (10).

In the last decade, the methods and approaches of teaching medical courses worldwide have transformed. Thus, students tend to learn diverse and enjoyable issues and questions in diverse educational environments. However, traditional teaching methods can still be used in some classrooms that leads to the feeling that learners are only receivers of information (11). The traditional method of lecturing, as the most common method of education, has caused the lack of time necessary for students' intellectual exchange and examination of the subject. Therefore, the student is out of the active state and passively attends the classrooms (12). Studies in Iran show that 76% of nursing instructors use passive teaching methods like lectures, while 92% of nursing students use active and modern teaching methods (13). For example, nursing students prefer using mobile phones and computers versus traditional and passive methods that show a great desire to use them (14).

Nowadays, the use of the newest electronic teaching method, gamification, has attracted the attention of many students and teachers. Gamification is defined as a tangible way to learn new content in active educational fluency through individual or social electronic games, friendly user experiences, and comparative courses for reinforcing the learning processes by confronting the participants to solve the allocated assignments or duties in multi-dimensional virtual spaces; also, it encourages them to analyze the planned educational missions, strengthen the mental ability of learners, and cause them to use their thinking power and use their rational powers to reason and find answers to problems (15); It is a known entertaining and effective method used by students and is recommended broadly to teachers for use. In other words, the concept of gamification means using the characteristics and advantages of virtual games in the real world to promote learning and solve problems (16).

Gamification is a suitable method for creating higher levels of thinking skills forcing the learner to get involved in the learning process (17), and changing the toughest educational content curriculum to happy, motivating, and deeply active topics so that the students can immerse through the virtually and graphically simulated similar space with research target by experiencing the related learning courses and problem-based scenarios (18, 19). Gamification allows the learner to be actively present in the learning process, understand the consequences of learning, and learn in less time and cost-effectively (16). The result of a study done to investigate learning skills and managing patient's conditions by gamification showed that gamification stimulated and increased motivation, a sense of competition, and the experience of risk without engaging with the real patient and improved creative thinking, critical and analytical thinking skills, knowledge measurement, decision making, multiple communication tasks and psychological skills (20) as the related factors to the process of learning.

In the process of teaching and learning, various factors affect the students' academic success or failure. Self-directed Learning is one of the most pivotal factors affecting performance and refers to the students' perception to create sufficient learning (21). The research shows the relationship between Self-directed Learning in acquiring knowledge, academic progression, and the method of acquiring learning that is considered an important method in acquisition of knowledge (22, 23).

Learning through gamification in an appropriate environment according to course plans can make the learners more interested in the educational progress and play a main role in

approaching educational goals (24). According to the results of a study, gamification has been reported as a connector role for strengthening previously learned content with new learning material, and it can help the learners retain what they have learned. In fact, simulative gamification increases the retention time of acquired knowledge in the learners' minds (7). Considering that learning and remembering are two important principles in nurses' careers, to strengthen those factors before graduation, modern teaching methods can be considered suitable and practical methods among them (25, 26).

According to the above-mentioned points and the fact that nursing students will be the members of first-line cardiac disorders management who should interpret ECG correctly and use their stored knowledge, this study was conducted to determine the effect of online gamification on the ability to interpret ECG and Self-directed Learning in nursing students.

Methods

Study Design

The present study was a quasi-experimental research done after obtaining approval from the Ethics Committee of Ilam University of Medical Sciences (IR.MEDILAM.REC.1402.159) at the School of Nursing and Midwifery of Ilam, Iran 2023.

Setting and Participants

The study participants were selected among the nursing students studying in the fifth semester in the school of Nursing and Midwifery of Ilam using convenience sampling method; the inclusion criteria were being willing to participate in the research, having a personal smartcell phone, attending the study full-time, obtaining a score of less than 12 in the ECG interpretation learning test (EILT), and obtaining a score of 24 and above in Mini-Mental Status Examination (MMSE). The exclusion criteria were the absence in more than one session, transfer to another university, working history as a paramedic or doing student work in a hospital, history of being rejected in the practical nursing unit during previous semesters, the history of attending ECG interpretation workshops in the last 6 months, and incomplete completion of questionnaires. After entering the study, all participants gave their informed and written consent.

Sample Size, Randomization and Blinding

According to the convenience sampling method, 44 nursing students of the fifth semester were randomly divided into control (22 participants) and intervention groups (22 participants) by four permutations balanced blocks with eleven sealed envelopes with allocated randomized codes on them by a researcher who was not involved in the intervention. The participants' names were written on the list of the class alphabetically. When the frist participant entered the study, he/she chose one of the sealed envelopes and sent the written code on the envelope to an online system drawn by the research team to determine the student and three participants after that. Then, the 5th participant chose another envelope to sequence determination; this continued until the final participant was allocated. Finally, a list was generated, and the participants were categorized into groups by this randomization before the start of the intervention. It was guaranteed that participants and the research team did not have any access to the groups to manipulate the allocation.

Measurement,Validity and Reliability

1. Demographic Information Form

It included age, gender, marital status, type of residence, and grade point average.

2. Self-Directed Learning (SDL)

This questionnaire was designed by Fisher and colleagues to study Self-directed Learning in the form of 40 items. The scale is cored using a 5-point Likert scale ranging from completely disagree [1] to completely agree [5]. The minimum and maximum scores obtained in this questionnaire are 40 to 200. higher grades indicate improvement of the learning of the strategy itself. To check the validity and reliability of the original version of this tool, the Content Validity Ratio (CVR) was 0.85, and the Content Validity Index (CVI) was 0.83 (27). In Iran, for examining the validity and reliability of this questionnaire, conducted on 379 nursing and midwifery students, CVR was 0.83, and CVI was 0.94 (28). In this study, this tool was used to examine Self-directed Learning in the participants before the intervention and two weeks after the end of the intervention.

3. Mini-Mental Status Examination (MMSE)

This tool was made by Foltsin et al. and is valid and usable 17-question questionnaire for evaluating and examining cognitive impairment. The maximum score in this questionnaire is 30, and the cutoff point for that scores is 24. Cognitive dysfunction is not present with a score of 24 or above; mild dysfunction is indicated by a score between 18 to 23, medium dysfunction is shown by a score between 10 to 17, and harsh

dysfunction is shown by a score under 10. In a study, for estimation of the validity and reliability of the original version of this tool with a cut-off point of 24, CVR was 0.85, and CVI was 0.71 (29). In Iran, for examining the validity and reliability of this questionnaire, which was filled out by 152 students of medical sciences, CVR was 0.81, and CVI was 0.76 (30). In this research, this questionnaire was used as a tool to investigate cognitive impairment and learnability in students to enter the study.

4. Electrocardiogram Interpretation Learning Test (EILT)

This tool was designed by the research team to measure learning; it has 40 questions with multiple choices that are given half a point for each correct answer and a zero for a wrong answer or no answer. The minimum score of this tool was 0 and the maximum was 20; the questions were designed based on the chapters presented by the Ministry of Health for teaching the theoretical unit of nursing in special care. Before the test was given to the participants, to measure CVR and CVI based on Baltz and Wassel's method, 10 faculty members of the Faculty of Nursing and Midwifery who had at least 4 semesters of teaching experience in theoretical or practical nursing units in care had special features, examined it and made corrections. After performing the necessary calculations and corrections, by implementing EILT on 67 nursing internships, we found that CVR was 0.88 and CVI was 0.77. In this study, this tool was used to examine the learning of ECG interpretation in participants before the intervention and two weeks after the end of the intervention.

Ethical Considerations

Ethical considerations in this research included obtaining the code of ethics from Ilam University of Medical Sciences, obtaining written and informed consent from the participants in the research, keeping the participants' information confidential, ensuring optional participation in the study or withdrawal from it, and considering ethical principles according to Declaration of Helsinki for collecting library, research, and human information.

Intervention

After the ethics committee approval, randomization, and criteria evaluation, the intervention began. Then, the participants completed the demographic information form, SDL, and EILT questionnaires in an online paper sheet.

In the intervention group, ECG interpretation in the form of common cardiac rhythmic disorders including Normal Sinus Rhythm (NSR), Sinus Bradycardia (SBC), Sinus Tachycardia (STC), Paroxysmal Supraventricular Tachycardia (PSVT), Atrial Flutter (AF), Atrial fibrillation (Af), Normal Junctional Rhythm (NJR) and Accelerated Junctional Rhythm (AJR), Premature Ventricular Contraction (PVC), Ventricular Fibrillation (Vf), Ventricular Flutter (VF), AV node block I degree, AV block II degree, and AV block III degree along with specific measures and treatments in the form of content training on the Storyline platform by the same instructor in the format 4 face-to-face training sessions once a week (Saturdays) and in the last half hour of each session, diagnosis and completion of the ECG puzzle, brainstorming, short answer questions, true and false questions, ECG type animation and the arrangement of measures according to each type of dysrhythmia was done individually by the students in Socrative mobile phone software. After answering correctly to the steps placed in Socrative software, this method was such that every student went to a higher step, and each step was assigned a higher degree of difficulty compared to the previous step. Finally, six students who had obtained the highest scores were announced as the session winners at each stage.

The control group participants also received the same content taught to the intervention group in the form of a lecture and presentation of PowerPoint slides (the common method) by the same instructor in the format 4 face-to-face training sessions once a week (Tuesdays). Then, two weeks after the end of the intervention and without prior notice, the participants completed SDL and EILT (Figure 1).

Statistical Data Analysis

Descriptive statistics were used for the demographic data, and the variables were reported as mean, standard deviation, frequency, and percentage. Analytical statistics tests included Shapiro-Wilk (S-W) (for assessing the normal distribution), independent t-test and chi-square (for comparing the two groups regarding the demographic variables), paired t-test (for comparing before and after scores), and multiple linear regression (for the association between independent variables with dependent variables). To compare the difference between the scores of the two groups, independent t-test was utilized. SPSS V.16 was used for data analysis, and the standard error was considered 0.05.

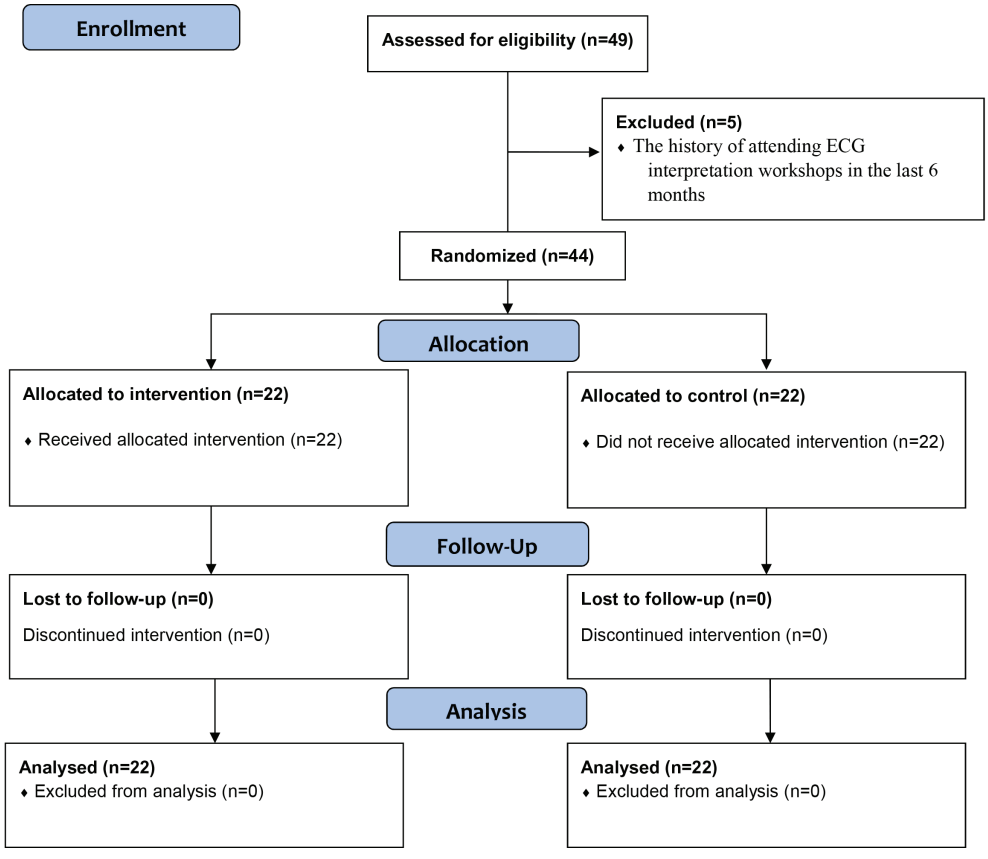

Figure 1: Conducting the study and assigning participants to the control and intervention groups

Table 1: Normal distribution of quantitative variables according to the control and intervention groups

Variable		Group	
		Control	Intervention
		P value (Shapiro-Wilk)	P value (Shapiro-Wilk)
ECG Interpretation	Before	0.061	0.134
	After	0.107	0.482
Self-Directed Learning	Before	0.364	0.219
	After	0.198	0.807

Results

To check the normal distribution of the data, was used the Shapiro-Wilk (S-W) test, and its results showed that ECG interpretations in the control and intervention groups before the intervention were (P=0.061), (P=0.134) ; after the intervention, they were (P=0.107), (P=0.482). Also, Self-directed Learning in the control and intervention groups before te hintervention was (P=0.364), (P=0.219) and after the intervention (P=0.198) and (P=0.807), showing a normal distribution (Table 1).

The mean and standard deviation of the participants' age was 21.35±1.02. The majority of participants were between the ages of 21 and 23 years old, were male and single, lived in private residences, and had a grade point average between 15 and 17.99. The results of the chi-square test showed that there was no significant difference between the age (P=0.116), gender (P=0.956), marital status (P=0.713), type of residence (P=0.349), and grade point average (P=0.274) in both groups, as shown in Table 2.

The mean scores of ECG interpretation in the control and intervention groups did not have a significant difference before the intervention (P=0.249), but after the intervention, this difference was significant (P=0.007). Also, the mean scores of Self-directed Learning in the control and intervention groups did not have a significant difference before the intervention (P=0.094). Still, after the intervention, this difference was significant (P=0.003). The results of the independent t-test showed that there was a statistically significant difference in the mean scores of ECG interpretation (P=0.002) and Self-directed Learning between the two groups (P=0.001) (Table 3).

Table 2. The frequency of the participants in the study according to demographic variables in the control and intervention groups

Variable		Control	Intervention	P value (chi-Square)
Age	18-20 Years old	1 (%4.5)	2 (%9)	0.116
	21-23 Years old	18 (%82)	19 (%86.5)	
	24 and Above Years old	3 (% 13.5)	1 (%4.5)	
Gender	Male	10 (% 45)	16 (%73)	0.956
	Female	12 (% 55)	6 (% 27)	
Marital status	Single	17 (% 76.5)	15 (% 68)	0.713
	Married	5 (% 23.5)	7 (% 32)	
Type of residence	Dormitory	4 (% 18)	9 (%41)	0.349
	Private	18 (% 82)	13 (% 59)	
Grade point average	12-14.99 (Weak)	2 (% 9)	3 (% 13.5)	0.274
	15-17.99 (Mean)	18 (% 82)	14 (%64)	
	18 and above (Excellent)	2 (% 9)	5 (% 22.5)	

Table 3: Comparison of the average scores of ECG interpretation and Self-directed Learning in the participants of the study before and after the intervention in the control and intervention groups

Variable		Group		Independent t-test
		Control	Intervention	
		Mean±SD	Mean±SD	
ECG Interpretation	Before	9.20±1.12	8.30±2.23	P=0.249
	After	8.80±1.36	14.10±2.94	P=0.007
Mean Difference		-0.4	5.8	P=0.002
Paired t		P=0.181	P=0.010	--
Self-Directed Learning	Before	136±6.97	129±7.54	P=0.094
After	125±4.3	168±10.42	P=0.003	
Mean Difference		-11	39	P=0.001
Paired t		P=0.072	P=0.006	--

Table 4: Effect of intervention on Self-directed Learning and ECG interpretation by considering demographic variables using multiple linear regression

Dependent	Model	Independent	Coefficient (CI %95)	P value	R Squared
Self-Directed Learning	Full model	Group (1=Intervention)	-43 (-46.6 to -39.4)	<0.001*	0.943
		Age (1=18-20 years old))	-1.65 (-6.13 to 2.83)	0.461	
		Gender (1=Male)	-0.5 (-4.24 to 3.24)	0.787	
		Marital Status (1=Single)	-1.14 (-1.979 to 0.021)	0.601	
		Type of Residence (1=Private)	-0.82 (-4.74 to 3.1)	0.674	
		Grade Point Average (1=Weak)	-3.39 (-7.16 to 0.38)	0.077	
	Reduced model	Group (1=Intervention)	-43.18 (-46.39 to -39.96)	<0.001*	0.945
ECG interpretation	Full model	Group (1=Intervention)	-6.38 (-7.31 to -5.46)	<0.001*	0.831
		Age (1=18-20 years old))	-0.25 (-1.37 to 0.86)	0.647	
		Gender (1=Male)	0.21 (-0.73 to 1.16)	0.654	
		Marital Status (1=Single)	-0.39 (-1.51 to 0.73)	0.486	
		Type of Residence (1= Private)	-0.36 (-1.35 to 0.63)	0.470	
		Grade Point Average (1=Weak)	-0.19 (-1.12 to 0.75)	0.690	
	Reduced model	Group (1=Intervention)	-6.24 (-7.06 to -5.42)	<0.001*	0.846

All model was adjusted for before the intervention score. The full model was developed according to the Enter approach. Reduced model was developed according to the Backward approach by considering the P-value<0.05 for removing the variable. CI: Confidence Interval; *Significant; Group: 1=Intervention, 2=Control.

The results of the paired t-test showed that there was no statistically significant difference in the average scores of ECG interpretation before and after the intervention in the control group (P=0.181). Still, this difference was significant in the intervention group (P=0.010). This same pattern is visible in the average scores of Self-directed Learning before and after the intervention in the control group (P=0.072) and intervention group (P=0.006) (Table 3).

The results of multiple linear regression showed the effect of gamification on the study results by considering demographic variables and adjusting the values before gamification with backward modeling at a significance level of less than 0.05. In the full model, gamification had a significant

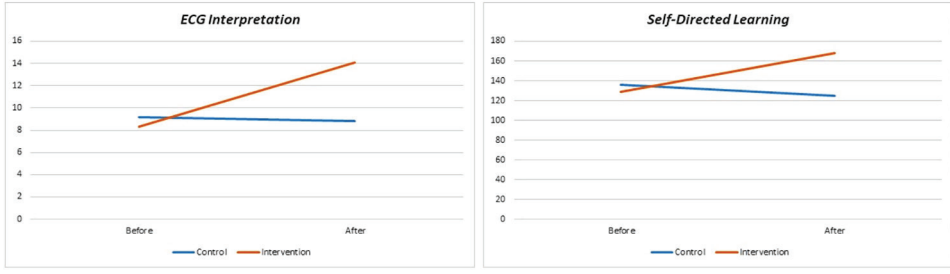

Figure 2: The graph of changes in the mean scores of ECG interpretation and Self-directed Learning of the participants in the study before the intervention and two weeks after the end of the intervention in both groups

effect on Self-directed Learning, and this value was controlled by demographic variables and values before gamification (Coefficient=-43; CI 95%: -46.6 to -39.4; P<0.001; R-Squared=0.943). Also, after using the backward approach and removing ineffective variables, gamification had a significant effect on Self-directed Learning (Coefficient=-43.18; CI 95%: -46.39 to -39.96; P<0.001; R-Squared=0.945) (Table 4). In addition, in the full model, gamification had a significant effect on ECG interpretation, and this value was controlled by demographic variables and values before gamification (Coefficient=-6.38; CI 95%: -7.31 to -5.46; P<0.001; R-Squared=0.831). Besides, after the use of the backward approach and removing ineffective variables, gamification still had a significant effect on the ECG interpretation (Coefficient=-6.24; CI 95%: -7.06 to -5.42; P<0.001; R-Squared=0.846) (Table 4).

As shown in Figure 2, before the intervention and between both groups, the corrected answers of ECG Interpretation were less than ten. However, two weeks after the end of the intervention, in the control group, corrected answers declined. In contrast, in the intervention group, corrected answers grew sharply, which shows the effect of gamification. Also, this same pattern is visible in Self-directed Learning, indicating that gamification enhanced the scores of Self-directed Learning in the intervention group.

Discussion

The present study aimed to determine the effect of online gamification on the ability to interpret ECG and Self-directed Learning in nursing students. The findings of this research showed that there was a statistically significant difference between the control and intervention groups in the average scores of ECG interpretation and Self-directed Learning after the intervention. In other words, online gamification improved the interpretation of ECG and Self-directed Learning among students.

The findings of the current study are consistent with those of the research by Inangil et al. (2022), which was conducted to compare gamification and animation on learning and diagnosis of diabetes and academic motivation in medical students (31). In their research, gamification led to more accurate and faster diagnosis of diabetes and improved learning and academic motivation in students. The common feature of these two types of research is the use of gamification to promote student learning. Antit et al. (2020) also conducted a study to compare gamification and reverse learning on ECG interpretation and learning strategies in medical students. The results showed that gamification, compared to reverse learning, improvesd the students' competence in ECG interpretation and was an effective strategy for learning compared to the reverse learning method, which is consistent with the results of the current study (32). In their research, the samples learned to play the game offline using playing cards with heart tapes on them. In addition, the number of sessions for each group was two, and the variables were measured immediately after the end of the intervention without considering the learning stabilization time. However, in the current study, the students were from the nursing group, and before entering the study, they were assessed for their ability to interpret ECG; four training sessions were held for each group, and two weeks after the end of the intervention, the variables were examined. The results of both studies showed that gamification improved learning in ECG interpretation. In the study of Atashzadeh et al. (2008), which was conducted to compare ECG interpretation with lecture, problem-solving, and computer-assisted self-learning in nursing students, it was shown that after the intervention, the computer-assisted self-learning method, compared with other methods, had the lowest efficiency, which is inconsistent with the results of the current research (33). The reasons for the disparity were the type and duration of the intervention, the designed content, inappropriate entry and exit criteria, and how the samples were measured.

Self-directed learning is one of the consequences of consolidating what has been learned and improving the quality of education (21). In the study by Tan et al. (2007) on the

effect of gamification on learning blood product injections and their side effects on nursing students, it was shown that gamification increased the students' learning of strategies, which is consistent with the current research (34). In their research, gamification was done on the Kahoot platform along with clinical scenarios as an intervention, and the questionnaires were completed by the samples immediately after the end of the intervention. The common feature of these two researches is the effect of gamification on the promotion of learning. The study of Haghgou et al. (2013), which was conducted to compare the lecture method and web-based question and answer method on the willingness and consolidation of learning to interpret ECG in nursing students, showed that the web-based question and answer method increased the willingness to learn and consolidation of what has been learned, which is consistent with current research (35). The common feature of the two studies was the positive effect of the intervention on learning and its related factors as a low-cost and practical intervention for medical students.

Conclusion

Using online simulation games as a new educational method in nursing students improves the ability to interpret ECG and Self-directed Learning. The current research results showed that online gamification significantly improved the accuracy and ability to interpret the ECG and learning strategy.

The limitations of this research include the duration of the research, the number of samples, and the target group. Among the strengths of the current research, we can mention the use of the new Storyline platform, the design of clinical scenarios to manage the patient's condition, the classification of ECG disorders training, and the creation of a competitive environment to accelerate learning.

According to the results obtained from this research, it is suggested that further studies should be conducted with a higher number of samples, a variety of new teaching methods, and the latest free online platforms for other theoretical units used in clinical education.

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Authors' Contribution

All authors contributed to the discussion, read and approved the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated resolved.

Conflict of Interest

The authors declare no conflicts of interest.

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