

The Impact of Game-Based Learning on Electrocardiogram Interpretation Skills of Medical Students Compared to Conventional Learning Methods: A Comparative Pilot Study

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Abstract

Background: In the contemporary landscape of technology, the integration of gamification in education has gained significant traction. Past research has indicated that gamified learning fosters motivation and engagement among 21st-century students in academic pursuits. Although well-documented in general education, there remains a dearth of empirical studies evaluating the efficacy of gamified learning in medicine. This discrepancy is apparent in the disparate guidance about incorporating gamification in medical education.

Objectives: This research aimed to assess the effectiveness of game-based ECG learning (G-ECG) in undergraduate medical students.

Methods: The current study utilized a quasi-experimental design involving the recruitment of 120 second-year medical students during the 2023-2024 academic year at the Faculty of Allied Health Sciences (AHS) within a Private Medical College and Hospital in Chennai, Tamil Nadu. The G-ECG group engaged in educational activities utilizing the Six-Second ECG (SS-ECG) web-based game offered by SKILLSTAT. The G-ECG group used a one-hour gamified application to attain proficiency in identifying 27 ECG rhythms. Conversely, the Conventional (C-ECG) group participated in a one-hour training session led by certified ECG professionals to develop competency in recognizing 27 ECG rhythms. The performance of both groups was evaluated through an online assessment, and statistical analysis was utilized to compare scores and response times for each question. The data were analyzed using the Chi-square and independent t-test within the SPSS software environment.

Results: In a study of 120 second-year students, 34.1% were male, and 65.8% were female. The mean age was 19.23 ± 0.50 years for the conventional learning group and 19.15 ± 0.60 years for the game-based learning group, with no significant differences in demographics ($P > 0.05$). Both groups had 60 participants each. The participants utilized the game-based ECG learning method and achieved a knowledge attainment level of 61.7%, with a p-value of < 0.001 . In contrast, those involved in the conventional ECG learning method attained only 33.3%.

Conclusion: The study found that game-based ECG learning proves more effective than conventional methods in improving diagnostic accuracy. However, when it comes to enhancing interpretation skills, gamified learning proves equally effective as conventional ECG learning.

Keywords: Electrocardiogram; Gamification; Game-Based Electrocardiogram; ECG Learning; Undergraduate Medical Students; Learning Methods

Background

Gamification is the strategic integration of game design principles into non-game environments, a term first coined by Brett Terrill in 2008 and gaining

widespread recognition around 2010. While extensively embraced in marketing, economics, research, and healthcare, its implementation in education has been relatively gradual (1).

Nonetheless, with the advancements in technology-enhanced learning (TEL) and the use of digital platforms, such as social networks, digital media, and the Internet, a diverse range of electronic educational games, virtual patient simulations, and online gamified quizzes and puzzles have increased, with varying degrees of success in recent years (2).

The electrocardiogram (ECG) is a pivotal diagnostic tool in contemporary healthcare practices (3). Proficiency in ECG interpretation is a paramount requirement for medical professionals, serving as a foundational element in the training framework for medical students during their clinical rotations. Recent literature reviews have highlighted significant deficiencies in electrocardiogram (ECG) interpretation skills among interns, residents, and attending physicians across various medical specialties, including internal medicine, family practice, and emergency medicine. These inadequacies could adversely affect patient care outcomes. Additionally, there is a pressing need for further research to explore strategies aimed at enhancing ECG interpretation skills (4, 5).

The integration of gamification into medical education has attracted considerable interest from educators, resulting in increased research within this domain due to its potential to enhance motivation and engagement among medical students (6, 7). Furthermore, a recent landscape review study authored by McCoy, Lewis, and Dalton delved into gamified learning platforms in medical education, unearthing that game-based learning integrated into medical curricula has amplified student engagement, promoted collaborative learning, and improved decision-making (8).

This evidence has prompted the application of gamification principles in the context of ECG education. However, the implementation of gamification in ECG training remains nascent in the medical field, likely due to the limited availability of platforms in this discipline. Consequently, there is a compelling need for meticulously designed research to evaluate the effects of gamification on educational outcomes in ECG training.

Objectives

The primary aim of this study was to assess the educational outcomes derived from ECG-focused game sessions compared to traditional teaching methods among a cohort of medical students.

Methods

A comparative study was undertaken to evaluate the effectiveness of game-based ECG learning (G-ECG) when compared to conventional ECG learning (C-ECG) among second-year medical students during the academic year 2023-2024 at the Faculty of Allied Health Sciences (AHS), Dr. M.G.R Educational and Research Institute, located in Chennai, Tamil Nadu, India. The participants were selected utilizing the census method from the second-year medical students ($n = 120$) enrolled at the above-mentioned private medical college. A total of 120 students participated in the study, with 60 students allocated to the experimental group (game-based ECG learning) and the remaining 60 assigned to the control group (conventional ECG learning) through a stratified random assignment process.

The allocation of learning methods (G-ECG versus C-ECG) to students with varying levels of academic proficiency was determined through a random process, such as a coin toss. Both groups underwent a 30-minute lecture on fundamental ECG concepts provided by certified ECG professionals.

The Six-Second ECG (SS-ECG) is a web-based simulation tool designed to facilitate the learning of twenty-seven familiar cardiac rhythms. Through its "explore-review" feature, users can access detailed information on each rhythm by simply clicking on its name. The "explore-review-play" function also enables users to diagnose ECG patterns by customizing the game settings, including the time period, dynamic or static rhythm display, sound volume, and grid display (9).

The experimental cohort engaged in learning via the Six-Second ECG (SS-ECG) web-based game offered by SKILLSTAT. The G-ECG group engaged with a game application for one hour to gain proficiency in recognizing 27 ECG rhythms. In contrast, the C-ECG group received a one-hour training session from certified ECG professionals to develop competency in identifying 27 ECG rhythms. The 27 different types of ECG rhythms were categorized into 5 sections: Sinus Arrhythmias, Atrial Arrhythmias, Heart Blocks, Junctional Arrhythmias, and Ventricular Arrhythmias. Sinus Arrhythmias include 6 types of ECG patterns: Sinus Rhythm, Sinus Bradycardia, Sinus Tachycardia, Sinus Arrhythmia, Sinus Exit Block, and Sinus Arrest. Atrial Arrhythmias consist of 5 types of ECG patterns: NSR with PAC, SVT, Atrial Fibrillation, Atrial Flutter, and Paced Atrial.

Heart Blocks comprise 5 types of ECG patterns: NSR with 1° AVB, 2° AVB Type I, 2° AVB Type II, 2° AVB 2:1, and 3° AV Block. Junctional Arrhythmias include 5 types of ECG patterns: NSR with PJC, Junctional Rhythm, Accelerated Junctional, Junctional Tachycardia, and Wandering Pacemaker. Ventricular Arrhythmias consist of 6 types of ECG patterns: NSR with PVC, Idioventricular, Accelerated IVR, Ventricular Tachycardia, Ventricular Fibrillation, and Paced Ventricular.

In the game-based learning group, platforms were secured with password protection and administered to prevent contamination bias in the study's outcome. Participants were explicitly instructed not to use alternative platforms during the experimental period. Both the G-ECG and C-ECG groups utilized identical learning materials. The audio-visual department verified that all ECG images used in the study were of high quality. The effectiveness of both groups was evaluated through an online test, with scoring and response times for each question compared using statistical analysis. The Institutional Ethical Committee (IEC/ACSMCH) approved the study under reference No. 957/IEC/ACSMCH.

Statistical analysis: The research data were obtained using a pre-tested form and subsequently entered into SPSS 20 (SPSS Inc., Chicago, USA). Descriptive statistics for quantitative variables were expressed as the mean and standard deviation. The chi-square test was used to analyze the association between the knowledge and the two groups. The Independent t-test was employed to assess time consumption differences between groups for continuous variables. In this study, a significance level of 0.05 was considered for statistical tests.

Results

In a study involving 120 second-year students, 41 (34.1%) were male, and 79 (65.8%) were female. Among them, 60 participated in conventional learning, and 60 were part of the game-based learning group. Of the participants, 24 (40%) and 17 (28.3%) were male, while 36 (60%) and 43 (71.7%) were female in the conventional and game-based learning groups, respectively.

The mean (SD) age was 19.23 ± 0.50 years in the conventional learning group and 19.15 ± 0.60 years in the game-based learning group. No statistically significant differences in age ($P=0.412$), gender ($P=0.241$), academic year ($P=0.312$), or distribution were observed between the two groups. All participants

from both groups reported no prior experience in gamified learning.

The efficacy of Game-Based ECG Learning (G-ECG) vs conventional ECG Learning (T-ECG) based on score attainment and time consumption: The comparison of the Game-Based ECG learning method with the conventional ECG learning approach revealed no significant difference in the time consumed by both groups ($P>0.05$) across various aspects, including Sinus Arrhythmias, Atrial Arrhythmias, Heart Blocks, Junctional Arrhythmias, and Ventricular Arrhythmias, within the two cohorts (Table 1).

Out of 27 ECG rhythms evaluated, 7 ECG rhythms exhibited a significant association between the two groups, evidenced by a p-value <0.001 (Table 2). Participants utilizing the game-based ECG learning method achieved a sufficient knowledge attainment level of 61.7% (33 cases) compared to 33.3% (20 cases) in the conventional ECG learning method ($P<0.001$). This finding suggests that the G-ECG Method resulted in a markedly higher level of knowledge attainment than the conventional ECG learning approach.

The efficacy of conventional ECG Learning (T-ECG) based on Gender: In the context of our analysis of conventional-based ECG learning, we assessed the knowledge levels of male and female participants. Out of 27 ECG rhythms evaluated, 4 ECG rhythms exhibited a statistically significant association between the two gender groups, as indicated by a p-value <0.001 (Table 3).

Female participants who engaged in the conventional-based ECG learning method attained a knowledge level of 58.3% (21 cases), unlike male participants, who achieved only 16.7% (4 cases), with a p-value of <0.001 . These findings suggest that female participants demonstrated a considerably higher level of knowledge attainment than their male counterparts.

The female participants exhibited a longer duration of time consumption compared to the male participants with statistically significant p-values ($P<0.001$ for all) observed across various parameters, including Sinus Arrhythmias, Atrial Arrhythmias, Heart Blocks, Junctional Arrhythmias, and Ventricular Arrhythmias (Table 4).

The efficacy of Game-Based ECG Learning (G-ECG) based on Gender: In the context of our analysis of game-based ECG learning, we evaluated the knowledge levels of male and female participants. Among the 27 ECG rhythms assessed, 3 ECG rhythms demonstrated a

statistically significant association between the two gender groups ($P < 0.001$) (Table 5). 58.1% of female participants who engaged in the game-based ECG learning method (25 cases) achieved a sufficient knowledge level in contrast to 47.1% of male participants (8 cases), with a p-value of < 0.001 . These findings indicate that female participants exhibited a markedly higher level of knowledge acquisition than their male counterparts.

The female participant exhibited a longer duration of time consumption compared to the male participant, with statistically significant p-values (< 0.001) observed across various parameters, including Sinus Arrhythmias, Atrial Arrhythmias, Heart Blocks, Junctional Arrhythmias, and Ventricular Arrhythmias (Table 6).

Discussion

Prior research has highlighted the insufficient Skills in 12-lead ECG interpretation skills among medical students, emphasizing the need for innovative pedagogical approaches to enhance ECG competency (10-12).

In today's educational landscape, online ECG learning has gained traction as a supplementary instructional method, offering the flexibility often lacking in conventional classroom settings. However, the engagement and enthusiasm of students in online learning courses remain inadequate. In response to this educational challenge, we utilized a web-based gamified ECG learning platform (SS-ECG, SKILLSTAT) as a gamified online active learning approach to enhance student engagement through a competitive and interactive learning environment (10).

The present study demonstrated that Game-Based ECG Learning (G-ECG) significantly improved ECG diagnostic accuracy and interpretation skills. The results indicate that game-based learning is more effective than conventional ECG learning in enhancing factual knowledge among undergraduate medical students. This is likely due to the collaborative and competitive elements of gamified learning, which create a stimulating learning environment and actively engage students in the learning process.

According to a review article focused on computer programs designed to facilitate the teaching of ECG interpretation, there was no evidence in the literature concerning the existence of an application or webpage that incorporates gamification for this purpose before the completion of the data analysis presented in this study. Although no studies were identified that explicitly

utilize gamification technologies, it is important to highlight several related studies that have explored the application of alternative technologies for teaching ECG interpretation (13, 14).

Determining the most effective method for teaching ECG interpretation remains inconclusive, as indicated by Fent et al. (15). They found that integrating multiple instructional techniques is essential for optimal learning outcomes.

In a comparative study conducted by Kopeć, which assessed two e-learning approaches for ECG interpretation among medical students, it was similarly concluded that collaborative e-learning proved more effective than self-directed e-learning (16).

Furthermore, Nilsson suggested that enhancing traditional ECG instruction with online learning modalities could significantly bolster ECG comprehension among medical students (17). Montassier et al. (18) conducted a research study to assess the efficacy of an e-learning strategy for interpreting ECG through a randomized controlled trial.

The findings demonstrated that this approach significantly enhanced the acquisition of ECG interpretation skills among medical students. This study distinguishes itself from similar investigations by developing and evaluating an application augmented by artificial intelligence to foster a personalized pedagogical approach. Furthermore, the application incorporates gamification elements to bolster student engagement, thereby offering valuable contributions to the existing body of literature.

The incorporation of gamification elements can encompass reward strategies designed to enhance student motivation in the learning of ECG interpretation. Further research is essential to assess students' acceptance of and progress in ECG learning through gamification.

The incorporation of gamification This study aims to propose gamified strategies designed to enhance student engagement and to compare these gamified methods with alternative educational approaches. Moreover, the present study's evidence suggests that game-based learning is comparable to traditional methods in improving students' abilities to interpret ECGs. It is anticipated that this academic inquiry will contribute to future research initiatives and ultimately support the development of innovative tools for ECG instruction.

Conclusion

We have demonstrated that using games as an instructional method is equally effective as conventional ECG teaching, offering a more interactive and learner-centered experience. This approach is promising for students who thrive in relaxed, learner-focused environments. Furthermore, the level of knowledge attained through the game-based approach surpassed that of conventional ECG teaching, with both methods requiring a similar amount of time.

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Table 1. The efficacy of Game-Based ECG Learning (G-ECG) vs traditional ECG Learning (T-ECG) based on time consumption

ECG group	Group	Mean (SD)	Mean Difference	95% Confidence interval of the differences		DF	P value
				Lower	Upper		
				Sinus Arrhythmias Time (Q-6)	T-ECG		
	G-ECG	63.3(19.5)					
Atrial Arrhythmias Time (Q-5)	T-ECG	50.8(23.8)	-3.45	-11.1	4.2	118	0.386
	G-ECG	54.3(18.7)					
Heart Blocks Time (Q-5)	T-ECG	50.4(22.0)	-6.28	-13.8	1.2	118	0.104
	G-ECG	56.6(19.5)					
Junctional Arrhythmias Time (Q-5)	T-ECG	50.7(22.2)	-3.26	-10.6	4.1	118	0.386
	G-ECG	54.0(18.5)					
Ventricular Arrhythmias Time (Q-6)	T-ECG	60.8(25.9)	-5.60	-14.5	3.3	118	0.217
	G-ECG	66.4(23.4)					
Overall Time	T-ECG	479.8(184.9)	-43.20	-104.2	17.8	118	0.166
	G-ECG	523.0(151.0)					

Table 2. The efficacy of Game-Based ECG Learning (G-ECG) vs traditional ECG Learning (T-ECG)

ECG		Traditional ECG Learning (*) (N=60)	Game-Based ECG Learning (**)(N=60)	P-value
Normal Sinus Rhythm	Correct	29(48.3%)	33(55.0%)	0.461
	Incorrect	31(51.7%)	27(45.0%)	
Sinus Exit Block	Correct	21(35.0%)	38(63.3%)	<0.001
	Incorrect	39(65.0%)	22(36.7%)	
Paced Atrial	Correct	19(31.7%)	26(43.3%)	0.181
	Incorrect	41(68.3%)	34(56.7%)	
Accelerated Idioventricular Rhythm	Correct	21(35.0%)	26(43.3%)	0.353
	Incorrect	39(65.0%)	34(56.7%)	
Sinus Tachycardia	Correct	25(41.7%)	23(38.3%)	0.704
	Incorrect	35(58.3%)	37(61.7%)	
Atrial Flutter	Correct	25(41.7%)	41(68.3%)	<0.001
	Incorrect	35(58.3%)	19(31.7%)	
Second Degree Av Block Mobitz Type 2	Correct	20(33.3%)	19(31.7%)	0.842
	Incorrect	40(66.7%)	41(68.3%)	
Sinus Arrest	Correct	26(43.3%)	22(36.7%)	0.453
	Incorrect	34(56.7%)	38(63.3%)	
Junctional Rhythm	Correct	15(25.0%)	19(31.7%)	0.415
	Incorrect	45(75.0%)	41(68.3%)	
Third Degree AV Block	Correct	16(26.7%)	25(41.7%)	0.081
	Incorrect	44(73.3%)	35(58.3%)	
Atrial Fibrillation	Correct	22(36.7%)	23(38.3%)	0.855
	Incorrect	38(63.3%)	37(61.7%)	
Premature Atrial Contraction	Correct	19(31.7%)	21(35.0%)	0.697
	Incorrect	41(68.3%)	39(65.0%)	
Sinus Bradycardia	Correct	22(36.7%)	35(58.3%)	<0.001
	Incorrect	38(63.3%)	25(41.7%)	
First Degree AV Block	Correct	14(23.3%)	21(35.0%)	0.161
	Incorrect	46(76.7%)	39(65.0%)	
Supraventricular Tachycardia	Correct	22(36.7%)	35(58.3%)	<0.001
	Incorrect	38(60.3%)	25(41.7%)	
Sinus Arrhythmia	Correct	26(63.4%)	15(25.0%)	<0.001
	Incorrect	34(56.7%)	45(75.0%)	
Second Degree Av Block 2:1 Ratio	Correct	16(26.7%)	18(30.0%)	0.683
	Incorrect	44(73.3%)	42(70.0%)	
Paced Ventricular	Correct	22(36.7%)	28(46.7%)	0.265
	Incorrect	38(63.3%)	32(53.3%)	
Second Degree Av Block Mobitz Type 1	Correct	10(16.7%)	14(23.3%)	0.364
	Incorrect	50(83.3%)	46(76.7%)	

Premature Junctional Complex	Correct	27(45.0%)	32(53.3%)	0.366
	Incorrect	33(55.0%)	28(46.7%)	
Ventricular Fibrillation	Correct	18(30.0%)	35(58.3%)	<0.001
	Incorrect	42(70.0%)	25(41.7%)	
Accelerated Junctional Rhythm	Correct	20(33.3%)	14(23.3%)	0.224
	Incorrect	40(66.7%)	46(76.7%)	
Idioventricular Rhythm	Correct	26(43.3%)	28(46.7%)	0.716
	Incorrect	34(56.7%)	32(53.3%)	
Ventricular Tachycardia	Correct	36(60.0%)	43(71.7%)	0.177
	Incorrect	24(40.0%)	17(28.3%)	
NSR With Isolated PVC	Correct	20(33.3%)	23(38.3%)	0.566
	Incorrect	40(66.7%)	37(61.7%)	
Junctional Tachycardia	Correct	25(41.7%)	26(43.3%)	0.853
	Incorrect	35(58.3%)	34(56.7%)	
Wandering Atrial Pacemaker	Correct	19(31.7%)	31(51.7%)	<0.001
	Incorrect	41(68.3%)	29(48.3%)	

Table 3. The efficacy of Traditional ECG Learning (T-ECG) based on Gender

ECG		Gender		P-value
		Male	Female	
Normal Sinus Rhythm	Correct	10(41.7%)	19(52.8%)	0.393
	Incorrect	14(58.3%)	17(47.2%)	
Sinus Exit Block	Correct	7(29.2%)	14(38.9%)	0.433
	Incorrect	17(70.8%)	22(61.1%)	
Paced Atrial	Correct	2(8.3%)	17(47.2%)	<0.001
	Incorrect	22(91.7%)	19(52.8%)	
Accelerated Idioventricular Rhythm	Correct	9(37.5%)	12(33.3%)	0.741
	Incorrect	15(62.5%)	24(66.7%)	
Sinus Tachycardia	Correct	11(45.8%)	14(38.9%)	0.593
	Incorrect	13(54.2%)	22(61.1%)	
Atrial Flutter	Correct	8(33.3%)	17(47.2%)	0.285
	Incorrect	16(66.7%)	19(52.8%)	
Second Degree Av Block Mobitz Type 2	Correct	7(29.2%)	13(36.1%)	0.574
	Incorrect	17(70.8%)	23(63.9%)	
Sinus Arrest	Correct	6(25.0%)	20(55.6%)	<0.001
	Incorrect	18(75.0%)	16(44.4%)	
Junctional Rhythm	Correct	6(25.0%)	9(25.0%)	1.000
	Incorrect	18(75.0%)	27(75.0%)	
Third Degree Av Block	Correct	7(29.2%)	9(25.0%)	0.721
	Incorrect	17(70.8%)	27(75.0%)	
Atrial Fibrillation	Correct	6(25.0%)	16(44.4%)	0.122
	Incorrect	18(75.0%)	20(55.6%)	
Premature Atrial Contraction	Correct	5(20.8%)	14(38.9%)	0.144
	Incorrect	19(79.2%)	22(61.1%)	
Sinus Bradycardia	Correct	8(33.3%)	14(38.9%)	0.663
	Incorrect	16(66.7%)	22(61.1%)	
First Degree Av Block	Correct	3(12.5%)	11(30.6%)	0.101
	Incorrect	21(87.5%)	25(69.4%)	
Supraventricular Tachycardia	Correct	8(33.3%)	14(38.9%)	0.662
	Incorrect	16(66.7%)	22(61.1%)	
Sinus Arrhythmia	Correct	8(33.3%)	18(50.0%)	0.203
	Incorrect	16(66.7%)	18(50.0%)	
Second Degree Av Block 2:1 Ratio	Correct	8(33.3%)	8(22.2%)	0.345
	Incorrect	16(66.7%)	28(77.8%)	
Paced Ventricular	Correct	8(33.3%)	14(38.9%)	0.664
	Incorrect	16(66.7%)	22(61.1%)	
Second Degree Av Block Mobitz Type 1	Correct	3(12.5%)	7(19.4%)	0.486
	Incorrect	21(87.5%)	29(80.6%)	
Premature Junctional Complex	Correct	6(25.0%)	21(58.3%)	<0.001
	Incorrect	18(75.0%)	15(41.7%)	

Ventricular Fibrillation	Correct	6(25.0%)	12(33.3%)	0.491
	Incorrect	18(75.0%)	24(66.7%)	
Accelerated Junctional Rhythm	Correct	6(25.0%)	14(38.9%)	0.263
	Incorrect	18(75.0%)	22(61.1%)	
Idioventricular Rhythm	Correct	8(33.3%)	18(50.0%)	0.206
	Incorrect	16(66.7%)	18(50.0%)	
Ventricular Tachycardia	Correct	12(50.0%)	24(66.7%)	0.195
	Incorrect	12(50.0%)	12(50.0%)	
NSR With Isolated PVC	Correct	5(20.8%)	15(41.7%)	0.094
	Incorrect	19(79.2%)	21(58.3%)	
Junctional Tachycardia	Correct	8(23.3%)	17(47.2%)	0.281
	Incorrect	16(66.7%)	19(52.8%)	
Wandering Atrial Pacemaker	Correct	3(12.5%)	16(44.4%)	<0.001
	Incorrect	21(87.5%)	20(55.6%)	

Table 4. The efficacy of traditional ECG Learning (T-ECG) based on time consumption

Traditional ECG learning group	Gender	Mean (SD)	Mean difference	95% Confidence interval of the differences		DF	P-value
				Lower	Upper		
Sinus Arrhythmias Time (Q-6)	Male	45.9(16.1)	-19.3	-31.4	-7.2	58	<0.001
	Female	65.2(26.4)					
Atrial Arrhythmias Time (Q-5)	Male	40.1(14.7)	-17.9	-29.6	-6.1	58	<0.001
	Female	58.0(26.1)					
Heart Blocks Time (Q-5)	Male	42.1(18.6)	-13.7	-24.9	-2.6	58	<0.001
	Female	55.9(22.7)					
Junctional Arrhythmia Time (Q-5)	Male	38.4(16.7)	-20.5	-31.0	-9.9	58	<0.001
	Female	58.9(21.8)					
Ventricular Arrhythmias Time (Q-6)	Male	46.7(18.3)	-23.4	-35.8	-11.1	58	<0.001
	Female	70.1(26.1)					
Overall Time	Male	379.8(118.6)	-166.5	-254.6	-78.4	58	<0.001
	Female	546.4(192.2)					

Table 5. The efficacy of Game-Based ECG Learning (G-ECG) based on Gender

ECG		Gender		P-value
		Male	Female	
Normal Sinus Rhythm	Correct	9(52.9%)	24(55.8%)	0.841
	Incorrect	8(47.1%)	19(44.2%)	
Sinus Exit Block	Correct	9(52.9%)	29(67.4%)	0.294
	Incorrect	8(47.1%)	14(32.6%)	
Paced Atrial	Correct	8(47.1%)	18(41.9%)	0.715
	Incorrect	9(52.9%)	25(58.1%)	
Accelerated Idioventricular Rhythm	Correct	6(35.3%)	20(46.5%)	0.426
	Incorrect	11(64.7%)	23(53.5%)	
Sinus Tachycardia	Correct	7(41.2%)	16(37.2%)	0.776
	Incorrect	10(58.8%)	27(62.8%)	
Atrial Flutter	Correct	9(52.9%)	32(74.4%)	0.104
	Incorrect	8(47.1%)	11(25.6%)	
Second Degree Av Block Mobitz Type 2	Correct	7(41.2%)	12(27.9%)	0.312
	Incorrect	10(58.8%)	31(72.1%)	
Sinus Arrest	Correct	3(17.6%)	19(44.2%)	<0.001
	Incorrect	14(82.4%)	24(55.8%)	
Junctional Rhythm	Correct	5(29.4%)	14(32.6%)	0.812
	Incorrect	12(70.6%)	29(67.4%)	
Third Degree Av Block	Correct	7(41.2%)	18(41.9%)	0.963
	Incorrect	10(58.8%)	25(58.1%)	
Atrial Fibrillation	Correct	6(35.3%)	17(39.5%)	0.765
	Incorrect	11(64.7%)	26(60.5%)	

Premature Atrial Contraction	Correct	6(35.3%)	15(34.9%)	0.974
	Incorrect	11(64.7%)	28(65.1%)	
Sinus Bradycardia	Correct	9(52.9%)	26(60.5%)	0.596
	Incorrect	8(47.1%)	17(39.5%)	
First Degree Av Block	Correct	3(17.6%)	18(49.1%)	0.077
	Incorrect	14(82.4%)	25(58.1%)	
Supraventricular Tachycardia	Correct	13(76.5%)	22(51.2%)	0.077
	Incorrect	4(23.5%)	21(48.8%)	
Sinus Arrhythmia	Correct	7(41.2%)	8(18.6%)	0.065
	Incorrect	10(58.8%)	35(81.4%)	
Second Degree Av Block 2:1 Ratio	Correct	5(29.4%)	13(30.2%)	0.954
	Incorrect	12(70.6%)	30(69.8%)	
Paced Ventricular	Correct	10(58.8%)	18(41.9%)	0.232
	Incorrect	7(41.2%)	25(58.1%)	
Second Degree Av Block Mobitz Type 1	Correct	1(5.9%)	13(30.2%)	<0.001
	Incorrect	16(94.1%)	30(69.8%)	
Premature Junctional Complex	Correct	6(35.3%)	26(60.5%)	0.072
	Incorrect	11(64.7%)	17(39.5%)	
Ventricular Fibrillation	Correct	7(41.2%)	28(65.1%)	0.094
	Incorrect	10(58.8%)	15(34.9%)	
Accelerated Junctional Rhythm	Correct	6(35.3%)	8(18.6%)	0.162
	Incorrect	11(64.7%)	35(81.4%)	
Idioventricular Rhythm	Correct	7(41.2%)	21(48.8%)	0.591
	Incorrect	10(58.8%)	22(51.2%)	
Ventricular Tachycardia	Correct	9(52.9%)	34(79.1%)	<0.001
	Incorrect	8(47.1%)	9(20.9%)	
NSR With Isolated PVC	Correct	8(47.1%)	15(34.9%)	0.387
	Incorrect	9(52.9%)	28(65.1%)	
Junctional Tachycardia	Correct	7(41.2%)	19(44.2%)	0.836
	Incorrect	10(58.8%)	24(55.8%)	
Wandering Atrial Pacemaker	Correct	10(58.8%)	21(48.8%)	0.488
	Incorrect	7(41.2%)	22(51.2%)	

Table 6. The efficacy of Game-Based ECG Learning (G-ECG) based on time consumption

Game ECG group	Gender	Mean (SD)	Mean difference	95% Confidence interval of the differences		DF	P-value
				Lower	Upper		
Sinus Arrhythmias Time (Q-6)	Male	50.9(17.0)	-17.24	-27.6	-6.8	58	<0.001
	Female	68.1(18.4)					
Atrial Arrhythmias Time (Q-5)	Male	45.6(14.0)	-12.09	-22.4	-1.7	58	<0.001
	Female	57.7(19.3)					
Heart Blocks Time (Q-5)	Male	43.8(14.5)	-17.94	-28.2	-7.6	58	<0.001
	Female	61.7(19.0)					
Junctional Arrhythmias Time (Q-5)	Male	46.4(18.3)	-10.58	-20.9	-0.2	58	<0.001
	Female	57.0(17.8)					
Ventricular Arrhythmias Time (Q-6)	Male	53.6(18.7)	-17.79	-30.5	-5.0	58	<0.001
	Female	71.4(23.4)					
Overall Time	Male	427.2(131.7)	-133.54	-213.5	-53.5	58	<0.001
	Female	560.8(142.3)					