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Original Article

Effectiveness of gamification for electrocardiogram interpretation training among intensive care nurses: a randomized controlled trial

Davood Aminnasab [1], Soleiman Ahmady [1], Davood Rasouli [2], Mohsen Masoumian Hosseini[3], Ali Karimi Rozveh[4,5]*

[1]Department of Medical Education, School of Medical Education and Learning Technologies, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]CyberTex Institute of Technology, Austin, Texas, USA
[3]Department of E-learning in Medical Sciences, Smart University of Medical Sciences, Tehran, Iran
[4]Medical-Surgical Department, Nursing & Midwifery School, Tehran University of Medical Sciences, Tehran, Iran
[5]Al-Subtain university of Medical Sciences, international branch of Tehran University of Medical Sciences in Iraq, Karbla, Iraq

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***Corresponding author:**
Ali Karimi Rozveh, Medical-Surgical Department, Nursing & Midwifery School, Tehran University of Medical Sciences, Tehran, Iran, Al-Subtain university of Medical Sciences, international branch of Tehran University of Medical Sciences in Iraq, Karbla, Iraq.
Email: Karimirozveh@gmail.com

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Abstract

Background & Objective: Accurate ECG interpretation is a critical clinical competency for ICU nurses, yet conventional lecture-based training has shown limited efficacy in achieving durable skill acquisition. This study aimed to evaluate a gamification-based educational intervention for improving ECG interpretation competence among ICU nurses.

Materials & Methods: This randomized controlled educational trial was conducted among 100 ICU nurses at Shariati Hospital, Tehran, Iran. Participants were randomly allocated to a gamification-based intervention group ($n = 50$) or a lecture-based control group ($n = 50$). The intervention was delivered over two weeks. ECG interpretation competence was assessed using a validated 20-item multiple-choice questionnaire at baseline and four weeks post-intervention. The questionnaire was developed through content validation by an expert panel (I-CVI $\geq$ 0.83, S-CVI/Ave = 0.92) and pilot testing with item analysis (difficulty index: 0.35–0.75; discrimination index: 0.30–0.55). Data were analyzed using independent and paired t-tests.

Results: Baseline ECG scores were comparable between groups (intervention: 14.34 ± 1.18; control: 13.75 ± 1.22; $p = 0.064$). After the intervention, the adjusted post-test mean score was significantly higher in the gamification group than in the control group (15.43 ± 1.16 vs. 14.84 ± 1.12; $p = 0.042$; Cohen's d = 0.52). Prior experience with educational games was a significant predictor of post-test performance in the intervention group ($\beta = 0.63$, SE = 0.27, 95% CI [0.11, 1.15], $p = 0.019$).

Conclusion: Gamification-based education was more effective than traditional lectures in enhancing ECG interpretation competence among ICU nurses and may serve as a practical approach for continuing nursing education.

Keywords: gamification; electrocardiogram interpretation; intensive care nurses; nursing education; randomized controlled trial

Introduction

Cardiovascular Disease (CVD) remains the leading cause of death worldwide, accounting for an estimated 19.8 million deaths in 2022, approximately 32% of all global mortality [1]. The global age-standardized death rate stood at 235.2 per 100,000 population in 2021 [2], and in Iran, cardiovascular disease accounts for roughly 42% of all deaths [3]. Rapid recognition of acute coronary syndromes is central to reducing this burden; as outlined in the National Service Framework for CVD, timely diagnosis enables thrombolytic therapy and other urgent interventions [4]. The electrocardiogram (ECG) is the primary tool for this purpose, and its accurate interpretation is central to early detection of ischemic patterns, minimization of myocardial injury, and improved patient outcomes [5]. Nurses in acute care settings are therefore expected to be proficient in 12-lead ECG acquisition and interpretation, as early identification of abnormalities directly shapes treatment decisions [6].

Despite this critical responsibility, ECG interpretation skills among nurses remain inadequate. A national study in China involving coronary and intensive care units found that nurses frequently performed poorly on ECG monitoring tasks [7]. Funk et al. similarly reported that nearly half of the nurses in their sample misidentified normal ECG tracings as signs of ischemia [7]. Collectively, these findings are consistent with broader evidence linking insufficient ECG interpretation competence to reduced quality of care and adverse clinical outcomes [8–10].

Various educational interventions targeting ECG interpretation among medical students and nurses have been reported [4, 11, 12], yet conventional approaches have not consistently produced the competency levels required in acute care settings. The healthcare environment is evolving rapidly, driven by technological change and shifting expectations of clinical practice [14, 15]. Contemporary nursing education literature emphasizes developing autonomous, responsible, and patient-centered practitioners [16], and Felton and Royal argue that curricula must remain aligned with the advanced care demands of diverse clinical contexts [17]. These pressures underscore the need for instructional approaches that go beyond passive knowledge transfer.

E-learning has emerged as an effective strategy for developing ECG interpretation skills, particularly as healthcare education shifts toward flexible, digitally-based delivery [18, 19]. Blended formats combining computer-based modules with face-to-face instruction have shown improved learner performance, and computer-assisted learning offers advantages over traditional teaching through open access to digital content and immediate feedback [20]. Gamification extends this further by embedding game-like elements—challenges, rewards, and interactive design—into the learning environment [21]. McCoy et al. highlight several benefits of gamified medical education tools, including enhanced motivation, realistic clinical problem-solving, and improved judgment; such platforms also support distance learning and generate performance data that can guide individualized feedback [22, 23].

Hosseini et al. demonstrated that gamification in nursing triage education significantly improved undergraduate students' knowledge and performance beyond basic comprehension toward practical application [24]. A crossover study similarly reported enhanced learning outcomes in surgical instrument training through gamified methods [25], and converging evidence supports the utility of gamification as a pedagogical approach in nursing education [26, 27]. Nevertheless, few high-quality experimental studies have specifically examined ECG interpretation competence among ICU nurses, and instructional design in this area has rarely been grounded in explicit theoretical frameworks. This study therefore evaluates a gamified ECG training program designed according to the Fong instructional model.

Materials & Methods

Design and setting(s)

This Randomized Controlled Trial (RCT) evaluated the effectiveness of a gamification-based educational intervention in improving Electro-Cardio-Gram (ECG) interpretation competence among Intensive Care Unit (ICU) nurses. The study was conducted at Shariati Hospital, a tertiary referral teaching hospital affiliated with Tehran University of Medical Sciences, Tehran, Iran, between June 26 and September 17, 2024. The intervention was implemented across 11 specialized clinical units, including two cardiac intensive care units, two internal medicine intensive care units, two surgical intensive care units, one emergency department intensive care unit, one neurosurgical intensive care unit, one coronary care unit, and the hospital's affiliated laboratory. The study was designed and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guideline for randomized controlled trials.

Participants and sampling

The study population comprised registered nurses working in the ICUs of Shariati Hospital. Eligibility criteria included holding a bachelor's degree in nursing, having at least three months of ICU clinical experience, access to a smartphone and the internet, willingness to participate, and no participation in a similar ECG educational program during the preceding three months. Nurses who did not complete the educational intervention or failed to participate in the post-intervention assessment were excluded from the analysis. The required sample size was estimated using a power analysis based on findings from a previous study [28], assuming a significance level of 0.05 and a statistical power of 90%. The calculation indicated that a minimum of 41 participants was required in each group. To compensate for possible attrition, 50 participants were recruited per group, resulting in a total sample of 100 nurses. Among 187 nurses assessed for eligibility, 100 met the inclusion criteria, agreed to participate, and provided written informed consent. Following completion of the baseline assessment, participants were randomly allocated to either the gamification-based intervention group or the traditional lecture-based control group using a computer-generated randomization sequence prepared by an independent statistician. Allocation concealment was achieved through Sequentially Numbered, Opaque, Sealed Envelopes (SNOSE), which were opened by the principal investigator only after eligibility had been confirmed and informed consent had been obtained. The participant recruitment, allocation, follow-up, and analysis processes are presented in the CONSORT flow diagram (**Figure 1**).

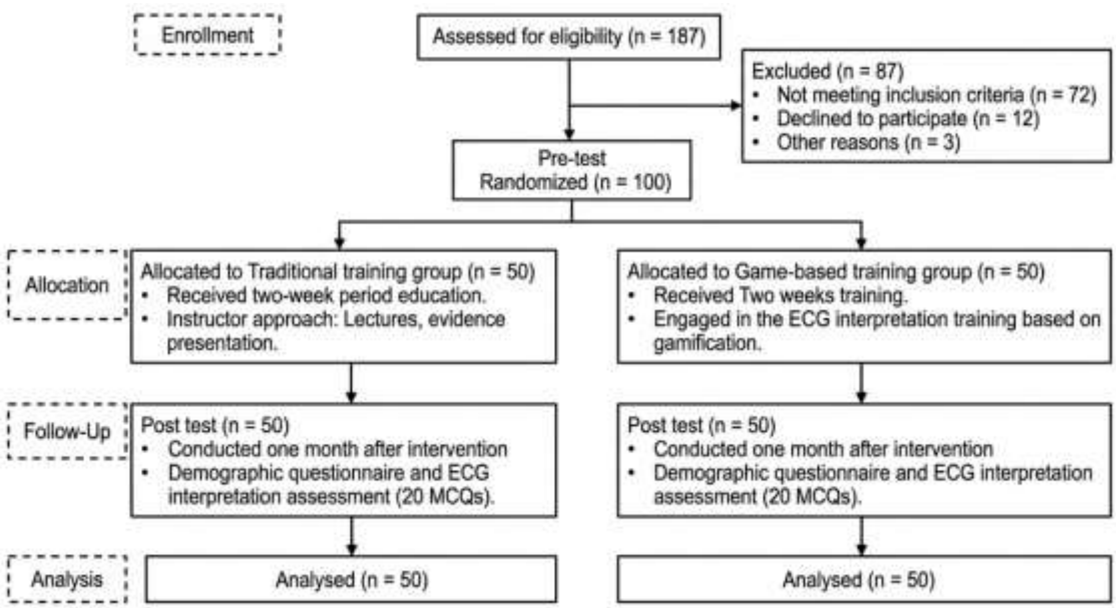

Figure 1. Flowchart diagram of the study

Tools/Instruments

Participants' electrocardiogram (ECG) interpretation competence was assessed using a researcher-developed 20-item multiple-choice questionnaire, entitled the ECG Interpretation Knowledge Questionnaire (ECG-IKQ). The instrument was specifically designed for this study following established principles of educational measurement and test development [29]. The complete questionnaire is provided as **Supplementary Material 1**. The development of the ECG-IKQ began with a comprehensive review of the literature on ECG interpretation competencies required for critical care nurses [4, 5, 7]. Based on this review, five content domains were identified: ECG fundamentals and waveform analysis, supraventricular arrhythmias, ventricular arrhythmias, atrioventricular and bundle branch blocks, and junctional and pacemaker rhythms. A test blueprint was subsequently prepared to determine the proportional distribution of items across these domains according to their clinical importance and frequency in ICU practice (**Table 1**). In addition, the cognitive level of each item was mapped according to Bloom's taxonomy, with questions targeting recall/recognition (40%), comprehension/application (45%), and analysis/synthesis (15%). An initial pool of 35 multiple-choice questions was developed independently by two members of the research team (MMH and DA). Each item consisted of one correct answer and three plausible distractors and was constructed according to established recommendations for writing high-quality multiple-choice questions, emphasizing clarity, a single best answer, and the avoidance of negative wording or unintended grammatical cues [30].

Table 1. Test blueprint for ECG interpretation knowledge questionnaire

Content Domain	Cognitive Level	Items	Weight (%)
ECG fundamentals	Recall/Comprehension	4	20
Supraventricular arrhythmias	Comprehension/Application	5	25
Ventricular arrhythmias	Comprehension/Application	4	20
AV blocks/BBB	Analysis/Application	4	20
Junctional rhythms/pacemakers	Application/Analysis	3	15
Total	—	**20**	**100**

Note: This table outlines the test blueprint for the ECG knowledge questionnaire.
Abbreviations: n, number of participants; ECG, electrocardiogram; AV, atrioventricular; BBB, bundle branch block.

Content validity was evaluated by an expert panel comprising two cardiologists with subspecialty training in electrophysiology, three nursing faculty members specializing in critical care education, and three experienced ICU nurses with at least five years of clinical practice. Experts independently rated each item for relevance, clarity, and representativeness using a four-point Likert scale. The Item Content Validity Index (I-CVI) was calculated for each item as the proportion of experts assigning ratings of 3 or 4, and items with an I-CVI of at least 0.78 were considered acceptable [31]. Scale-level content validity was assessed using both the average (S-CVI/Ave) and universal agreement (S-CVI/UA) approaches.

Of the initial 35 items, 26 demonstrated satisfactory content validity at the first evaluation. Six items with borderline ratings were revised according to reviewers' comments and reassessed, whereas three items with inadequate content validity were discarded. The final questionnaire consisted of 20 items and demonstrated excellent content validity, with an S-CVI/Ave of 0.92 and an S-CVI/UA of 0.80. Mean ratings for clarity ranged from 3.38 to 4.00, while representativeness scores ranged from 3.25 to 4.00 across all retained items.

The psychometric properties of the final questionnaire were further examined in a pilot study involving 35 ICU nurses from a hospital not participating in the main trial. Item analysis was conducted according to Classical Test Theory principles [32]. Item difficulty was calculated as the proportion of participants answering each question correctly. Consistent with established recommendations, items with difficulty indices within the acceptable range were retained following review of their educational relevance [32, 33]. Item discrimination was assessed using the point-biserial correlation coefficient, with values of at least 0.20 considered acceptable and values of 0.30 or greater considered desirable [34]. Distractor effectiveness was also examined, and distractors selected by fewer than 5% of participants were considered nonfunctional and reviewed for possible revision.

Pilot testing demonstrated satisfactory psychometric performance for all retained items. Difficulty indices ranged from 0.35 to 0.75 (mean ± SD: 0.54 ± 0.11), whereas discrimination indices ranged from 0.30 to 0.55 (mean ± SD: 0.42 ± 0.07). All distractors functioned appropriately, with response frequencies ranging from 8% to 42%; therefore, no further revisions were required (**Table 2**).

Table 2. Item analysis results from pilot testing (n = 35)

Item	Content domain	DI	D	Status
1–4	ECG fundamentals	0.54	0.41	Retained
5–9	Supraventricular arrhythmias	0.54	0.42	Retained
10–13	Ventricular arrhythmias	0.51	0.43	Retained
14–17	AV blocks/BBB	0.51	0.41	Retained
18–20	Junctional rhythms/pacemakers	0.46	0.44	Retained
Mean ± SD	—	**0.51 ± 0.04**	**0.42 ± 0.01**	—

Note: Item analysis was conducted to evaluate the difficulty and discrimination indices of the questionnaire items.
Abbreviations: n, number of participants; DI, difficulty index; D, discrimination index; SD, standard deviation; ECG, electrocardiogram; AV, atrioventricular; BBB, bundle branch block.

Internal consistency reliability of the ECG-IKQ was evaluated using Cronbach's alpha, yielding a coefficient of 0.88 (95% CI: 0.82–0.93), which indicated excellent reliability [35]. Item-total correlations ranged from 0.31 to 0.56, and no item demonstrated a negative or negligible correlation with the total score. Test-retest reliability was assessed in an independent sample of 20 ICU nurses who completed the questionnaire twice at a two-week interval. The intraclass correlation coefficient was 0.84 (95% CI: 0.68–0.93), indicating good temporal stability. The same questionnaire was administered before the intervention and again four weeks after its completion. Using the same assessment instrument at both time points was considered appropriate because the interval between assessments was sufficient to minimize recall bias, the questionnaire primarily evaluated knowledge application rather than memorization of individual responses, and participants were continuously exposed to routine clinical practice during the study period. Each correct response received one point, resulting in a total possible score ranging from 0 to 20. Total scores were categorized as weak (<10), average (10–15), and good (>15).

Educational intervention (Gamification design)

The educational intervention was developed using the three-layered thinking model for web-based educational game design proposed by Fong and Sheng [36]. This instructional framework integrates pedagogical objectives, game design principles, and achievement mechanisms to ensure that game elements support meaningful learning rather than serving solely as motivational features (**Figure 2**).

The development process began with defining the educational objectives based on the competencies required for ECG interpretation in critical care practice. These objectives guided the design of learning activities and game mechanics to ensure alignment between instructional content and gameplay. The research team subsequently designed the game's core structure, including its progression system, scoring rules, and competitive elements. Educational objectives and clinical scenarios were reviewed and refined through consultation with cardiologists and nursing educators before the final version of the game was produced.

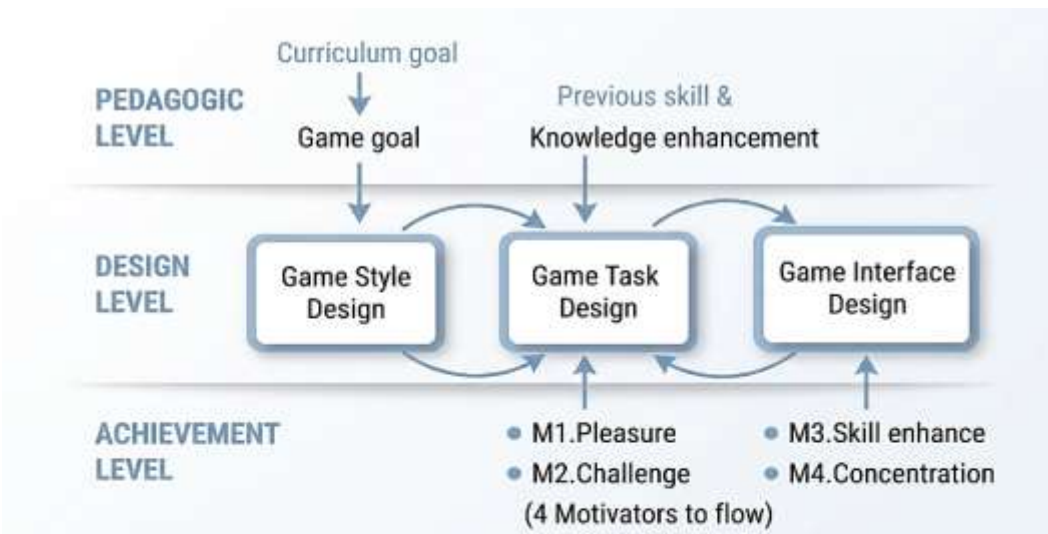

Figure 2. Three-layered thinking model of web-based educational game design (Fong & Sheng, 2008) [36]

Particular attention was given to maintaining an appropriate balance between task difficulty and reward mechanisms. Participants earned points by correctly completing progressively more challenging learning activities, while the sequence of tasks was designed to accommodate their existing knowledge and facilitate gradual acquisition of new competencies.

The educational game was developed using Articulate Storyline 3 (Articulate Global Inc., New York, NY, USA). Programming and implementation were performed by the principal researcher (M.M.H.) without the involvement of external software developers. The completed program was deployed through an online learning management system, which enabled participants to access the educational content remotely and allowed the research team to monitor learning progress and engagement throughout the intervention. Representative screenshots of the game environment are presented in **Figure 3**.

Data collection methods

Data were collected at two time points: immediately before the educational intervention (pre-test) and four weeks after completion of the intervention (post-test). At both assessments, participants completed the ECG Interpretation Knowledge Questionnaire (ECG-IKQ) individually in a quiet environment under the supervision of a member of the research team. Participants were instructed to answer all questions independently without consulting external resources or discussing their responses with colleagues. Although the researcher remained available to clarify procedural questions or ambiguities in the questionnaire, no feedback regarding the correctness of responses was provided during the assessment.

Following completion of the baseline assessment, participants assigned to the intervention group received access to the web-based gamification program through the learning management system, whereas those in the control group participated in the conventional lecture-based educational session covering the same ECG learning objectives. After four weeks, participants in both groups completed the post-test using the same questionnaire under conditions comparable to those of the baseline assessment. All completed questionnaires were collected immediately after administration and scored manually using a standardized answer key by a member of the research team.

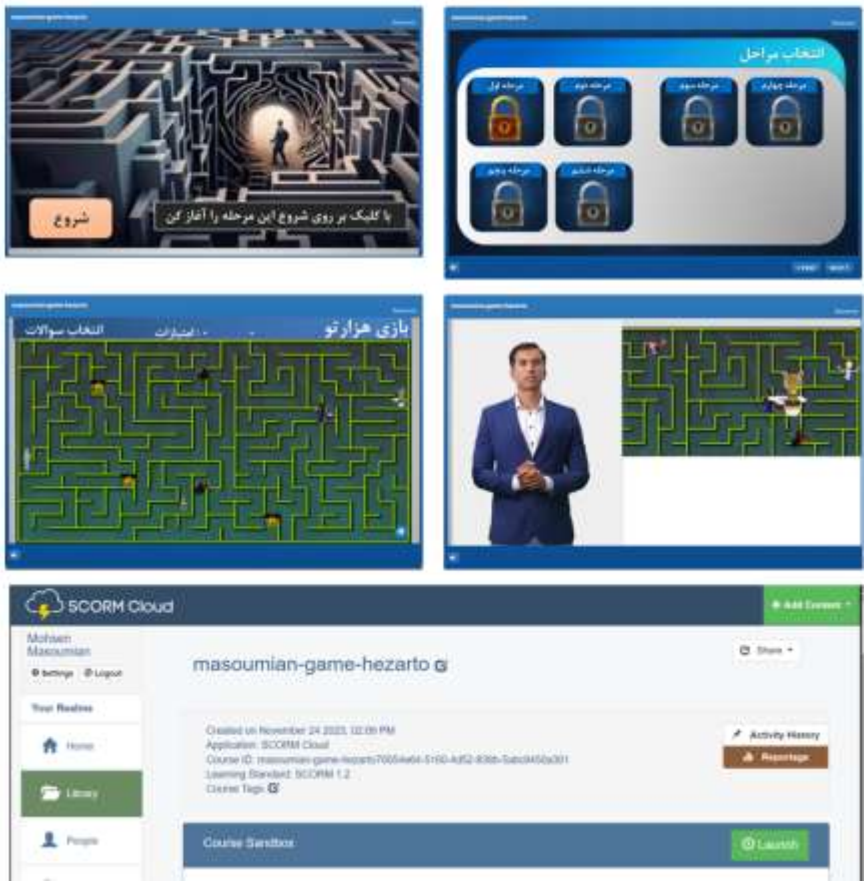

Figure 3. The game environments

Data analysis

Prior to inferential analyses, the normality assumption was assessed for all continuous dependent variables. This preliminary step involved the Shapiro–Wilk test, supplemented by visual inspection of quantile-quantile (Q–Q) plots for each group and time point. These diagnostic procedures confirmed that the data did not deviate significantly from a normal distribution. Consequently, parametric statistical tests were deemed appropriate for the primary analyses, as they offer greater statistical power when their underlying assumptions are satisfied. To examine differences in mean ECG knowledge scores between the gamification and traditional lecture groups, an independent-samples t-test was used. This test is suited for comparing the means of two independent groups on a continuous outcome measure. Its application was justified by the study design and confirmation that the data met the normality criterion and the assumption of homogeneity of variances (verified by Levene's test). In addition to comparing group means, we calculated the effect size using Cohen's d to quantify the magnitude of the observed difference.

For within-group analyses, a paired-samples t-test was used to evaluate changes in participants' ECG knowledge from pre-test to post-test. This repeated-measures approach was selected because it assesses the same individuals at two time points, controlling for inter-individual variability. For within-group analyses, a paired-samples t-test was used to evaluate changes in ECG knowledge scores from pre-test to post-test. This repeated-measures approach accounts for inter-individual variability and provides a direct estimate of learning gain within each educational condition. To explore the influence of potential confounding or moderating variables, additional analyses were conducted using linear regression. This method examined the relationship between several covariates—including participants' age, gender, years of work experience, and prior experience with educational games—and post-test scores, while controlling for baseline performance. This approach allowed us to assess whether specific learner characteristics moderated the effectiveness of the gamification intervention, providing a nuanced understanding of its impact across diverse subgroups. All statistical tests were performed at a significance level of $\alpha = 0.05$. Effect sizes for between-group comparisons were quantified using Cohen's d. All data analyses were conducted using SPSS version 26 (IBM Corp., Armonk, NY, USA).

Results

A total of 100 participants were enrolled, with 50 assigned to each group. The mean age was 32.8 ± 5.0 years, with comparable distributions between the intervention (32.4 ± 4.8 years) and control groups (33.1 ± 5.2 years). Females constituted the majority of participants (70%), with similar gender distributions across groups. More than half were married (60%), approximately one-third had prior ECG training (34%), and 44% reported previous educational game experience, with a slightly higher proportion in the intervention group. Mean work experience was 5.4 ± 2.0 years and mean ICU experience was 18.7 ± 6.9 months. No statistically significant between-group differences were observed for any demographic or professional variable (**Table 3**). At baseline, ECG interpretation scores did not differ significantly between groups ($t_{(98)} = 1.87$, $p = 0.064$). Following the intervention, the gamification group achieved significantly higher post-test scores than the control group ($t_{(98)} = 2.04$, $p = 0.042$) (**Table 4**). Within-group comparisons revealed significant pre- to post-test improvements in both groups ($p < 0.001$ for each). To further characterize the intervention effect, linear regression was used to examine the relationships between post-test scores and in-game performance and the following covariates: age, gender, marital status, work experience, and prior educational game experience—analyzed separately within each group.

Table 3. Demographic characteristics of participants (n = 100)

Variable	Intervention Group (n = 50)	Control Group (n = 50)
Age (years), mean ± SD	32.40 ± 4.80	33.10 ± 5.20
Gender, n (%)		
Male	16 (32.00)	14 (28.00)
Female	34 (68.00)	36 (72.00)
Marital status, n (%)		
Married	28 (56.00)	32 (64.00)
Single	22 (44.00)	18 (36.00)
Prior ECG training, n (%)		
Yes	18 (36.00)	16 (32.00)
No	32 (64.00)	34 (68.00)
Educational game experience, n (%)		
Yes	24 (48.00)	20 (40.00)
No	26 (52.00)	30 (60.00)
Work experience (years), mean ± SD	5.20 ± 2.10	5.50 ± 1.90
ICU experience (months), mean ± SD	18.30 ± 6.70	19.10 ± 7.20

Note: Independent t-test was used to compare continuous demographic variables between groups.
Chi-square test was employed to compare qualitative demographic variables between groups.
Abbreviations: n, number of participants; SD, standard deviation; ICU, intensive care unit; ECG, electrocardiogram.

Table 4. Comparison of pre-test and post-test scores between the intervention and control groups

Comparison / Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Statistical test	t	df	p-value
Intervention group (n = 50)	14.34 ± 1.18	15.43 ± 1.16	Paired t-test	4.00	49	< 0.0001
Control group (n = 50)	13.75 ± 1.22	14.84 ± 1.12	Paired t-test	4.00	49	< 0.0001
Between-group comparison at pre-test	14.34 ± 1.18	13.75 ± 1.22	Independent t-test	1.87	98	0.064
Between-group comparison at post-test	15.43 ± 1.16	14.84 ± 1.12	Independent t-test	2.04	98	0.042

Note: Values are expressed as mean ± SD. Between-group comparisons were analyzed using independent t-tests. Within-group comparisons (pretest to posttest) were analyzed using paired t-tests.
Abbreviations: SD, standard deviation; df, degrees of freedom; p, probability value.

Discussion

This study examined the educational impact of a gamified intervention on ECG interpretation skills in ICU nurses. The gamification group demonstrated significantly higher post-test scores than the control group, supporting the effectiveness of gamification relative to standard lecture-based education. Pre-intervention equivalence between groups strengthens the internal validity of this comparison. Regression analyses further indicated that learner-related variables may influence outcomes: prior exposure to educational games was associated with higher in-game performance, and age was associated with pre-test scores. These findings suggest that gamified learning can build on existing competencies, and point to the value of learner profiling instructional design.

These results corroborate Rosselli et al., who found enhanced ECG competency among nurses exposed to a gamified intervention compared to conventional approaches [38]. Similarly, Antit et al. reported greater gains in ECG interpretation competence with gamification than with flipped learning [39]. Although these studies differ in population, format, and measurement timing, the consistency of direction across findings supports the broader applicability of gamified ECG education. Conversely, some prior computer-assisted interventions have not demonstrated superiority over lectures. Ghezelghash et al. found computer-assisted self-learning to be less effective than other approaches for ECG interpretation [40]. This discrepancy may reflect differences in how the learning environment is structured. Exploratory or search-dependent formats can increase cognitive load and expose learners to unveted material, whereas the current intervention delivered tailored content directly through gameplay. Features such as immediate feedback, progress tracking, and reward mechanisms likely enhanced engagement and error correction—elements consistently identified as central to gamification's educational value [41]. Evidence from broader nursing education aligns with these findings. Tan et al. found that serious games enhance knowledge and confidence, though effects on performance outcomes were less consistent [42]. This distinction matters here because the primary outcome was knowledge acquisition, not clinical performance. Gamified environments can promote active learning through iterative challenges and rapid feedback loops [43], and several studies have reported improvements in post-test scores, motivation, and retention among nurses receiving gamified education [44–46]. The role of professional experience warrants consideration. Nurses with more work experience demonstrated more favorable post-intervention responses, potentially reflecting better contextualization of ECG patterns through prior clinical exposure. Prior research has suggested that age, gender, and prior experience may moderate motivational responses to gamification [44, 47–49]; however, in the current study, none of these variables reached statistical significance as predictors of primary outcomes. One possible explanation is that the direct clinical relevance of ECG interpretation for ICU nurses may have sustained engagement relatively uniformly across demographic groups.

Several limitations of this study should be acknowledged. First, the absence of an active comparator in the control group precluded a comparative analysis of the efficacy of gamification against other active educational interventions. Second, this was a single-center study conducted in specialist wards of one hospital, which may limit the generalizability of the findings to other settings. Third, no blinding was implemented; researchers and participants were aware of group allocation, which may have introduced performance bias. Fourth, the four-week follow-up period was relatively short and may not reflect long-term knowledge retention or the durability of the educational effect. Fifth, the outcome measure focused solely on knowledge (assessed via a multiple-choice questionnaire) without evaluating clinical performance in real-patient care scenarios. Consequently, whether the observed improvements translate to practical bedside ECG interpretation skills remains unclear. Future studies should incorporate longer follow-up periods, blinded designs, and direct assessments of clinical performance.

Conclusion

The results demonstrate that a gamification-oriented educational intervention significantly improves ECG interpretation competence among intensive care nurses. By incorporating structured game components into nursing education, educators can facilitate active learning and improve clinical skill acquisition. As a feasible and cost-effective resource, gamified learning can be integrated into continuing education courses to support professional development and enhance patient care outcomes. Further research is warranted to assess long-term knowledge retention and the potential application of gamification in diverse educational environments.

Ethical considerations

The study was approved by the Ethics Committee of the School of Medical Education and Learning Technologies, Shahid Beheshti University of Medical Sciences (Ethics code: IR.SBMU.SME.REC.1402.032). Written informed consent was obtained from all participants, and data confidentiality was strictly maintained throughout the study.

Artificial intelligence utilization for article writing

AI-assisted language editing (QuillBot) was used to improve clarity and grammar. The authors accept full responsibility for the content.

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Conflict of interest statement

We declare no conflicts of interest.

Author contributions

DA and AKR designed and supervised the procedure. MMH, SA, and DA performed the intervention and collected the data. The game was designed and developed by MMH. Data analysis was performed by DR, who also participated in planning the study. All authors read and approved the manuscript.

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None.

Data availability statement

Data from this study may be disclosed upon a reasonable request submitted to the corresponding author.

References

1. World Health Organization. Cardiovascular diseases (CVDs) [Internet]. Geneva: World Health Organization; 2025. [cited 2026 Mar 27]. Available from: https://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)

2. Martin SS, Aday AW, Allen NB, Almarzooq ZI, Anderson CAM, Arora P, et al. 2025 Heart disease and stroke statistics: a report of US and global data from the American Heart Association. *Circulation*. 2025;151(8):e41–e660. https://doi.org/10.1161/CIR.0000000000001303

3. Tehran Times. Cardiovascular diseases responsible for 42% of deaths [Internet]. 2022. [cited 2026 Mar 27]. Available from: https://www.tehrantimes.com/news/477160/Cardiovascular-diseases-responsible-for-42-of-deaths

4. Zhang H, Hsu LL. The effectiveness of an education program on nurses' knowledge of electrocardiogram interpretation. *Int Emerg Nurs*. 2013;21(4):247–51. https://doi.org/10.1016/j.ienj.2012.11.001

5. Ho JKM, Yau CHY, Wong CY, Tsui JSS. Capability of emergency nurses for electrocardiogram interpretation. *Int Emerg Nurs*. 2021;54:100953. https://doi.org/10.1016/j.ienj.2020.100953

6. Docherty B. 12-lead ECG interpretation and chest pain management: 1. *Br J Nurs*. 2003;12(21):1248–55. https://doi.org/10.12968/bjon.2003.12.21.11867

7. Funk M, Fennie KP, Stephens KE, May JL, Winkler CG, Drew BJ. Association of implementation of practice standards for electrocardiographic monitoring with nurses' knowledge, quality of care, and patient outcomes: findings from the Practical Use of the Latest Standards of Electrocardiography (PULSE) Trial. *Circ Cardiovasc Qual Outcomes*. 2017;10(2):e003132. https://doi.org/10.1161/CIRCOUTCOMES.116.003132

8. Belay YH, Gezahegn D, Melaku B, Adal O. Nurses' competency on electrocardiography interpretation in adult emergency room: Addis Ababa, Ethiopia, 2021. Multicenter cross-sectional study. *Int Emerg Nurs*. 2024;74:101453. https://doi.org/10.1016/j.ienj.2023.101453

9. Mobrad A. Electrocardiogram interpretation competency among paramedic students. *J Multidiscip Healthc*. 2020;13:823–8. https://doi.org/10.2147/JMDH.S268048

10. Kashou A, May A, DeSimone C, Noseworthy P. The essential skill of ECG interpretation: How do we define and improve competency? *Postgrad Med J*. 2020;96(1133):125–127. https://doi.org/10.1136/postgradmedj-2019-137191

11. Viljoen CA, Millar RS, Manning K, Burch VC. Effectiveness of blended learning versus lectures alone on ECG analysis and interpretation by medical students. *BMC Med Educ*. 2020;20(1):488. https://doi.org/10.1186/s12909-020-02410-6

12. Brooks CA, Kanyok N, O'Rourke C, Albert NM. Retention of baseline electrocardiographic knowledge after a blended-learning course. *Am J Crit Care*. 2016;25(1):61–7. https://doi.org/10.4037/ajcc2016598

13. Qayumi K, Hosseini ST, Hosseini MM, Nejat A, Salih M, Azimi M, et al. Enhancing medical training in conflict zones and remote areas through innovation: introducing the Canadian Virtual Medical University Initiative. *EClinicalMedicine*. 2024;76:102830. https://doi.org/10.1016/j.eclinm.2024.102830
14. Watson R. Clinical competence: starship enterprise or straitjacket? *Nurse Educ Today*. 2002;22(6):476–80. https://doi.org/10.1016/S0260-6917(02)00150-1
15. Masoumian Hosseini M, Masoumian Hosseini ST, Qayumi K, Ahmady S, Koohestani HR. The aspects of running artificial intelligence in emergency care; a scoping review. *Arch Acad Emerg Med*. 2023;11(1):e38. https://doi.org/10.22037/aaem.v11i1.1965
16. Hosseini MM, Koohpaei A, Ebrahimipour H, Masoumian Hosseini ST. Policy options to address the effectiveness of health service management graduates in solving Iranian health system challenges: a mixed scoping review and policy Delphi approach. *EClinicalMedicine*. 2024;77:102871. https://doi.org/10.1016/j.eclinm.2024.102871
17. Felton A, Royal J. Skills for nursing practice: Development of clinical skills in pre-registration nurse education. *Nurse Educ Pract*. 2015;15(1):38–43. https://doi.org/10.1016/j.nepr.2014.11.009
18. Fent G, Gosai J, Purva M. Teaching the interpretation of electrocardiograms: which method is best? *J Electrocardiol*. 2015;48(2):190–3. https://doi.org/10.1016/j.jelectrocard.2014.12.014
19. Pontes PA, Chaves RO, Castro RC, Souza ÉF, Seruffo MC, Francês CR. Educational software applied in teaching electrocardiogram: a systematic review. *Biomed Res Int*. 2018;2018(1):8203875. https://doi.org/10.1155/2018/8203875
20. Viljoen CA, Millar RS, Engel ME, Shelton M, Burch V. Is computer-assisted instruction more effective than other educational methods in achieving ECG competence amongst medical students and residents? A systematic review and meta-analysis. *BMJ Open*. 2019;9(11):e028800. https://doi.org/10.1136/bmjopen-2018-028800
21. Werbach K, Hunter D. *For the win: How game thinking can revolutionize your business*. Philadelphia: Wharton Digital Press; 2012.
22. McCoy L, Lewis JH, Dalton D. Gamification and multimedia for medical education: a landscape review. *J Am Osteopath Assoc*. 2016;116(1):22–34. https://doi.org/10.7556/jaoa.2016.003
23. Pereira LA, Leão LLdS, Dermeval D, Coelho JAPdM. ECG Tutor: a gamified intelligent tutoring system for electrocardiogram teaching. *Rev Bras Educ Med*. 2023;47:e080. https://doi.org/10.1590/1981-5271v47.1-20220223.ing
24. Masoumian Hosseini M, Masoumian Hosseini ST, Qayumi K, Hosseinzadeh S, Ahmady S. Crossover design in triage education: the effectiveness of simulated interactive vs. routine training on student nurses' performance in a disaster situation. *BMC Res Notes*. 2023;16(1):313. https://doi.org/10.1186/s13104-023-06587-4
25. Masoumian Hosseini M, Sadat Manzari Z, Gazerani A, Masoumian Hosseini ST, Rohaninasab M. Can gamified surgical sets improve surgical instrument recognition and student performance retention in the operating room? A multi-institutional experimental crossover study. *BMC Med Educ*. 2023;23(1):907. https://doi.org/10.1186/s12909-023-04893-x
26. Masoumian Hosseini M, Masoumian Hosseini ST, Qayumi K. Nursing student satisfaction with a crisis management game-based training: a quasi-experimental study. *Iran J Emerg Med*. 2023;10(1):e22. https://doi.org/10.22037/ijem.v10i1.40194
27. Masoumian Hosseini M, Masoumian Hosseini ST, Qayumi K, Baeradeh N. Game-based vs. case-based training for increasing knowledge and behavioral fluency of nurse students regarding crisis and disaster management: a quasi-experimental study. *Arch Acad Emerg Med*. 2022;10(1):e77. https://doi.org/10.22037/aaem.v10i1.1718
28. Najafi SS, Haghgou M, Kaveh MH, Mansoory P. Comparison of the effect of WebQuest and lecture on students' learning of electrocardiogram interpretation. *J Nurs Educ*. 2013;1(2):62–72. [cited 2026 Mar 27]. Available from: http://jne.ir/article-1-44-en.html
29. Wynd CA, Schmidt B, Schaefer MA. Two quantitative approaches for estimating content validity. *West J Nurs Res*. 2003;25(5):508–518. https://doi.org/10.1177/0193945903252998
30. Haladyna TM, Downing SM, Rodriguez MC. A review of multiple-choice item-writing guidelines for classroom assessment. *Appl Meas Educ*. 2002;15(3):309–333. https://doi.org/10.1207/S15324818AME1503_5
31. Polit DF, Beck CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health*. 2006;29(5):489–497. https://doi.org/10.1002/nur.20147
32. Wu M, Tam HP, Jen T-H. Classical Test Theory. Educational Measurement for Applied Researchers: Theory into Practice. Singapore: Springer Singapore;

2016. p. 73-90. https://doi.org/10.1007/978-981-10-3302-5_5

33. Khairani AZ, Shamsuddin H, editors. Assessing item difficulty and discrimination indices of teacher-developed multiple-choice tests. In: *Assessment for Learning Within and Beyond the Classroom*. Singapore: Springer; 2016.

34. Butakor P. Using Classical Test and Item Response Theories to Evaluate Psychometric Quality of Teacher-Made Test in Ghana. European Scientific Journal, ESJ. 2022;18:139. https://doi.org/10.19044/esj.2022.v18n1p139

35. Nunnally JC, Bernstein IH. *Psychometric theory*. 3rd ed. New York: McGraw-Hill; 1994.

36. Fu FL, Yu SC. Three layered thinking model for designing web-based educational games. In: *Advances in Web Based Learning – ICWL 2008*. Berlin: Springer; 2008. p. 265–276.

37. Hosseini MM, Hosseini TM, Qayumi K, Hosseinzadeh S. How to develop a memory game for clinical courses: A leading approach to the interaction of education. *J Med Educ*. 2023;22(1):e134934. https://doi.org/10.5812/jme-134934

38. Rossley AC. A comparison of registered nurses' motivation and knowledge levels between gamified and traditional courses [dissertation]. Greeley (CO): University of Northern Colorado; 2023.

39. Antit S, Zairi I, Bellakhal S, Mzoughi K, Ouali S, Mghaieth F, et al. Evaluation of students' motivation during the gamification of electrocardiogram interpretation learning. *Tunis Med*. 2020;98(11):776–82.

40. Ghezelghash A, Atashzadeh Shourideh F, Alavi Majd H, Yaghmaei F. Comparing methods of lecturing, problem solving and self-learning via internet to learn proper interpretation of electrocardiogram among nursing students. Iran J Nurs Res. 2008;3(10):7-15.

41. White M, Shellenbarger T. Gamification of nursing education with digital badges. *Nurse Educ*. 2018;43(2):78–82. https://doi.org/10.1097/NNE.0000000000000427

42. Tan AJQ, Lee CCS, Lin PY, Cooper S, Lau LST, Chua WL, et al. Designing and evaluating the effectiveness of a serious game for safe administration of blood transfusion: a randomized controlled trial. *Nurse Educ Today*. 2017;55:38–44. https://doi.org/10.1016/j.nedt.2017.05.007

43. Hamari J, Koivisto J, Sarsa H. Does gamification work? A literature review of empirical studies on gamification. In: *Proceedings of the 2014 47th Hawaii International Conference on System Sciences*; 2014 Jan 6–9; Waikoloa, HI, USA. Piscataway (NJ): IEEE; 2014. p. 3025–3034. https://doi.org/10.1109/HICSS.2014.377

44. Garrison E, Colin S, Lemberger O, Lugod M. Interactive learning for nurses through gamification. *J Nurs Adm*. 2021;51(2):95–100. https://doi.org/10.1097/NNA.0000000000000976

45. O'Neill K, Robb M, Kennedy R, Bhattacharya A, Dominici NR, Murphy A. Mobile technology, just-in-time learning and gamification: innovative strategies for a CAUTI education program. *Online J Nurs Inform*. 2018;22(2).

46. Woolwine S, Romp CR, Jackson B. Game on: evaluating the impact of gamification in nursing orientation on motivation and knowledge retention. *J Nurses Prof Dev*. 2019;35(5):255–260. https://doi.org/10.1097/NND.0000000000000578

47. González-González CS, Toledo-Delgado PA, Muñoz-Cruz V, Arnedo-Moreno J. Gender and age differences in preferences on game elements and platforms. *Sensors (Basel)*. 2022;22(9):3567. https://doi.org/10.3390/s22093567

48. Tondello GF, Wehbe RR, Diamond L, Busch M, Marczewski A, Nacke LE. The gamification user types Hexad scale. In: *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play*; 2016 Oct 16–19; Austin, TX, USA. New York: ACM; 2016. p. 229–243. https://doi.org/10.1145/2967934.2968082

49. Jent S, Janneck M. Using gamification to enhance user motivation: the influence of gender and age. In: Ahram T, editor. *Advances in Human Factors in Training, Education, and Learning Sciences*. Cham: Springer; 2017. p. 331–341. https://doi.org/10.1007/978-3-319-60018-5_32