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A randomized controlled trial of an escape laboratory challenge through gamified learning to improve cardiopulmonary resuscitation performance among nursing students

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Abstract

Effective cardiopulmonary resuscitation (CPR) training is a cornerstone of nursing education. However, conventional instruction often leads to inconsistent skill acquisition and fails to prepare students in emergencies situation. Although gamified learning can improve motivation, structure practice, and teamwork, there is still a lack of randomized evidence regarding its effectiveness in undergraduate CPR training. Therefore, the study aimed to assess the effectiveness of the *Nusantara 1: CPR Adventure* gamified module in improving CPR performance relative to conventional training methods. The research utilizes an intervention design to fulfill the study's objectives. A two-arm, parallel-group randomized controlled trial was conducted with undergraduate nursing students who had no prior formal CPR training. Participants were allocated 1:1 to either gamified or conventional training, ensuring equal contact time and comparable group sizes. This study was conducted in December 2024 at the Faculty of Nursing, Universitas Muhammadiyah Banjarmasin, Indonesia. The research team established specific inclusion and exclusion criteria to determine student eligibility for participation in this project. The sample size was calculated using G*Power software. A total of 140 nursing students participated and were randomly assigned to two groups of 70 students each. CPR performance was evaluated by blinded assessors using an 18-item Objective Structured Clinical Examination (OSCE) based on the Basic Trauma Cardiac Life Support (BTCLS) checklist. Assessments were conducted at baseline (T0) and 14 days post-training (T1). To analyze the results, between-group differences were compared using the Mann-Whitney U test, while within-group changes over time were assessed with the Wilcoxon signed-rank test. At follow-up, the gamified group significantly outperformed the control group (Cliff's $\delta=0.259$), with a 63% probability of superiority. Improvements were consistent across all critical CPR components, including chest compressions, ventilation, resuscitation, and Automated External Defibrillator (AED) utilization. These findings indicate that integrating escape room-style gamification into nursing curricula can enhance clinical performance.

Keywords: Cardiopulmonary resuscitation, escape lab, gamification, nursing skills, nursing students, randomized controlled trial

Introduction

Nurses are often the first responders to cardiac arrest incidents in clinical settings (Koželj et al., 2021). Thus, mastery of cardiopulmonary resuscitation (CPR) is a critical learning outcome during their undergraduate studies (Donoghue et al., 2021). Out-of-hospital cardiac arrest incidence in apparently healthy adults younger than 40 years ranges from 4 to 14 per 100 000 person-years worldwide (Tseng & Nakasuka, 2025). Meanwhile, in-hospitals cardiac arrest remains common, with an incidence of 10.6 patients per 100 admissions (Barros & Enfield, 2023). Survival to hospital discharge for these patients is poor (25.8%), with little known about the functional status at discharge or long-term outcomes (Virani et al., 2020). Because the quality of resuscitation is a primary determinant of survival, any deficiency in provider skill can have life-altering consequences. Recent evidence shows that nursing students often fail to meet CPR quality standards,

specifically regarding Automated External Defibrillator (AED) pad placement and procedural sequencing (Baghi et al., 2024). Furthermore, many students report feeling anxious or underprepared during real or simulated cardiac arrests (Miri et al., 2025; Nasiri et al., 2025). These performance gaps reflect a reliance on lecture-based instruction and brief demonstrations, which fail to provide the repetitive, realistic practice necessary for mastery (Lee et al., 2023). Findings from different countries confirm that this problem is global rather than local. For instance, research from the Czech Republic illustrates this point: although extended manikin-based training significantly improved chest compression depth among nursing students, it was insufficient for mastering optimal compression rates and recoil (Spatenkova et al., 2023). Other studies have noted that CPR skills deteriorate rapidly unless practice is delivered through brief, high-frequency sessions supported by objective feedback devices (Donoghue et al., 2025; Oermann et al., 2024). The pattern is consistent with broader evidence syntheses indicating that high-fidelity simulation can improve CPR skills compared with traditional training approaches (Herrero-Izquierdo et al., 2025).

Preliminary observations at the institution where this study was conducted mirror these global trends. CPR training is typically delivered through scheduled skill-laboratory sessions dominated by instructors' demonstrations and short, turn-taking practice on manikins. Students frequently report that they have few chances to repeat skills, refine their techniques, or practice under time pressure. During formative and summative skills assessments, many still struggle to maintain consistent compression depth, follow the CPR algorithm in the correct sequence, and work effectively in teams during sudden cardiac arrest scenarios. These local findings are consistent with literature, which shows that CPR performance declines rapidly without opportunities for repeated practice in realistic simulated environments (Ghazali et al., 2023). In this context, simulation is not a peripheral add-on but an essential pedagogical strategy to bridge the gap between theoretical understanding and real-world CPR competence (Kang & Yu, 2025). At the policy level, the Indonesian government has articulated a clear commitment to strengthening emergency care competencies among nursing graduates. National competency standards and Ministry of Health regulations identify CPR as a core skill that must be mastered by registered nurses. The statement is known as nursing professional standards (*Standar Profesi Perawat*) issued by the Ministry of Health of the Republic of Indonesia through Decree No. HK.01.07/MENKES/425/2020 (Ministry of Health of the Republic of Indonesia [MOH], 2020). The National Objective Structured Clinical Examination (OSCE) blueprint includes high-stakes CPR stations, and the Association of Indonesian Nurse Education Institutions has embedded emergency nursing competencies, including CPR, within the learning outcomes of the national undergraduate curriculum (Asosiasi Pendidikan Ners Indonesia [AIPNI], 2024). In parallel, the Ministry of Education promotes student-centered learning and active learning strategies in higher education as stated in Guidelines for Student-Centered Learning Implementation (*Panduan Implementasi Pembelajaran Berpusat pada Mahasiswa*) (Directorate General of Higher Education, Ministry of Education, Culture, Research, and Technology, 2023). Despite these policy directions, implementation at the program level remains uneven. In Indonesia, nursing educators report that student-active and simulation-based methods are still partially embedded in curricula, with teacher-centered traditions remaining strong (Grøndahl et al., 2025). International evidence shows that high-fidelity simulation is not yet widely implemented in nursing schools because of cost, infrastructure limitations, and lack of trained faculty, which restrict students' opportunities for practice (Park et al., 2025).

Against this phenomenon, more interactive, repetitive, and challenging learning designs are particularly relevant to help students easily understand emergency management concepts such as CPR. Gamification offers a framework for transforming learning into a more goal-oriented by embedding clear objectives, tiered tasks, rules, and immediate feedback into educational activities (Qiao et al., 2025; Khaldi et al., 2023). Studies have shown that game-based CPR programs enhance learner engagement, motivation, knowledge acquisition, and confidence when grounded in learner-centered design principles and integrated with clinical scenarios (Baek & Lee, 2024; Cheng et al., 2024; Demirtas et al., 2022). To evolve past standard simulation practices, a randomized trial comparing haptic virtual versus high-fidelity simulation found both approaches can improve CPR knowledge and skills (Kabuk et al., 2024). A recent scoping review highlights that virtual, augmented, or mixed reality is a rapidly expanding area within Basic Life Support (BLS) training research (Dubreucq et al., 2025). One format that has gained significant attention is escape-based learning (Dalbey & Fuller, 2025). In this model, teams must solve mission-based tasks within a strict time limit, requiring rapid interpretation of clinical cues, effective communication, and coordinated action (Kim et al., 2025). These activities are associated with improved knowledge, confidence, teamwork, and critical thinking; furthermore, learners frequently describe the experience as both engaging and realistic (Nodehi et al., 2025).

Systematic reviews likewise report positive impacts on motivation, collaboration, and satisfaction when escape activities are aligned with learning objectives and structured debriefing (Esmaeilzadeh & Aygün, 2025; Fernandes et al., 2025; Quek et al., 2024). Nevertheless, most existing studies are descriptive or quasi-experimental, randomized

controlled trials directly comparing escape-based gamification with conventional CPR teaching remain scarce, particularly in low- and middle-income country. To address these gaps, *Nusantara 1: CPR Adventure* was developed as a seven-level gamified CPR module integrating theoretical reinforcement, case-based learning, laboratory skills practice, structured simulation, and an escape laboratory challenge that replicates time pressure and teamwork demands. In this study, CPR performance refers to end-to-end CPR skill execution, including safety procedures, responsiveness assessment, activation of help and emergency response, high-quality chest compression, ventilation technique, AED use, and maintenance of continuous resuscitation cycles. This randomized controlled trial compares *Nusantara 1: CPR Adventure* with conventional CPR training to determine whether the gamified, simulation-rich module produces greater improvements in CPR performance than standard instructor-centered teaching used in many nursing programs. The findings of this study are expected to provide an innovative approach to teaching methods, particularly within emergency nursing curricula.

Method

The study conducted a single-center randomized controlled trial to evaluate the efficacy of a gamified CPR training program featuring an escape laboratory challenge, relative to conventional CPR instruction for undergraduate nursing students. This process employed a two-arm, parallel-group superiority design with a 1:1 allocation ratio. To ensure methodological rigor, it was planned and reported in strict accordance with CONSORT recommendations. Participants were limited to a single training modality to avoid crossover. Given that CPR training results in lasting learning effects, a parallel design was preferred over a crossover design to eliminate the risk of carry-over effects and ensure the integrity of between-group comparisons. This study was conducted in December 2024 at the Faculty of Nursing, Universitas Muhammadiyah Banjarmasin, Indonesia. The research took place at a single academic site equipped with a basic life support simulation laboratory, CPR manikins, AED trainers, and standardized instructional materials. The population target of the study included 162 full-time nursing students in their fifth semester. At this stage of the curriculum, CPR instruction is a required part of their emergency nursing coursework.

In selecting the sample, this study defined clear inclusion and exclusion criteria. The inclusion criteria were active enrollment as a fifth-semester student, current registration in the emergency nursing course, able to perform chest compressions and basic CPR maneuvers without medical contraindications. In contrast, the exclusion criteria were prior completion of any accredited Basic Life Support (BLS) or CPR course, self-reported musculoskeletal or cardiovascular conditions that could preclude safe CPR performance, and refusal or withdrawal of informed consent. Recruitment was coordinated by the course instructor and academic advisor through an information session at the start of the semester. Students were informed that participation was voluntary and that non-participation would not affect their course grades. Eligibility screening and baseline assessments were completed before randomization. Sample size was estimated using G*Power version 3.1.9.7, based on the primary outcome of OSCE psychomotor CPR performance scores. Assuming a moderate between-group effect size (Cohen's $d=0.50$), 80% power ($\beta=0.20$), and two-tailed $\alpha=0.05$, the minimum required sample was 64 participants per group. To allow for potential attrition, the target sample was inflated to 70 participants per group (total $n=140$). Participants who met the inclusion criteria and completed baseline assessments were randomly assigned in a 1:1 ratio to the gamified or the conventional training arm. The randomization sequence was generated using Microsoft Excel and implemented via fixed blocks of nine to ensure balanced group allocation. Allocation was concealed using sequentially numbered, sealed, and opaque envelopes. These were prepared by an independent research department that was not involved in recruitment, intervention delivery, or outcome assessment. Envelopes were opened only after baseline assessment was completed, ensuring concealment until assignment.

Instruments used in this study were categorized into intervention tools and data collection tools. Data collection involved a self-administered demographic questionnaire, which comprised age, sex, and prior CPR training experience. Baseline CPR performance score was not part of the demographic questionnaire; rather, it was recorded separately as the pre-intervention outcome measure and is presented together with baseline characteristics to demonstrate comparability between groups at baseline. The primary outcome was psychomotor CPR performance, which was assessed using a structured checklist based on American Heart Association (AHA) 2020 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (Merchant et al., 2020) and Indonesian Basic Trauma Cardiac Life Support (BTCLS) training curriculum guidelines (Ministry of Health of the Republic of Indonesia, Directorate General of Health Professionals, Directorate of Quality Improvement for Health Professionals, 2022). The checklist comprised 18 items across key domains of adult CPR performance, including safety procedures, responsiveness assessment, activation of help and emergency response, high-quality chest compressions (rate, depth, recoil), ventilation technique, AED use, and maintenance of continuous resuscitation cycles. Each item was scored on a 0–2 ordinal scale (0=did not

act, 1=performed but not according to procedure, 2=performed correctly and properly), producing a total score range of 0–36, with higher scores indicating better performance. For analysis and reporting, total scores were converted to percentages (0–100%). Outcome assessments were conducted at two time points as follows baseline before training (T0) and 14-day follow-up (T1) after completion of training. OSCE examiners were emergency nursing educators who were not involved in delivering either intervention and were blinded to group allocation. Interrater reliability based on 40 double-rated OSCE performances was excellent (ICC [2,1]=0.994). The Intraclass Correlation Coefficient (ICC) demonstrated excellent inter-rater reliability, confirming high consistency between evaluators. The study used two data collection tools such as a self-administered demographic questionnaire for baseline participant characteristics and a structured 18-item OSCE checklist for psychomotor CPR performance assessment. The module and facilitator guide were used solely as intervention materials and not as measurement instruments.

The interventions tool consists of the *Nusantara 1: CPR Adventure* was developed using an instructional design process based on the ADDIE model (Analyze-Design-Develop-Implement-Evaluate). The module integrates theoretical reinforcement, case-based learning, skills practice, simulation, and an escape laboratory challenge across seven sequential levels. Content validity was established by a group of specialists, including three emergency nursing lecturers, two nurse practitioners with resuscitation training roles, and four emergency physicians from Malaysia and Indonesia. Experts independently rated the relevance and clarity of each level, activity, and checklist item using a four-point scale. All item-level content validity indices (I-CVI) exceeded 0.86, and the scale-level CVI by averaging (S-CVI/Ave) exceeded 0.95, indicating excellent content validity. A pilot implementation with a small cohort of nursing students (not included in the present trial) was used to refine game mechanics, timing, instructions, and debriefing questions based on participant and facilitator feedback. A total of 30 nursing students were recruited for the pilot study. This pilot was conducted at the same university but utilized a distinct cohort of third-semester students, whereas the main trial specifically targeted fifth-semester students. To mitigate the risk of contamination, pilot participants were drawn from this different academic level and were strictly excluded from the main trial. Furthermore, the pilot and main trials were carried out with separate groups at different time intervals, thereby further reducing the likelihood of cross-contamination and ensuring the integrity of the data. The pilot findings demonstrated that the module was feasible, comprehensible, and appropriate for student use. Following participant feedback, the module underwent minor refinements to specifically improve instructional clarity and optimize the sequence of learning activities. Furthermore, wording was simplified and visual cues were strengthened to ensure layout consistency. To maintain the study's internal validity, the finalized intervention materials were strictly withheld from the main study participants until the trial was completed.

Educators in the intervention arm were trained using a written manual based on the final protocol. This document detailed the level objectives, activity flow, facilitator scripts, timing, scoring rules for the escape laboratory, and debriefing guides. Twelve certified nursing educators, each with at least five years of experience in emergency nursing education, facilitated the training sessions. All educators attended a one-day briefing to standardize the delivery of both the gamified and conventional protocols. To minimize instructor effects, the educator-to-student ratio, room size, and equipment were matched across trial arms, and the only planned difference between groups was the presence or absence of gamification elements.

The intervention group received gamified CPR training using the *Nusantara 1: CPR Adventure*, a seven-level curriculum designed to enhance CPR skills through scenario-driven activities and an escape laboratory challenge. Training was delivered over three consecutive days (Sessions 1–4; 11 hours total), followed by a 1-hour follow-up assessment 14 days after training (T1), resulting in 12 hours of total study contact time. Each training group consisted of 11 to 12 students. Session 1 included orientation and baseline assessment (T0). Sessions 2–4 progressed through Level 1–6 consist of levels 1–3 focused on theoretical content and case-based quiz activities with facilitator-led debriefing. Levels 4–5 included laboratory practice (compressions, ventilations, AED skills) with educator feedback and an escape laboratory challenge featuring time-pressured team CPR scenarios with missions, points, and penalties. At last, level 6 emphasized team simulation and role-play with peer and facilitator feedback. Session 5 (Level 7) consisted of the follow-up assessment at T1. Instructional resources included manikins, AED trainers, printed scenario guides, and digital platforms used to reinforce key concepts and engagement. All activities were standardized across participants, with no individual customization. Meanwhile, the control group received conventional CPR training aligned with the national nursing curriculum, consisting of theory lectures, instructor demonstrations, and repeated hands-on CPR practice using manikins and AED trainers. The total duration, session structure, group sizes, educator-to-student ratio, facilities, and scenarios matched the intervention arm. No gamified components were used (**Table 1**).

Table 1. Data collection protocols.

Session	Intervention group	Duration	Control group	Duration
Session 1	Orientation and baseline assessment (T0)	2 hours	Orientation and baseline assessment (T0)	2 hours
Session 2	Level 1: Brainstorming and Wheel of Concepts. Level 2: Theory review. Level 3: Case-based quiz game and facilitator-led debriefing	3 hours	Theory review and instructor-led Q&A using the same CPR guideline content and learning objectives	3 hours
Session 3	Level 4: Skills laboratory practice (compressions, ventilations, AED drills) with educator feedback. Level 5: Escape Lab Challenge (time-pressured team CPR scenarios with missions, points, and penalties) followed by debriefing	4 hours	Manikin-based skills practice (compressions, ventilations, AED drills) with educator feedback, followed by extended practice using standard scenarios (no gamification elements)	4 hours
Session 4	Level 6: Team simulation and role-play, peer feedback, and facilitator-led debriefing	2 hours	Team simulation and role-play, peer feedback, and facilitator-led debriefing (same scenarios and objectives; no gamification elements)	2 hours
Session 5	Level 7: Follow-up assessment (T1, 14 days after training)	1 hour	Follow-up assessment (T1, 14 days after training)	1 hour

To maintain fidelity, educators followed a pre-session plan and completed adherence checklists after each session. Attendance was recorded for all activities, and performance was tracked during simulations. To minimize contamination between groups, experimental and control sessions were conducted in separate rooms and skills laboratories. Students remained in their allocated groups throughout the study and were not allowed to attend or observe sessions from the other arm. Participants in the intervention group were asked not to share game materials until all post-intervention assessments were completed. Educators were assigned exclusively to either the intervention or the conventional arm and did not cross-teach. Several procedures were used to minimize bias and confounding. For instance, selection bias was reduced through allocation concealment and assignment after baseline assessment. Then, performance bias was reduced by standardizing both protocols using a written manual, facilitator briefing, matched educator-to-student ratios, identical facilities and equipment, and equivalent training duration across arms; the only planned difference was the inclusion of gamification elements in the experimental arm. Contamination was minimized by conducting intervention and control sessions in separate rooms/laboratories, keeping students in their allocated groups throughout the study, prohibiting attendance or observation of the other arm's sessions, and requesting that intervention participants not share game materials until all post-training assessments were completed. Detection bias was reduced by using independent OSCE examiners who were not involved in intervention delivery and were blinded to group allocation. Baseline variables (e.g., age, sex, and prior CPR exposure) were recorded to describe group comparability.

Data were analyzed using IBM SPSS Statistics (version 29). Baseline characteristics were summarized using descriptive statistics. To compare between-group changes in OSCE psychomotor performance from baseline (T0) to follow-up (T1), the Mann-Whitney U test was employed, as the score distributions were non-normal. Within-group changes from T0 to T1 were analyzed using the Wilcoxon signed-rank test. Effect sizes for between-group comparisons were reported using Cliff's delta alongside the probability of superiority. All statistical tests were two-tailed with a significance level of $\alpha=0.05$. Ethical approval was granted by the Health Research Ethics Committee of Universitas Muhammadiyah Banjarmasin (No. 259/UMB/KE/V/2024). Throughout the study, the researchers strictly adhered to ethical principles, including the provision of informed consent and the protection of participant autonomy, beneficence, and fairness. To ensure privacy, all data were handled with strict confidentiality and anonymity. Furthermore, participants were explicitly informed of their right to withdraw from the study at any time without any negative repercussions to their academic standing.

Results

A total of 162 students were assessed for eligibility. Twenty-two were excluded (12 did not meet the inclusion criteria, six declined to participate, and four for other reasons), leaving 140 participants who were randomized equally to the intervention and control groups ($n=70$ per group). All randomized participants completed the assigned training and the follow-up assessment at T1. Recruitment and baseline assessments were conducted from September to December 2024, the training was delivered in December 2024, and a follow-up assessment was conducted 14 days after training completion (**Figure 1**).

Baseline characteristics were comparable between groups. None of the participants reported prior formal CPR training at baseline. Baseline psychomotor CPR performance was assessed before any CPR skills in the semester and was similarly low in both arms. At T0, the median total OSCE CPR score (0–100%) was 0.0% (IQR 0.0–2.8) in both groups, supporting baseline balance for the primary outcome (**Table 2**). Domain-specific performance scores were summarized across seven key CPR components. Improvements were observed across all domains in both arms, with consistently larger gains in the intervention arm, particularly in chest compression, ventilation, and the resuscitation process (**Table 3**). Total OSCE scores (0–100%) are presented in this finding. The intervention arm shows a marked increase in post-training scores relative to baseline with a narrower interquartile range, indicating more consistent performance at follow-up. The control arm also improved, but variability remained higher. Within-group analyses showed significant improvement from T0 to T1 in both arms (intervention: $Z=7.282$, $p<0.001$; control: $Z=7.275$, $p<0.001$). For the primary between-group comparison, change scores (T1–T0) were significantly larger in the intervention arm than in the control arm (Mann-Whitney U, $p=0.008$), and this result was consistent in permutation-based sensitivity analyses ($p=0.009$). The between-group effect was small to moderate (Cliff's $\delta=0.259$, 95% CI 0.073–0.436) (**Table 4**), corresponding to a probability of superiority of 63%, indicating that a randomly selected participant in the intervention arm was more likely to achieve a higher CPR performance score than a randomly selected participant in the control arm (**Figure 2**).

Discussion

The finding presented that an escape-based gamified approach resulted in higher post-training psychomotor CPR performance than conventional instruction. Both groups improved from baseline, which is expected when participants receive structured CPR instruction and hands-on manikin practice as discussed in previous study (Abbasi et al., 2024). However, the intervention arm showed a clearer advantage in OSCE components that depend on accurate sequencing and coordinated execution, especially ventilation, the resuscitation process, and AED use. Several early procedural steps improved strongly in both arms, leaving less room for separation between groups. Overall, the effect size was small to moderate but practically meaningful, because CPR quality depends on consistent execution across the full sequence, not only completing isolated steps. The findings suggest that escape-based gamification can strengthen skill execution (Rushdan et al., 2025), particularly when integrated into simulation-rich CPR education. With placing students in high-pressure scenarios, this approach mirrors the urgency and complexity of real-world clinical emergencies (Kavakli & Konukbay, 2024). It forces learners to move beyond rote memorization, requiring them to prioritize life-saving

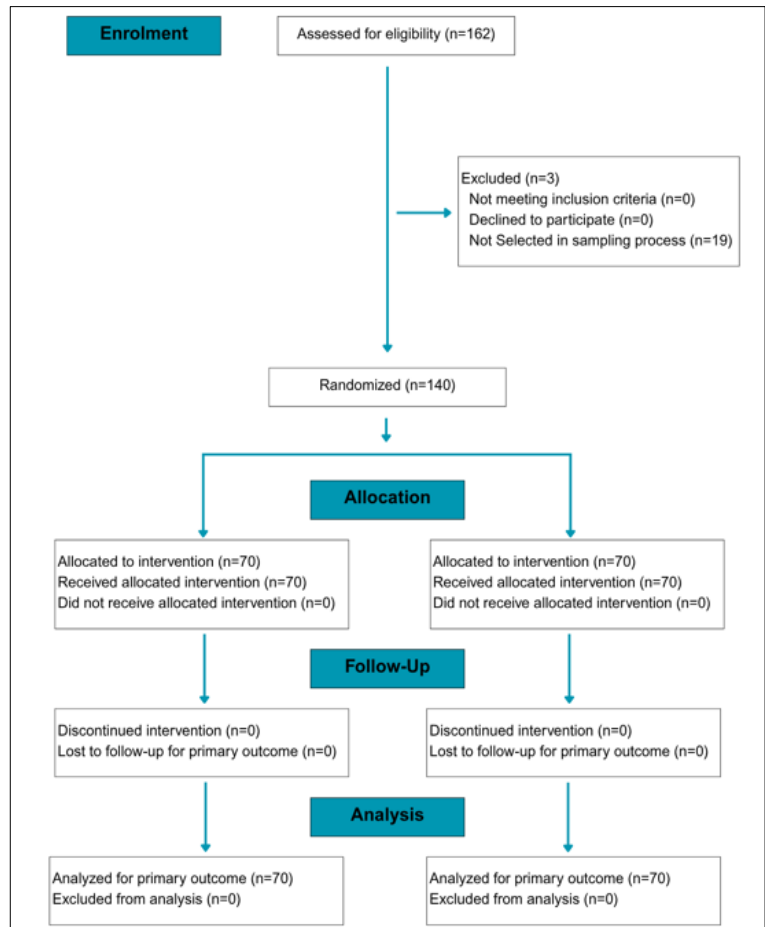


Figure 1. CONSORT Flow Diagram.

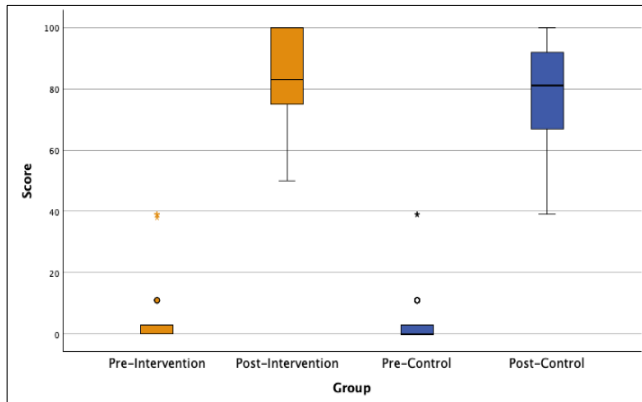


Figure 2. Boxplots of total CPR competency score.

interventions though managing environmental distractions. Integrating gamified elements into the nursing curriculum promotes the clinical judgment for effective bedside performance (Sanz-Martos et al., 2024). These findings align with evidence that interactive and game-based strategies can enhance CPR training outcomes relative to traditional approaches. A systematic review with meta-analysis of randomized trials reported that serious games are effective approaches in CPR training as it can improve performance-related outcomes across studies (Cheng et al., 2024). Nursing education research also highlights persistent challenges in CPR instruction, particularly limited structured repetition and inconsistent feedback opportunities, which can contribute to variable competence (Donoghue et al., 2025; Baghi et al., 2024).

Table 2. Baseline characteristics and CPR performance.

Characteristic (T0)	Intervention group (n=70)	Control group (n=70)
Age, years, median (IQR*)	20.0 (19.0–21.0)	20.0 (19.0–21.0)
Sex		
Male	14 (20.0)	14 (20.0)
Female	56 (80.0)	56 (80.0)
Prior CPR training, n (%)	0.0 (0.0)	0.0 (0.0)
Baseline CPR OSCE total score (0–100%)-median (IQR*)	0.0 (0.0–2.8)	0.0 (0.0–2.8)

*IQR: Interquartile Range.

Table 3. Domain-specific CPR performance scores.

Domain	Max Score	Intervention group		Control group	
		T0	T1	T0	T1
		Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Safety and scene assessment	6	0 (0–1)	6 (6–6)	0 (0–1)	6 (6–6)
Responsiveness and breathing	4	0 (0–1)	4 (3–4)	0 (0–1)	4 (3–4)
Activate help or AED	4	0 (0–0)	4 (3–4)	0 (0–0)	4 (3–4)
Chest compression	6	0 (0–0)	4 (4–6)	0 (0–0)	4 (3–5)
Ventilation	6	0 (0–0)	6 (4–6)	0 (0–0)	4 (3–6)
Resuscitation process	8	0 (0–0)	6 (5–8)	0 (0–0)	5 (4–6)
AED use	2	0 (0–0)	2 (1–2)	0 (0–0)	1 (1–2)

Table 4. Hypothesis testing analysis.

Analysis	Groups	Statistical test		Result	p	Interpretation
Within-group change	Intervention arm, T0 to T1	Wilcoxon	signed-rank test	Z=7.282	<0.001	Significant
Within-group change	Control arm, T0 to T1	Wilcoxon	signed-rank test	Z=7.275	<0.001	Significant
Between-group comparison	Change score (T1–T0) between intervention and control	Mann-Whitney U test	U	U=1815.500, Z=2.672	0.008	Significant
Sensitivity analysis	Change score (T1–T0) between intervention and control	Monte Carlo exact test		99% CI=0.006–0.011	0.009	Significant
Effect size	Between-group effect	Cliff's δ		0.259 (95% CI 0.073–0.436)	—	Small to moderate

In nursing student populations, several trials further support the value of structured simulation-based formats for CPR training (Nasiri et al., 2025; Ougli et al., 2024). Taken together, prior evidence supports the plausibility that adding a well-designed gamified framework to standard training time may yield incremental gains in performance. Escape room-based learning offers a focused explanation for why the intervention may be particularly beneficial for sequence-dependent CPR domains. Evidence syntheses on educational escape rooms for healthcare learners report positive outcomes when activities are aligned with explicit objectives and followed by structured debriefing (Sarin et al., 2025). A review focusing on the escape room-based approach in nursing education similarly supports escape room as an effective game-based strategy when design quality and facilitation are strong (Köse & Özcan, 2025). A meta-analysis also reported improvements in nursing students' knowledge, clinical skills, and critical thinking outcomes after escape-room learning (Yang et al., 2025). This evidence base matches the logic of the escape laboratory challenge, which requires teams to act under time pressure, coordinate roles, and maintain the correct sequence of resuscitation actions (Vuillaume et al., 2021; Freyer et al., 2025; Le Guellec et al., 2025; Pelaccia et al., 2020). Through placing students in high-stakes environment, the escape laboratory transforms passive knowledge into decisive clinical action. This immersive pedagogical approach compels participants to manage cognitive load while executing demanding skills. As the scenario unfolds, the necessity for precise communication and leadership becomes paramount in a cardiac arrest event (Pittman et al., 2001; Akwe, 2024). These training environments reinforce clinical competence and psychological readiness for future healthcare professionals. So, the integration of gamified challenges serves as a vital bridge between the safety of the classroom and the unpredictable nature of acute clinical practice.

A credible mechanism is improved deliberate practice through repetition and feedback. Resuscitation education evidence indicates that CPR skills decay without structured, feedback-rich practice and that maintenance is supported by repeated rehearsal with real-time feedback (Nicolau et al., 2024; Vella et al., 2025). The 2025 AHA Resuscitation Education Science update reinforces the importance of training designs that promote practice quality, feedback, and sustained skill development in resuscitation education (Donoghue et al., 2025). Consistent with the principle, a systematic review and meta-analysis found that CPR training supported by feedback devices improves key CPR quality metrics (Lin et al., 2025). In this study, the escape laboratory structure increased the density of meaningful practice by enforcing repeated cycles under time pressure and making performance expectations explicit. Furthermore, enabling immediate correction through debriefing may explain the stronger gains observed in complex CPR components. The modest effect size should be interpreted in the context of an active, dose-matched comparator. Because both arms received equivalent contact time and structured hands-on practice, improvements in OSCE performance were expected in both groups, reducing the room for large between-group separation. Conventional lecture-demonstration formats can also provide limited opportunities for structured repetition and feedback, which may contribute to inconsistent CPR performance in routine educational settings. However, the control condition still received a strong practical component. The added value of the escape laboratory challenge is therefore best viewed as an incremental advantage in psychomotor performance beyond conventional training delivered at the same dose. Domain-level findings help explain where gains clustered, though the primary inference remains anchored to the total OSCE score.

This study advances the global nursing education landscape by pioneering a shift from passive, lecture-heavy instruction to high-stakes, immersive gamification. With utilizing an escape laboratory challenge, the research addresses the universal problem of rapid psychomotor skill decay that plagues traditional CPR training. It provides a framework for educators worldwide to integrate time-pressure and cognitive-load management directly into the clinical curriculum. Furthermore, the study offers empirical evidence that gamified learning hones technical precision such as AED sequencing and compression depth. It challenges existing pedagogical norms by proving that emotional engagement and teamwork are just as critical as rote memorization in nursing interventions. The research also establishes a new gold standard for evidence-based teaching in emergency nursing. Additionally, it highlights the importance of objective feedback mechanisms in maintaining long-term competence among future healthcare professionals. Consequently, this study serves as a global call to action for nursing programs to embrace pedagogical innovation and optimize training methodologies in the pursuit of superior patient survival outcomes. Notwithstanding its contributions, the research encountered a few constraints during its implementation. For instance, the single-center design limits the generalizability to other settings. Although outcome assessment was strengthened by blinded OSCE examiners, follow-up was limited to 14 days, so longer-term retention and transfer to clinical performance cannot be determined from this study. Differential expertise bias was mitigated through standardized educator briefings, scripted delivery, and the use of an adherence checklist. However, multicenter longitudinal trials with broader participant diversity are still required to strengthen external validity.

Conclusion

This study demonstrated that the escape laboratory challenge, a gamified CPR intervention, resulted in significantly higher nursing students' psychomotor CPR performance. The findings support the integration of immersive, game-based strategies within nursing curricula to enhance skill mastery and preparedness for emergency response. The module may help address limitations of conventional CPR education by promoting repeated practice, accurate sequencing, and coordinated execution during resuscitation. Nursing schools are expected to implement these findings as part of the learning process regarding the implementation of theory into emergency practice. Suggestions for future research include developing methods beyond gamified learning to enhance the clinical performance of nursing students within the context of emergency nursing. Additionally, advanced procedure simulations in emergency conditions can also serve as a medium to improve student capabilities.

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AI statements

The authors did not use generative AI for study design, data analysis, or manuscript preparation. Scite AI was used solely for citation-context and DOI verification, with all outputs manually verified. The authors supervised all language editing and remain fully responsible for the integrity of the content.

Author's declaration

All authors made substantial contributions to the conception and design of the study; acquisition, analysis, or interpretation of data; drafting or critical revision of the manuscript; and approved the final version for submission.

Availability of data and materials

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

Competing interests

There are no conflicts of interest to declare regarding this publication.

Ethical clearance

Ethical approval was granted by the Health Research Ethics Committee of Universitas Muhammadiyah Banjarmasin, Indonesia (Approval No. 259/UMB/KE/V/2024).

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Publishers and journal's note

This study offers significant innovative value to the nursing field, particularly in enhancing students' competency in emergency management. It is essential for the nursing profession and educational institutions to advance such initiatives to strengthen critical thinking and ensure the rapid resolution of emergency cases in hospitals and other clinical settings. Furthermore, nursing associations should prioritize support for research focused on emergency care innovation both in Indonesia and globally.

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Authors' insight

Key points

- An escape laboratory introduces game mechanics which boosts motivation and reduces the anxiety associated with high-pressure resuscitation drills.
- Students must practice closed-loop communication and clear leadership roles to solve the laboratory challenges, which mirrors the Crisis Resource Management (CRM) skills required during a cardiac arrest situation.
- The escape laboratory likely utilizes high-fidelity simulators that provide instant data on compression rate and ventilation volume.

Emerging nursing avenues

- Does the 'escape laboratory' design prioritize speed over technical accuracy when nursing students perform the simulation?
- In what specific manner was the control group structured to ensure a fair comparison and isolate the specific effects of gamification from the general effects of hands-on practice?
- What measures were taken to standardize the educational dosage across both cohorts to minimize potential selection and performance bias?

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