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The Effect of Gamification-Based Peer Learning on CPR Knowledge and Self-Efficacy Among Secondary School Students: A Quasi-Experimental Study

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ABSTRACT

Noncommunicable diseases are the leading cause of global mortality, and one of their serious complications is sudden cardiac arrest, which requires immediate intervention through cardiopulmonary resuscitation (CPR). CPR education at the school level is crucial for enhancing students' readiness to respond to cardiac arrest incidents outside of hospitals. This study aims to evaluate the effectiveness of gamification-based CPR training in improving knowledge and self-efficacy among high school students. A quasi-experimental study with a pretest–posttest control group design was conducted on 90 students. The intervention group received CPR training based on American Heart Association (AHA) guidelines through peer-to-peer learning integrated with gamification elements. The control group received peer-to-peer CPR training without gamification. The sample was selected using stratified random sampling based on grade level. Data were analyzed using the Wilcoxon Signed-Rank and Mann–Whitney U tests with a significance level of $\alpha = 0.05$. The results showed that the intervention group experienced a significant increase in knowledge ($p < 0.001$) and self-efficacy ($p = 0.010$), while the control group experienced a significant increase in knowledge ($p < 0.001$), but not in self-efficacy ($p = 1.000$). In the between-group analysis, post-test knowledge scores differed significantly with a small effect size ($p = 0.039$; Cohen's $d = 0.262$), but the change in knowledge scores did not differ significantly ($p = 0.795$; Cohen's $d = 0.030$). Significant differences were found in post-test self-efficacy ($p = 0.009$; Cohen's $d = 0.436$) and changes in self-efficacy ($p = 0.002$; Cohen's $d = 0.555$). Gamification-based CPR training is associated with increased knowledge and self-efficacy among high school students. However, this increase in knowledge was not significantly different from that of the control group. Therefore, gamification may be particularly beneficial for enhancing students' self-efficacy and their readiness to provide first aid in out-of-hospital cardiac arrest situations.

Keywords: Cardiopulmonary resuscitation; gamification; peer learning; knowledge; self-efficacy; high school students

INTRODUCTION

Non-communicable diseases remain one of the leading causes of global mortality and can lead to serious complications, including sudden cardiac arrest [1]. *Out-of-hospital cardiac arrest* is a medical emergency requiring a rapid response, as the victim's chances of survival depend heavily on the initial aid provided before medical personnel arrive [2]. *Cardiopulmonary resuscitation* (CPR) performed by laypeople immediately after the event has been shown to increase the victim's chances of survival by two to three times [3,4]. However, the public's limited knowledge of *basic life support* (BLS) remains a significant barrier to improving first-response efforts in cardiac arrest cases [5]. Therefore, CPR training starting in school is crucial, as students have great potential to become first responders in emergency situations.

School-based CPR training is a key strategy for increasing the number of individuals capable of providing first aid in cardiac arrest situations. The American Heart Association recommends that CPR training be provided to school-aged children, and several studies indicate that middle school students have both the interest and ability to learn CPR [6,7]. CPR training in schools has also been reported to improve students' knowledge, skills, chest compression quality, and skill retention following training [4,8]. Additionally, tiered training programs in schools not only enhance first aid and CPR skills but also enable students to serve as peer trainers for their peers [9]. This indicates that schools are a strategic environment for expanding CPR education among adolescents.

Although school-based CPR training has been extensively studied, there remains a lack of research integrating peer-to-peer learning with gamification approaches, particularly among high school students. Peer-to-peer learning allows students to learn through interaction, discussion, and support from their peers, while gamification can enhance motivation, engagement, and active participation through game elements such as leaderboards, badges, and group competitions. Several studies indicate that gamification in CPR training can improve participants' motivation, engagement, learning outcomes, and self-efficacy [10–12]. However, evidence regarding the effectiveness of combining

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peer-to-peer learning and gamification on CPR knowledge and self-efficacy among high school students remains limited.

In addition to knowledge, psychological factors such as self-efficacy are also crucial for the success of first aid, as they influence an individual's confidence, readiness, and willingness to perform CPR in an emergency [13]. Previous research indicates that CPR education can improve students' knowledge, attitudes, self-efficacy, and confidence in performing CPR, while active learning approaches such as simulation, practice-based learning, and repeated reinforcement can support the acquisition and retention of CPR-related competencies [14]. This study is based on Bandura's Social Cognitive Theory**,** which emphasizes that self-efficacy is an individual's belief in their ability to manage and perform the actions necessary to achieve specific outcomes. In the context of CPR training, self-efficacy is important because students who have a stronger belief in their abilities tend to be more prepared and willing to perform CPR in emergency situations [15,16]

Therefore, this study aims to evaluate the effect of gamified peer-to-peer learning on CPR knowledge and self-efficacy among high school students. This study is guided by the following research question: Can gamified peer-to-peer learning improve CPR knowledge and self-efficacy in high school students compared to peer-to-peer learning without gamification? We hypothesize that students who receive gamified peer-to-peer learning will demonstrate a greater increase in CPR knowledge and self-efficacy compared to students who receive peer-to-peer learning without gamification.

MATERIALS AND METHODS

This study employed a quasi-experimental design with a pretest–posttest control group. The study was conducted at two high schools in Makassar City: SMA Negeri 3 Makassar and SMA Muhammadiyah 1 Unismuh Makassar. SMA Negeri 3 Makassar was designated as the intervention group, while SMA Muhammadiyah 1 Unismuh Makassar was designated as the control group. The allocation of schools into the intervention and control groups was not done randomly but was determined non-randomly based on administrative considerations, the schools' willingness to participate, the ease of implementing the intervention, and to prevent cross-contamination between participants in both groups. Although the allocation of schools was not random, the baseline characteristics of participants in the intervention and control groups were compared at the beginning of the study to assess the equivalence of the two groups and reduce potential selection bias. The study subjects were divided into two groups. The intervention group consisted of students who received Cardiopulmonary Resuscitation (CPR) training based on American Heart Association (AHA) guidelines using a peer-learning method accompanied by gamification elements, such as leaderboards, badges, and group competitions. The control group consisted of students who received CPR training using a peer-learning method without the integration of gamification elements.

The CPR training protocol for both groups was designed based on American Heart Association (AHA) guidelines and conducted in 2 sessions, each lasting 120 minutes, resulting in a total intervention duration of 240 minutes. Each session followed the same sequence of activities: opening and activity explanation, pre-test administration, presentation of basic CPR material, demonstration of CPR steps and automated external defibrillator (AED) use by the instructor, CPR practice through peer-to-peer learning in small groups, feedback from the instructor, and post-test administration following the intervention. In the intervention group, the peer-learning phase included gamification elements such as leaderboards, badges, and group competitions. In the control group, participants received the same materials, instructors, training duration, and evaluation procedures, but without the integration of gamification elements.

The study population consisted of all students at each school. The sample size was determined using the Slovin formula with a 5% margin of error, resulting in 90 respondents, consisting of 45 students in the intervention group and 45 students in the control group. Sampling at each school was conducted using stratified random sampling based on grade levels X, XI, and XII, with 15 students selected from each grade level who met the inclusion criteria and did not meet the exclusion criteria. The inclusion criteria were high school students in grades 10–12 aged 15–18 years, willing to participate in the entire research process, including CPR training and post-test evaluation, having obtained written consent from the school and parents or guardians as required, attending the pre-test, and having not previously participated in formal CPR training within the past 6 months. The exclusion criteria included students who, during the study, experienced specific medical conditions or physical limitations/health reasons that prevented them from safely continuing CPR training. The dropout criteria included students who voluntarily withdrew, either verbally or in writing, or failed to attend two or more research sessions. Data were collected at two measurement time points: before the intervention and immediately after the intervention.

To minimize potential confounding factors at the school level, both groups used the same inclusion and exclusion criteria, uniform sampling techniques, the same CPR training materials based on AHA guidelines, and the same data collection procedures. Training was provided by instructors with experience in CPR or basic life support

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training. To ensure consistency in the implementation of the intervention, the research team used a standardized training protocol and a checklist. Each session was monitored to ensure that the content, duration, and learning procedures were carried out consistently across all groups. Written permission was obtained from the school before the study was conducted. Since the study participants were minors, consent from parents or guardians was obtained prior to participation. Students also provided consent after receiving an explanation regarding the study's objectives, procedures, benefits, potential risks, data confidentiality, and the voluntary nature of participation.

CPR knowledge was measured using a multiple-choice test designed based on the fundamental principles of Cardiopulmonary Resuscitation (CPR) according to the American Heart Association (AHA) guidelines. This instrument consisted of 20 items covering understanding of the CPR sequence, compression and ventilation techniques, use of an automated external defibrillator (AED), and rescuer safety aspects. Each correct answer is scored as 1, while an incorrect answer is scored as 0. A higher score indicates a better level of CPR knowledge. Knowledge assessment was conducted before and after the training.

Self-efficacy was measured using a self-efficacy questionnaire based on a 1–5 Likert scale. This instrument assessed participants' level of confidence in their ability to perform CPR correctly and effectively according to AHA standards, including confidence in performing chest compressions, providing ventilation, using an AED, and making decisions in emergency situations. A higher score indicates a higher level of self-efficacy. Self-efficacy was measured before and after the training.

Research data were analyzed descriptively to describe respondent characteristics and variable distributions. Hypothesis testing was performed using the Wilcoxon signed-rank test to assess differences in scores before and after the intervention (pre-test–post-test) in each group. Data normality was tested using the Shapiro–Wilk test. Since the data were not normally distributed, non-parametric statistical tests were used. The Wilcoxon signed-rank test was used to analyze differences in pretest and posttest scores within each group, while the Mann–Whitney U test was used to compare differences between the intervention group and the control group. The significance level was set at $\alpha = 0.05$.

RESULTS

Respondent Characteristics

Table1 . Respondent Characteristics in the Intervention and Control Groups

Variable	Intervention n (%)	Control n (%)	p-value*
Age (years)			0.109
15	5 (11.1)	13 (28.9)	
16	18 (40.0)	19 (42.2)	
17	15 (33.3)	8 (17.8)	
18	7 (15.6)	5 (11.1)	
Gender			0.291
Male	18 (40.0)	24 (53.3)	
Female	27 (60.0)	21 (46.7)	
Grade			0.873
X	15 (33.3)	15 (33.3)	
XI	15 (33.3)	15 (33.3)	
XII	15 (33.3)	15 (33.3)	

Chi-square test

Respondent characteristics based on age, gender, and grade did not differ significantly between the intervention group and the control group ($p > 0.05$). This indicates that both groups had relatively comparable baseline characteristics prior to the intervention.

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Table 2. Differences in Knowledge and Self-Efficacy Scores Before and After the Intervention in Each Group

Variable	Group	Pre-test Median (Min-Max)	Post-test Median (Min-Max)	p-value*
Knowledge	Intervention	55 (35–75)	65 (45–95)	<0.001
Knowledge	Control	60 (20–85)	75 (20–95)	<0.001
Self-efficacy	Intervention	57.5 (5–100)	75 (12.5–100)	0.010
Self-efficacy	Control	55 (0–100)	55 (0–100)	1.000

*Wilcoxon test; Min-Max = minimum-maximum values.

Based on Table 2, knowledge scores increased significantly in the intervention and control groups after CPR training, each with a p-value <0.001. Regarding the self-efficacy variable, the intervention group showed a significant increase after the intervention, from a median of 57.5 (5–100) to 75 (12.5–100), with a p-value of 0.010. Conversely, in the control group, there was no significant change in self-efficacy scores before and after training, with a p-value of 1.000. These findings indicate that CPR training using peer-to-peer learning combined with gamification elements contributes to an increase in participants' self-efficacy, while knowledge improvement occurred in both groups.

Table 3. Comparison of Knowledge and Self-Efficacy Scores between the Intervention and Control Groups at the Pre-test, Post-test, and Score Change (Δ) Stages

Variable	Intervention Median (Min–Max)	Control Median (Min–Max)	p-value*	Cohen's d
Pretest knowledge	55 (35–75)	60 (20–85)	0.065	0.335
Posttest knowledge	65 (45–95)	75 (20–95)	0.039	0.262
Change in knowledge	10 (0–55)	10 (-50–55)	0.795	0.030
Pre-test self-efficacy	57 (5.5–100)	55 (0–100)	0.381	0.060
Posttest self-efficacy	75 (12.5–100)	55 (0–100)	0.009	0.436
Change in self-efficacy	0 (-50–95)	0 (0–0)	0.002	0.555

Δ = difference between posttest and pretest scores; p analyzed using the Mann–Whitney U test; Min–Max = minimum–maximum values; Cohen's d indicates the effect size of the difference between groups.

A comparison of knowledge and self-efficacy scores between the intervention and control groups is presented in Table 3. For the knowledge variable, there was no significant difference between the intervention and control groups at the pretest (p = 0.065). At the posttest, there was a significant difference in knowledge scores between the two groups (p = 0.039), with the control group's median score being higher than that of the intervention group. However, the change in knowledge scores from the pretest to the posttest was not significantly different between the intervention and control groups (p = 0.795), so there is no evidence that the intervention resulted in a greater increase in knowledge compared to the control.

Regarding the self-efficacy variable, there was no significant difference between the intervention and control groups at the pretest (p = 0.381). After the intervention, the posttest self-efficacy scores in the intervention group were higher than those in the control group and were statistically significantly different (p = 0.009; Cohen's d = 0.436). Additionally, there was a significant difference in the distribution of changes in self-efficacy scores between the intervention and control groups (p = 0.002; Cohen's d = 0.555), indicating that the intervention has the potential to influence self-efficacy.

DISCUSSION

The characteristics of the respondents in this study showed a relatively balanced distribution between the intervention and control groups based on age, gender, and grade level (p > 0.05). This indicates that both groups had relatively comparable baseline characteristics prior to the intervention. This equivalence in baseline characteristics is important to minimize the potential for demographic bias in assessing changes in CPR knowledge and self-efficacy following the training.

The study results show that CPR knowledge scores increased significantly in the intervention group following gamification-based training. These findings suggest that structured CPR training can enhance students' understanding of basic CPR concepts, the sequence of actions, and first aid principles. This increase in knowledge aligns with previous evidence showing that school-based CPR training can improve students' knowledge of basic life support and resuscitation [17,18]. A gamification approach that uses elements such as points, competition, feedback, and rewards can

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also increase participants' engagement in the learning process, thereby helping students understand CPR material more actively [19,20].

Although post-test knowledge scores differed significantly between the intervention and control groups, the change in knowledge scores from pre-test to post-test did not differ significantly between the two groups. Thus, these results indicate that both training approaches can equally improve CPR knowledge, but the addition of gamification elements has not yet demonstrated a clear advantage in improving changes in knowledge scores compared to peer-to-peer learning without gamification. This finding may be due to the fact that the control group also received similar CPR materials and peer-learning procedures, so that participants in both groups still received sufficient learning exposure to improve their knowledge. Additionally, differences in baseline knowledge, prior learning experiences, and participants' engagement levels during training may have influenced final knowledge scores. Previous research has also shown that variations in CPR knowledge can be influenced by individual factors, prior training experience, and access to health information [21–23].

Another finding worth noting is that post-test knowledge scores in the control group were higher than those in the intervention group. This result does not necessarily indicate that gamification is less beneficial, as the increase in knowledge scores between the groups was not significantly different. Differences in final scores may be influenced by several factors, such as variations in participants' initial abilities, readiness to learn, school characteristics, or the effectiveness of peer-to-peer learning in the control group. Additionally, peer-to-peer learning without gamification can still be an effective method because it allows students to discuss, explain concepts to one another, and reinforce understanding through group interaction. Recent research indicates that CPR training conducted by peers or non-healthcare instructors can yield learning outcomes comparable to those from professional instructors, particularly in the context of school-based CPR training and BLS training, which is more easily implemented on a large scale [24–28]. Therefore, the findings regarding knowledge in this study are best interpreted to mean that CPR training, whether with or without gamification, contributes to improving students' knowledge, while the additional benefits of gamification on knowledge improvement still require further research.

In addition to knowledge, this study also demonstrated a significant increase in students' self-efficacy in the intervention group following gamification-based training. Self-efficacy is a crucial aspect of CPR education as it relates to an individual's belief in their ability to perform actions in emergency situations. Based on Bandura's Social Cognitive Theory, self-efficacy is understood as an individual's belief in their ability to organize and execute the actions necessary to achieve specific outcomes. In the context of CPR, students with higher self-efficacy tend to have a stronger belief in their ability to recognize emergency situations, perform CPR, and make decisions when faced with a cardiac arrest victim [15,16].

The increase in self-efficacy in the intervention group can be explained by the characteristics of gamified learning. Game elements such as rewards, group competition, and immediate feedback can create a more engaging learning experience and encourage active student participation. Experiences of success during practice, support from peers, and feedback from instructors can reinforce students' confidence in their ability to perform CPR. This aligns with previous research showing that CPR education can improve participants' knowledge, self-efficacy, and confidence after training [10,14]. Other studies also indicate that training methods emphasizing practice and psychological factors can enhance participants' confidence in performing CPR [29].

Conversely, in the control group, self-efficacy did not show a significant increase despite improved knowledge. This suggests that increased knowledge does not always lead to increased confidence in taking action. Students may cognitively understand CPR material, but they may not necessarily feel confident performing it in an emergency situation. These findings support the importance of learning strategies that not only convey information but also provide active, interactive learning experiences that foster self-confidence. In this study, gamification likely played a role in strengthening the affective and psychological aspects of learning, particularly self-efficacy, through more participatory and competitive activities.

Overall, the findings of this study indicate that CPR training can improve students' knowledge, in both the intervention and control groups. However, the additional benefits of gamification appear more evident in the improvement of self-efficacy compared to the improvement in knowledge. This aligns with previous research showing that gamification in CPR education can enhance participant engagement and psychological aspects such as self-efficacy [10,19]. Therefore, the use of gamification in CPR learning can be considered an innovative approach to strengthen students' belief in their ability to perform. Nevertheless, since the difference in knowledge improvement between the groups was not significant, claims regarding the effectiveness of gamification on knowledge should be limited and not overinterpreted.

The study results indicate that CPR knowledge scores increased significantly in the intervention group following gamification-based training. This improvement indicates that the structured delivery of CPR material, accompanied by interactive learning activities, can help students understand the basic concepts of CPR, the sequence

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of actions, and the principles of first aid. Gamification can support the learning process through elements such as points, competition, feedback, and rewards that encourage participant engagement in learning activities. These findings align with previous research showing that gamification in CPR education can enhance participant engagement and learning outcomes [10,11,19,30]. Furthermore, generally, gamification in learning is reported to improve motivation, participation, and knowledge retention through challenges, rewards, and immediate feedback [31,32].

This study has several limitations. First, this study used only a pretest–posttest design without a follow-up assessment, so long-term knowledge retention and self-efficacy could not be evaluated. However, previous research indicates that long-term evaluation is crucial for assessing the sustainability of CPR training outcomes among school students [33]. Second, the study was conducted in only two schools, and participants were allocated by school rather than randomly. This non-random allocation may have introduced residual school-level confounding, since comparisons of age, gender, and grade level alone may not fully account for differences between schools. Therefore, the generalizability of the findings should be interpreted with caution. Third, the study's findings focus on CPR knowledge and self-efficacy; therefore, they cannot be used to objectively conclude changes in CPR skills if those skills were not analyzed as primary outcomes. Direct evaluation of CPR skills remains essential for more objectively assessing participants' practical abilities [34,35]. Fourth, several factors such as prior training experience, learning motivation, and exposure to CPR information outside the intervention may also influence the study results. Future research is recommended to use a larger sample size, involve more schools, include follow-up assessments, and evaluate CPR skills objectively alongside knowledge and self-efficacy.

CONCLUSION

Gamification-based CPR training can improve high school students' knowledge and self-efficacy following the intervention. However, the increase in knowledge should be interpreted cautiously because both groups showed an increase in knowledge, and the change in knowledge scores between the intervention and control groups was not significantly different. Thus, the additional benefits of gamification appear more evident in the improvement of self-efficacy compared to the improvement in knowledge. The integration of gamification elements into school-based CPR learning can be considered an engaging and participatory educational strategy to strengthen students' confidence in performing CPR. Further research is recommended using a multi-school randomized design, involving a larger sample size, and adding follow-up assessments to evaluate the retention of knowledge and self-efficacy.

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ETHICS APPROVAL

This study has received ethical approval from the Health Research Ethics Committee, Faculty of Medicine and Health Sciences, Muhammadiyah University of Makassar, with approval number 001/UM.PKE/I/47/2026.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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