



Research article

The effects of flipped learning and gamification on nursing students' patient safety education: A mixed method study

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ABSTRACT

Background: The importance of enhancing education to promote nursing students' patient safety competency is increasing. Hence, implementing diverse educational programs and assessing their outcomes is essential.

Objectives: To examine the effects of flipped learning and gamification on nursing students' patient safety education.

Design: A mixed-method design employing a quasi-experimental design with a pre-post control group design and qualitative thematic analysis.

Methods: The study was conducted at a South Korean university in W City from September to December 2022. It included 55 s-year nursing students. The experimental group (n = 28) participated in a 30-h patient safety education course using flipped learning and gamification, whereas the control group (n = 27) received only written patient safety education materials. Learning motivation, collective efficacy, patient safety competency, and game evaluations were measured. Data were analyzed using the χ^2 test, Fisher's exact test, t-test, repeated-measures multivariate analysis of covariance, repeated measure analysis of covariance, and generalized estimating equations. Self-reflection journals on game participation experiences were analyzed using qualitative thematic analysis.

Results: Learning motivation scores did not differ significantly between groups for time, or interactions between groups and time, but collective efficacy and patient safety competency scores showed significant differences in the interactions between groups and time. The experimental group showed a high satisfaction score in game evaluation. Qualitative analyses were used to extract four themes—three positives: “fun and immersion differentiated from existing classes,” “improved the learning outcomes and learning motivation,” and “realized the value of collaboration and communication,” and one negative: “feeling down due to unfamiliarity.”

Conclusions: This program creates positive learning experiences and enhances nursing students' collective efficacy and patient-safety competencies. It is expected to be utilized in various future nursing courses.

1. Introduction

Patient safety (PS)—a medical standard for minimizing the possibility of unnecessary harm related to healthcare [1] ensures

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patients' rights to receive safe medical care [2]; hence, healthcare personnel must comply with it. PS emerged as a policy issue after it was instituted by the Institute of Medicine in 1999 and is currently operated as a national PS system according to the World Health Organization's (WHO) recommendations. Korea laid its legal and institutional foundations by enacting its PS Act in 2015. Since 2018, comprehensive PS planning strategies have been established and implemented to protect patients from PS accident risks and improve medical quality [3]. One such strategy is establishing and operating PS Education (PSE) courses in undergraduate departments so that prospective healthcare professionals can acquire competency in basic PS concepts before clinical work [3]. Korean universities are strengthening education and evaluation on patient safety nursing by creating items on patient safety nursing not only in theoretical classes in nursing education but also in simulation practice and clinical practice. Accordingly, PSE is being strengthened in undergraduate nursing education by configuring "safety" in the learning outcomes of nursing education program certification evaluations [4].

Undergraduate courses should provide nursing students with systematic training and education on PS concepts, principles, and techniques, which will directly impact PS after graduation. This can contribute to forming a PS culture in medical institutions through safe nursing in future clinical settings and improve teamwork and communication with other medical staff [5,6].

The United States' nursing education community developed Quality and Safety Education for Nurses—a conceptual framework—that focuses on patient-centered care, teamwork and collaboration, evidence-based practice, safety, quality improvement (six core competencies), and informatics [7]. WHO's curriculum guidelines comprise 11 topics on improving PS and preventing related incidents [1], whereas developing technical skills—nursing expertise; non-technical skills—situational awareness, decision-making, communication, teamwork, leadership, stress management; and system monitoring—have been recommended by the European and American PSE expert groups for coverage in PSE [8].

Despite growing recognition of the importance of education for improving nursing students' PS competencies, when exposed to PS issues, students often have insufficient opportunities to experience problem-solving processes through collaborating and communicating with healthcare professionals, owing to observation-oriented clinical practice limitations [9]. A previous study [2] revealed significant PSE-related differences among Korean nursing students—16.7%–56.5% in lectures and 9.6%–53.0% in practice, whereas a systematic literature review [10] revealed that lecture-type education was mainly used.

In the nursing field, where predicting PS-related situations is difficult, developing various educational strategies is necessary because, besides nursing skills—knowledge and expertise, professional competencies, including non-technical skills—situational awareness and decision-making, teamwork, cooperation, and communication are required. A variety of educational strategies are needed to improve these competencies. Flipped learning is a teaching method reported to have positive effects on enhancing interactions between instructors and learners, improving problem-solving abilities for learning topics, and promoting self-directed learning abilities [11]. As a result of training using the flipped learning method according to the WHO's patient safety curriculum guidelines, it was reported that although there was no significant improvement in attitude toward patient safety nursing, there was a statistically significant improvement in patient safety-related knowledge and skills [1,11].

Gamification, an innovative educational strategy that emerged in the 2010s, selectively gamifies situation-appropriate elements necessary for learning [12]. Education using games has been reported to be effective in improving knowledge and problem-solving [12]. In particular, a systematic review of educational programs using gamification for health care professionals, suggests that it is possible to improve learning outcomes in health professions education by using gamification, especially when employing game attributes that improve learning behaviors, satisfaction, and attitudes toward learning [13].

Escape room—a gamification technique—is a team-based activity wherein participants read a given scenario and solve puzzles in an enclosed space [14]. It combines knowledge, application of clinical and communication skills, teamwork, and critical thinking, and its elements are highly related to the nursing competencies that nursing students need to acquire through clinical practice [12]. Room of errors is a safety education game developed in 2009 by an instructor at the University of South Dakota, USA [15], wherein students identify and evaluate patients' risk factors in a space similar to a clinical situation. It allows instructors to flexibly organize and easily apply content in various environments according to their learning goals, and thus evokes students' interest and critical thinking [15]. Therefore, gamification is helpful as a strategy for patient safety nursing education for nursing students. However, no studies use gamification in PSE for nursing students, and research addressing PS needs improvement. Patient safety nursing is influenced by various factors, such as the clinical environment and nurses' professional knowledge and skills. Therefore, multiple strategies that can improve competency for future nurses should be considered in university education.

This study, therefore, attempted to confirm the usefulness of flipped learning and gamification for nursing students, using the escape room and room of errors PSE techniques. It hypothesized that the experimental group, which received PSE through flipped learning and gamification, would achieve higher scores in learning motivation, collective efficacy, and PS competency than the control group, which received only written PSE materials.

2. Methods

2.1. Study design

This study used a mixed-methods design, employing a quasi-experimental design with a pre-post control group and qualitative thematic analysis.

2.2. Setting and sample

It was conducted at a South Korean university in W City from September to December 2022. The selection criteria for participants include second-year nursing undergraduate students aged 19 and older who have not undergone any PSE-related training.

The sample size was calculated using the G*Power 3.1.9.4 program based on repeated measure multivariate analysis of variance [RM MANOVA], a statistic power $(1-\beta)$ of 95 %, significance level $(\alpha) = 05$, and large effect size $(f = 0.71)$. It reflects an estimate of the effect size from a prior study analyzing the impact of flipped learning on patient safety competency [16]. The minimum required sample size, calculated according to the above formula, is 28 participants (14 per group).

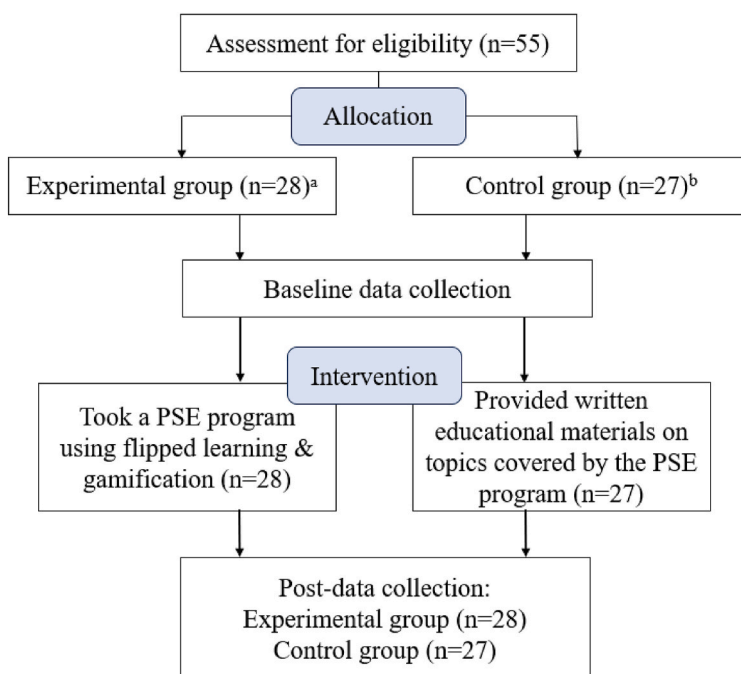
A co-researcher affiliated with another university and unconnected with the course recruited 55 participants. Uniform resource locators (URLs) of Google Forms, including recruitment materials for announcements, research explanations, consent forms, and questionnaires, were shared via a nursing student social networking channel. After reviewing the materials, students wishing to participate in the research were given the option to choose between the experimental and control groups based on their enrollment in the new PSE course. Out of a total of 95 s-year students, 55 enrolled in this elective course, with 28 of them participating in the experimental group. The control group consisted of 27 volunteers out of the 40 students who did not enroll in the PSE course. Therefore, blinding was not implemented from the participants' perspective (Fig. 1).

2.3. Intervention

2.3.1. Experimental group

This 15-week, 30-h PSE course was introduced in the fall semester of the 2nd year at a South Korean university in W City. All nursing colleges in South Korea offer four-year undergraduate programs. In the 2nd year, students learn major subjects required clinical practice, including PS and infection control, by referring to the Korean version [17] of WHO's PS curriculum guide [1]. The first nursing clinical practicum typically begins in the spring semester of the 3rd year in South Korea. Therefore, offering a PSE course during the fall semester of the 2nd year would adequately prepare nursing students for ensuring PS and their own safety during clinical practice.

Table 1 shows the PSE program's construction. The topics covered an overview of patient safety, teamwork and communication, patient and family engagement, infection prevention and control, medication safety enhancement, safe environment management, and patient safety related to invasive procedures, following the Korean version [17] of the WHO PS Curriculum Guide [1]. The class followed a flipped learning approach [18] from the 2nd to the 12th week. Students first studied the videos, and in face-to-face sessions, they participated in topic review quizzes using Google Forms or Slido, team activities (discussions among 2–3 students and presentations using Padlet) related to the subject (e.g., case studies on miscommunication, patient letters), and received feedback from the



^a Number of students who voluntarily agreed to participate in this study among students taking the PSE course.; ^b Number of students who voluntarily agreed to participate in this study among students who have not applied for the PSE course; PSE= Patient safety education

Fig. 1. Study design.

Table 1
Construction of the PSE program.^a

Flipped learning Week ^b	Subject	Contents		Method
2nd	Patient safety overview	<ul style="list-style-type: none"> - The concepts of patient safety and safety culture - Relationship between human factors and patient safety 		Online class
3rd	Teamwork and communication	<ul style="list-style-type: none"> - The importance of teamwork - Characteristics of a successful team - Communication skills for health care teams 		Online class
4th		<ul style="list-style-type: none"> - Teamwork improvement game - Case study - Practice SBAR^c communication - Practice patient care records 		Quiz Team activities
5th	Patient & family involvement	<ul style="list-style-type: none"> - Participation in healthcare services for patients and their families to prevent harm 		Online class
6th		<ul style="list-style-type: none"> - Case study 		Quiz Team activities
7th	Infection prevention and control	<ul style="list-style-type: none"> - Infection cycle and hand hygiene - Standard precaution and transmission-based precautions - Infection control caused by various medical devices and surgical sites - Infection control against multidrug-resistant bacteria 		Online class
8th		<ul style="list-style-type: none"> - Strategies to promote infection prevention - Check the hand hygiene effect using a view box 		Quiz Team activities
9th	Improving drug safety	<ul style="list-style-type: none"> - Overview of drug safety - How to improve the safety of drug usage 		Online class
10th		<ul style="list-style-type: none"> - Case study 		Quiz Team activities
11th	Safe environment management and Patient safety related to invasive procedures	<ul style="list-style-type: none"> - Falls and pressure sores - Accidents related to various medical equipment and supplies - Main types of adverse events related to invasive procedures - Confirmation process for safety related to surgery and invasive procedures 		Online class
12th		<ul style="list-style-type: none"> - Case study 		Quiz Team activities
Gamification Week ^b	Subject	Relevance to patient safety topics	Contents	Method
13th	Game activity orientation	–	<ul style="list-style-type: none"> - Guide on how to proceed with the game environment and activities 	Lecture and Simulation center tour
14th	Game activity	<ul style="list-style-type: none"> - Patient safety overview - Teamwork and communication - Infection prevention and control - Improving drug safety - Safe environment management - Teamwork and communication 	<ul style="list-style-type: none"> - Escape room game - Room of errors game 	Team activities Debriefing

Note. PSE, Patient Safety Education.

^cSBAR = situation, background, assessment, and recommendation.

^a In the 1st and 15th weeks, orientation and written examinations were conducted.

^b 2 hours of class per week.

instructor and colleagues. Additionally, depending on the topic, games (e.g., Zoom out games for team building) and role-playing (e.g., practicing “Situation, Background, Assessment, and Recommendation [SBAR]” scenarios) were incorporated.

It adopted gamification techniques during the 13th and 14th weeks. The game, comprising an escape room and a room of errors, was named “Welcome! Is this your first hospital game?” In the escape room game, students enter a room assigned to each team (2–3 students), find a password to open a box through a crossword puzzle, and read the instructions that appear after matching the puzzle in the box to succeed in escaping from the room. The crossword puzzle can only be solved by understanding PS concepts. Moreover, the instructions in the box include patients’ personal information, and guide students on what to do, which is crucial for their participation in the room of errors. Each team enters the room of errors based on their order of success in the escape room game, finds risk factors that threaten PS for 5 min, and performs a checkback by receiving a sudden call from the medical staff. During the debriefing session held after the game, the students were requested to submit self-reflection journal assignments.

The first author conducted this PSE program. During the game activity week, two pre-trained research assistants were assigned to

check each team's game progress and assist them.

2.3.2. Control group

The control group was provided with written educational materials (PDF file) covering the same topics and content as the online video lectures provided to the experimental group, which were delivered via email during the intervention period, allowing them to study at their own pace. A systematic review indicated that written educational materials slightly enhance healthcare professionals' practice compared to no intervention, and they are commonly utilized in healthcare settings due to their familiarity, user-friendliness, accessibility, and cost-effectiveness [19].

2.4. Measurements

2.4.1. Learning motivation

We used a 19-item learning motivation scale developed by Kim [20]. It measures each item on a 5-point Likert scale ranging from 1 (very rarely) to 5 (very often), with higher scores indicating higher learning motivation. During instrument development, Cronbach's alpha was 0.85, and in this study, it was 0.95 and 0.94 at two measurement points. McDonald's omega was also 0.95 and 0.94 at the same points.

2.4.2. Collective efficacy

This study used the modified Korean version [21] of Alavi and McCormick's [22] 19-item collective efficacy scale, in which, higher scores represent higher collective efficacy based on a 5-point Likert scale. It consists of 4 sub-factors: exercise of leadership (5 items), exchange of opinions (5 items), opinion evaluation (3 items), and integration of opinions (6 items).

During instrument development, Cronbach's alpha was 0.91. In this study, Cronbach's alphas and McDonald's omegas were all 0.97 at two measurement points.

2.4.3. PS competency

This study used the PS competency self-evaluation tool, validated among Korean nursing students [23]. It is a 5-point Likert scale for three domains: attitudes (14 items), skills (21 items), and knowledge (6 items), for a total of 41 items. A higher score means a higher PS competency. During instrument development, Cronbach's alpha was 0.91. In this study, Cronbach's alpha was 0.94 and 0.96 at two measurement points for whole items. McDonald's omega was also 0.94 and 0.96 at both points.

2.4.4. Evaluation of the gamification class among the experimental group

To assess participants' satisfaction after class using the gamification technique, we used a game satisfaction assessment tool developed by Boctor [24]. This scale comprises 6 positive items and 2 negative items, measured on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher average scores indicate greater satisfaction with the game. Cronbach's alpha was not reported during the instrument's development. In this study, it was 0.81, and McDonald's omega was 0.79.

To qualitatively analyze the evaluation of the game, participants were asked to write self-reflection journals about their game participation experience by responding to six open-ended questions: 1) Overall, how did you feel while practicing the game today? 2) What did you do well in the game? 3) What aspects did you overlook while participating in the game? 4) What did you learn from today's lesson? 5) How can you utilize the knowledge gained today in your future clinical practice? and 6) What did you like in today's game class and what needs improvement? The advantages of qualitative analysis include gaining deeper insights into novel and relatively unexplored areas, as well as discovering new issues or opportunities that may not be captured in surveys [25].

2.5. Data collection

Data collection was performed by a co-researcher affiliated with another university and unconnected with the course. Prospective participants accessed the provided URL, read the study details, checked consent for participation, and proceeded with the survey if they agreed. Participants of both groups responded to a questionnaire consisting of a total of 91 items, including age, gender, major satisfaction, and grade point average (GPA), through a shared online URL both at the beginning and end of the course during the fall semester of 2022. The written self-reflection journals of the experimental group were collected via email at the end of the same semester. Until the study's conclusion, no participants dropped out or withdrew, and there were no missing data.

2.6. Data analysis

Quantitative data were analyzed using SPSS version 28 (IBM Corporation, Armonk, NY, USA). As the study's primary objective was not just to test the impact of the time variable, various criteria were tested using different instruments (viz., data normality: Shapiro-Wilk hypothesis test; prior homogeneity between groups: independent t-tests, chi-square tests, and Fisher's exact tests; changes in the pre-and post-dependent variables for each group: repeated-measures multivariate analysis of covariance [RM MANCOVA], repeated-measures analysis of covariance [RM ANCOVA]). Gender and age, which were non-homogeneous between the groups, were treated as covariates. The only non-normally distributed dependent variable—the control group's pre-attitude scores in PS competency ($p = 0.013$)—was analyzed using the generalized estimating equation.

Qualitative data were analyzed using Braun and Clark's [26] qualitative thematic analysis. First, two authors with extensive

experience in qualitative research read through participants' self-reflection journals multiple times and made notes of their initial thoughts. Second, codes were generated by marking statements that stood out as major concepts in the data, and related codes were classified. Third, potential themes were created by determining the codes' relevance. Fourth, any inconsistencies between the themes and codes were thoroughly checked. Fifth, the reviewed themes were further refined to make them more explicit. Sixth, relevant quotations for each theme were selected, summarized, and compiled into a report. The themes were determined and agreed upon through discussions between the authors to ensure trustworthiness. Moreover, a nursing professor with extensive experience in qualitative research provided feedback on the results, which were also shown to two participants, to confirm if the results matched their thoughts.

2.7. Ethical considerations

This study was approved by the Institutional Review Board (IRB) of the researchers' affiliated university (IRB no. GWNUIRB-2022-17) and conducted in compliance with IRB guidelines and the Declaration of Helsinki. The research participants were students enrolled in a course conducted by the first author. Therefore, to minimize students' concerns about their non-participation affecting their grades or reputation, the first author did not participate in participant recruitment and data collection, so as not to know who was participating in the study. Informed consent was obtained from all the participants. We offered coffee coupons to all the participants at the end of the study.

3. Results

3.1. General characteristics and homogeneity between the two groups

The mean age of the experimental group ($n = 28$) and the control group ($n = 27$) was 21.00 ± 2.14 , 23.30 ± 4.56 , respectively. In the experimental group, there were 21 women (75.0%), while in the control group, all students were women (100%). The GPA of ≥ 4.0 was 6 (21.4%) in the experimental group and 9 (33.3%) in the control group, while the GPA of 3.0–3.9 was 21 (75.0%) and 17 (63.0%), respectively. The satisfaction scores for major were an average of 3.86 ± 0.45 in the experimental group and 3.67 ± 0.68 in the control group. There was no significant difference in GPAs, major satisfaction, learning motivation, collective efficacy, PS competencies between the groups. However, significant differences were observed in age ($t = 2.37$, $p = 0.023$) and gender ($t = 7.73$, $p = 0.010$).

3.2. Effect of the intervention on outcome variables

Analysis using RM-MANCOVA showed that the intervention had an impact on participants' learning motivation, collective efficacy, and PS competency (time \times group effect: Wilks lambda = 0.77, $F = 3.816$, $p = 0.001$). The results of the RM-ANCOVA analysis to determine which outcome variables showed the effect of the intervention are presented in Table 2.

After the intervention, learning motivation scores did not differ significantly between the groups ($F = 0.03$, $p = 0.861$), for time ($F = 1.62$, $p = 0.209$); or in the interaction between group and time ($F = 2.38$, $p = 0.129$). Therefore, it rejected the hypothesis that

Table 2

The program's effects on variables ($N = 55$).

Variables	Group	Pretest	Posttest	Source	F/χ^2^a	p	
		$M \pm SE$	$M \pm SE$				
Learning motivation	Exp. ($n = 28$)	3.59 ± 0.14	4.03 ± 0.12	Group	0.03	0.861	
	Cont. ($n = 27$)	3.70 ± 0.15	3.85 ± 0.13	Time	1.62	0.209	
				$G \times T$	2.38	0.129	
Collective efficacy	Exp. ($n = 28$)	3.72 ± 0.13	4.29 ± 0.13	Group	0.54	0.466	
	Cont. ($n = 27$)	4.10 ± 0.14	4.17 ± 0.13	Time	0.15	0.904	
				$G \times T$	7.66	0.008	
Patient safety competency	Total	Exp. ($n = 28$)	3.33 ± 0.11	4.44 ± 0.10	Group	1.23	0.273
		Cont. ($n = 27$)	3.63 ± 0.11	3.89 ± 0.10	Time	0.31	0.581
	Attitudes				$G \times T$	16.51	<0.001
		Exp. ($n = 28$)	4.44 ± 0.07	4.71 ± 0.07	Group	0.46	0.496 ^b
		Cont. ($n = 27$)	4.57 ± 0.07	4.43 ± 0.09	Time	2.05	0.153 ^b
	Skills				$G \times T$	19.86	<0.001 ^b
		Exp. ($n = 28$)	2.91 ± 0.15	4.24 ± 0.11	Group	0.35	0.555
		Cont. ($n = 27$)	3.51 ± 0.15	3.82 ± 0.11	Time	0.73	0.396
	Knowledge				$G \times T$	15.56	<0.001
		Exp. ($n = 28$)	2.64 ± 0.19	4.39 ± 0.15	Group	4.66	0.036
		Cont. ($n = 27$)	2.81 ± 0.19	3.40 ± 0.15	Time	0.42	0.522
				$G \times T$	11.09	0.002	

Note. Exp. = experimental group, Cont. = control group; M = estimated mean; SE = standard error; $G \times T$ = group \times time.

^a Wald chi-square test.

^b Obtained from generalized estimating equation analysis.

participants in the experimental group who engaged in a PSE program using flipped learning and gamification would exhibit higher learning motivation scores compared to the control group that received only written PSE materials.

The collective efficacy scores did not show statistically significant differences across groups ($F = 0.54, p = 0.466$) and timepoints ($F = 0.15, p = 0.904$). However, there were significant interactions between groups and timepoints ($F = 7.66, p = 0.008$) as the experimental group's pre and post-change collective efficacy scores were significantly greater than the control group's. Therefore, it supported the hypothesis that the experimental group's participants, who engaged in a PSE program using flipped learning and gamification, would exhibit higher collective efficacy scores than the control group, which received only written PSE materials.

The total PS competency scores did not show a statistically significant difference across groups ($F = 1.23, p = 0.273$) and timepoints ($F = 0.31, p = 0.581$). However, there were significant interactions between groups and timepoints ($F = 16.51, p < 0.001$). The attitude scores as a subscale of PS competency did not show a statistically significant difference across groups ($\chi^2 = 0.46, p = 0.496$) and timepoints ($\chi^2 = 2.05, p = 0.153$). However, there were significant interactions between groups and timepoints ($\chi^2 = 19.86, p < 0.001$). The skill scores, as a subscale of PS competency, did not show statistically significant differences across groups ($F = 0.35, p = 0.555$) and timepoints ($F = 0.73, p = 0.396$). However, there were significant interactions between groups and timepoints ($F = 15.56, p < 0.001$). Knowledge scores as a subscale of PS competency did not show statistically significant differences across timepoints ($F = 0.42, p = 0.522$). However, there were significant differences across groups ($F = 4.66, p = 0.036$) and interactions between groups and timepoints ($F = 11.09, p = 0.002$). Therefore, it supports the hypothesis that the experimental group's participants, who engaged in a PSE program using flipped learning and gamification, would exhibit higher PS competency scores than the control group, which received only written PSE materials.

3.3. Evaluation of the game

3.3.1. Satisfaction with the gamification class

As per the 8-item survey's results, the average total score was 4.71 ± 0.43 out of 5 points. The average scores for the six questions with positive content ranged from 4.61 ± 0.57 to 4.93 ± 0.26 . Conversely, the average scores for the two items with negative content were 1.50 ± 1.11 and 1.36 ± 0.95 , respectively (Table 3).

3.3.2. Qualitative analysis of self-reflection journals

The 17 codes derived through qualitative analysis were extracted into four themes (Table 4). The first theme was "fun and immersion differentiated from existing classes." Participants experienced academic stress, which decreased gradually as they continued participating in the games. Moreover, they showed that the process of solving the clues in a realistic and well-organized game was exciting and not boring. It is shown in the following example:

"If I had to define it in just one word, I think it would be "fun." I felt that I was focusing and immersing myself much faster and easier than in lecture-style classes." (P 24)

The second theme was "improved learning outcomes and learning motivation." Participants said that it would be useful for clinical adaptation in the future due to the broadening of the view on safety management, the responsibility of medical personnel, and the direct experience learning method. This class gave the participants an opportunity to reflect on the mistakes they experienced. This led to the motivation to develop composure and situational judgment. In addition, they said that they had the confidence to effectively cope with similar situations in the future and the will to study more. As one of the participants said,

"It was good that I was able to figure out what I lacked through practice using game techniques, and it gave me an opportunity to think about what areas I should focus on learning." (P 21)

The third theme was "realizing the value of collaboration and communication." Participants learned what they missed through communication and feedback. They discovered more through their role and collaboration and easily solved problems by communicating with their colleagues. In this process, they developed a sense of camaraderie and intimacy with their colleagues. The following is the example of it.

Table 3
Quantitative and qualitative analyses of game evaluation in the experimental group (N = 28).

Quantitative analysis	Score (M±SD)
Total (Possible range 1–5)	4.71 ± 0.43
I felt this learning activity was beneficial.	4.79 ± 0.50
I enjoyed playing this game.	4.82 ± 0.39
I feel this activity will help me to answer test questions better.	4.61 ± 0.57
I learned new information related to nursing.	4.93 ± 0.26
In the future, I want to use games like this to review material learned in class.	4.68 ± 0.55
This game helped me review the Fundamentals of Nursing information.	4.75 ± 0.52
I did not enjoy this game.	1.50 ± 1.11
I did not find this game beneficial to learning.	1.36 ± 0.95

Table 4
Qualitative analyses of game evaluation in the experimental group (N = 28).

Themes	Codes
Fun and immersion differentiated from existing classes	<ul style="list-style-type: none"> • Academic stress gradually reduced • The process of solving a well-designed and realistic game is exciting • The class was not boring and was enjoyable
Improved the learning outcomes and learning motivation	<ul style="list-style-type: none"> • A broader view of safety management and medical personnel's responsibilities • Effective experiential learning method that is beneficial for clinical adaptation • An opportunity to experience and reflect on mistakes • Motivated to develop composure and situational judgment • Feeling more confident to deal effectively with future similar situations • Willingness to study more in the future
Realizing the value of collaboration and communication	<ul style="list-style-type: none"> • Learned through communication and feedback what I missed • Discovering more through each role and collaboration • Solved the problem easily by communicating with colleagues • Developed a sense of camaraderie and intimacy with colleagues
Feeling down due to unfamiliarity	<ul style="list-style-type: none"> • Confused by the instructional approach I encountered for the first time • Found the real challenge to be difficult • Regretted not being able to handle it properly • Worried about whether I'll be able to perform well in future emergencies

"What I learned through today's class is "teamwork." Doing it alone was a burdensome practice, but by sharing it with others, I was able to address my areas of weakness. My team members helped me identify my areas for improvement, and I found things to learn." (P 12)

The last theme was 'feeling down due to unfamiliarity'. Participants were somewhat confused by the instructional approach they encountered for the first time. They believed they were well-prepared, but when it happened, they found the real challenge to be difficult and regretted not being able to handle it properly. They worried about how they would do well in an emergency situation in the future.

"In reality, it wasn't easy. Perhaps it was because I was very nervous from the start. I couldn't practice with a calm mind. I was worried about whether I would perform well when I went to the clinical setting and faced a much more critical situation during practice." (P 8)

4. Discussion

The results of the experimental group's collective efficacy improved significantly before and after the experiment, similar to those reported by Chen and Hwang [27]. Collective efficacy represents a shared belief in the team's ability to organize and execute effectively [28]. When collective efficacy is enhanced, team members trust each other's abilities and approach challenging tasks positively. Therefore, improved collective efficacy in the experimental group suggests that team members can work together harmoniously and achieve positive outcomes [29].

Unlike individual learning, the team learning process requires skills for effectively performing collaborative activities, such as communication, decision-making, and conflict resolution, which can influence team learning motivation and behavior [30]. Communication skills in team-based learning are crucial for knowledge sharing and problem-solving. Additionally, conflict resolution skills (active listening, negotiation, empathy, etc.) align with the principles of team-based learning [31]. In team-based learning requiring cooperation, as learners often report anxiety and dissatisfaction with collaborative learning, and their efficacy levels in collaborative activities may differ [32], collective efficacy training is essential. As collective efficacy improves through team-based learning experiences, members are more likely to communicate openly and strive towards common goals [29]. Consequently, licensed nurses become effective collaborators, maintaining high standards of care. Moreover, nurses with collective efficacy can evolve into influential team leaders, mentors, and patient-centered care advocates [33]. The qualitative analysis results of self-reflection journals also revealed that collaboration and communication enabled participants to discover more, solve problems easily, and experience increased camaraderie and intimacy with their colleagues. Educational games can accommodate various learning styles and promote student collaboration through group discussions and participation [24]. Participants' motivation and behavior during the team learning process is a highly influential variable in explaining team-level participation and achievement [32]. However, further research is needed on the collective efficacy that this study empirically examined.

Academic achievement includes cognitive, affective, and psychomotor subtopics [34]. This study showed that the experimental group's PS competency scores on attitude, knowledge, and skills improved significantly. Healthcare providers' lack of awareness regarding the seriousness of safety incidents is a significant factor contributing to accidents. Therefore, awareness and attitudes toward patient safety are crucial for preventing accidents. During the flipped learning period, team activities involved role-playing SBAR scenarios and identifying risk factors threatening patient safety in the error room, which contributed to the formation of awareness about patient safety. In the knowledge domain, understanding patient safety culture, analyzing error types and causes, and deriving strategies to prevent errors are essential for maintaining safety in nursing environments. Patient safety competency involves practical skills such as reporting errors and communicating accurately for patient safety. Nurses continuously monitor patients' conditions and

communicate with other healthcare professionals, making communication a vital element in patient safety [35,36]. Therefore, enhancing nursing students' knowledge, skills, and attitudes toward patient safety will improve their patient safety management activities as future nurses. Existing studies consistently emphasize the importance of attitude, knowledge, and skills in patient safety. Similar findings across different nursing education programs validate the significance of these competencies [37,38]. The qualitative analysis revealed that the opportunity to reflect on their mistakes gave students confidence about effectively dealing with similar situations. Previous studies [12,39,40] reported that escape room games led to increased knowledge of acute renal failure, immersive learning experiences, awareness of role assignment and communication's importance, and insights into nurses' duties and problem-solving methods. As these studies conducted these games as extracurricular programs, evaluating their long-term effects was difficult. Moreover, their not establishing a control group was another limitation.

While technical skills comprise nursing performance expertise, the non-technical include cognitive and social skills, such as situational awareness, decision-making, communication, and teamwork. PS requires a harmonious blend of technical and nontechnical skills. Recently, educators have been introducing non-technical skills in PSE, and interest in this area is increasing [6]. Demonstrating PS competency comprehensively requires teamwork and communication, and improving these through lectures and practice alone is challenging [5].

Nurse educators must continually consider how to effectively convey PS and quality-related topics and contents using appropriate and effective teaching methods [17]. Students must experience real-world clinical cases, including interpreting PS issues using various teaching methods [11]. As this study and a systematic literature review [41] reported that gamified flipped learning promotes learning performance improvements, actively using it in nursing education is necessary. Additionally, a common barrier to using escape rooms in nursing education is the time and effort required for the faculty to design and implement the experience [42]. As in this study, if researchers use a simulation lab as an escape room, they can create an educational environment more easily. This study's results, which showed no difference in learning motivation between the experimental and control groups, differ from other studies' results [43,44].

Flipped classes have an advantage in the possibility of repetitive attendance based on learners' ability to learn and efficiently manage class time. Flipped learning prepares students by providing foundational knowledge before they encounter gamified elements. Students review content independently, allowing them to arrive in class with a baseline understanding. This readiness enhances their ability to participate actively in gamified activities during face-to-face sessions [29]. However, there is a need for supplementary strategies to address concerns such as the burden of pre-listening to lectures [45] and the potential disruption of team activities during class if learners do not accurately grasp the learning content. Escape room games engage students in problem-solving, critical thinking, and teamwork. These activities reinforce concepts learned outside of class, making learning more memorable. Students deepen their understanding and retain information by applying knowledge in a gamified context [46]. Integrating both methods offers the advantage of students being motivated to finish pre-class assignments (flipped learning) to unlock gamified challenges. The gamified activities during the class reinforce the content learned through flipped learning [41].

Although gamification is an educational method that strengthens and supports flipped learning's effectiveness [41], some participants reported feeling burdened when exposed to unfamiliar learning methods. According to the study results, there was no significant difference in post-treatment learning motivation between the experimental and control groups. Potential reasons for this could be attributed to the potential burden of flipped learning and the incorporation of a novel learning method involving gamification. Additionally, the cause of its insufficient effect on learning motivation can be inferred from "feeling down due to unfamiliarity," derived from analyzing self-reflection journals. It should be considered that interest and motivation to learn may decrease if this happens [47]. Alleviating learners' anxiety about unexpected situations through a prior explanation of the games, detailed guidance on rules, and sufficient Q&A is, therefore, necessary. To further alleviate the apprehension associated with linking the game to grades, minimizing grading directly related to the game itself is recommended. Professors should engage in thorough pre-preparation, considering learning objectives and tailoring the content and difficulty of the game to align with students' comprehension and performance levels. Analyzing the self-reflection journals clarified that on continuing to play the game, over time, initial academic stress lessened, and participants began to enjoy solving the game's clues. This aligns with a previous study's findings [34], that learners acquired complex content with reduced stress in an enjoyable learning experience, as demonstrated in this study, which applied the room escape game for two weeks. However, adjusting the game's numbers/duration can alleviate its unfamiliarity and stress.

Additional research is needed as some studies showed that learning motivation reduced significantly after flipped learning [48], and using a control group was rare in gamification studies [13]. Nursing educators need to maintain students' motivation, and games capture attention and encourage in-depth learning [24]. Focusing on specific game elements helps identify the most effective game attributes and negative consequences [13].

One of the challenges to address is finding the right balance between flipped learning assignments, in-class activities, and gamified elements. Instructors must carefully manage students' time to ensure ample opportunity for pre-class preparation and engaging with gamified tasks. Additionally, instructors should design assessments that effectively evaluate content knowledge acquired through flipped learning and problem-solving skills developed through gamification [49].

According to a systematic literature review, gamification in nursing education predominantly involves digital gamification for online education. It is observed that immediate feedback methods utilizing Video immersion, Scenario-based with virtual video, Web-based games, and Self-paced scored testing are commonly employed [50]. Research on applying escape room games to nursing education in offline environments is limited, and most studies predominantly focus on descriptive accounts of students' experiences [51]. Therefore, the strength of this study lies in validating the effectiveness of a patient safety education program that combines flipped learning and simulation gamification, applied over a 15-week regular educational period through a quasi-experimental design. Additionally, the in-depth analysis of students' reflective journals on the game allowed for a comprehensive assessment of both positive and negative evaluations of the game.

5. Limitations

First, as PS competency was not measured objectively but self-reported, there may be differences. Hence, an objective evaluation of PS competencies by evaluators is recommended in future research. Second, as the intervention's effects on the main variables were only measured on the last day of class and not re-measured, there is no surety of its long-term effects; hence, time series measurements are recommended. Third, this study was conducted with a small population from a single South Korean university. Moreover, the distribution of male students across the experimental and control groups was uneven due to the voluntary participation of students. These factors may limit the study's generalizability. Forth, the researcher conducting the intervention was blinded; however, the lack of blindness among the participants and the inability to exclude contamination between the two groups are limitations of the study.

6. Conclusions

PS is a medical standard requiring healthcare professionals' adherence to ensure patients' rights to receive safe medical care. The importance of nursing students' PS competency is increasing, but more opportunities to experience problem-solving processes through collaboration and communication are needed. Applying flipped learning and gamification to PSE confirmed their benefits for enhancing collective efficacy and PS competency.

Furthermore, qualitative analyses of reflective journals were conducted to explore participants' game experiences. Flipped learning and escape room games can be introduced to improve learning outcomes and promote non-technical skills.

This study is significant because it confirmed the efficacy of flipped learning and gamification, not previously utilized in PSE, in enhancing PS competency. Additionally, it employed a pre-post experimental design with a control group, a methodology seldom employed in existing studies within gamification. Nevertheless, it is necessary to confirm the effectiveness of this PSE program through future double-blind and randomized experimental studies and also to compare the intervention effects across periods as the escape game's effective duration cannot be determined.

Consent for publication

All authors provided written informed consent to publish this study.

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Ethical considerations

All procedures were performed per the guidelines of the Institutional Review Board of Gangneung-Wonju National University (approval number: GWNUIRB-2022-17). All participant information was anonymously collected.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s.

CRedit authorship contribution statement

Soo Jung Chang: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Geun Myun Kim:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis. **Jeong Ah Kim:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

List of abbreviations

GPA	Grade Point Average
IRB	Institutional Review Board
PS	Patient Safety
PSE	Patient Safety Education
RM ANCOVA	Repeated-Measures Analysis of Covariance
RM MANCOVA	Repeated-Measures Multivariate Analysis of Covariance

RM MANOVA Repeated Measure Multivariate Analysis of Variance
SBAR Situation, Background, Assessment, and Recommendation
WHO World Health Organization

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