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Underground nursing students' experiences in a face-to-face, hybrid, and online escape room model: a comparative analysis in Serbian context

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ABSTRACT

Educational escape rooms (EERs) are gamified teaching and learning tools increasingly used in nursing education. This study aims to compare undergraduate nursing students' gameful experiences (GEs) across three EER models: face-to-face, hybrid, and online. A cross-sectional study was conducted with 136 first-year students in a Serbian undergraduate nursing programme. All models EERs had the same narrative, which included several topics from the Fundamentals of Nursing course. Face-to-face and hybrid EERs were implemented in faculty skills laboratories, while the online model used the Zoom® platform. Face-to-face EERs were conducted in 2021/2022. and hybrid and online in the 2022/2023 school year. Immediately after the EER activity, the Gameful Experience Scale (GAMEX) assessed students' GE across six dimensions (Enjoyment, Absorption, Creative Thinking, Activation, Absence of Negative Effects and Dominance). All students solved the puzzles in the allotted time and 'escaped from the room.' Median escape time from face-to-face EER was 39.2 (IQR = 2.1), from online 37.4 (IQR = 4.1), and hybrid 37.2 (IQR = 3.5) minutes. By comparing GE students in three EER models, significant differences were found in five dimensions of the GAMEX scale. Students in face-to-face EER enjoyed significantly more ($p < 0.001$) and thought more creatively ($p < 0.001$), while the GE of online model students indicated significantly higher levels of activation ($p < 0.001$), dominance ($p < 0.001$), and negative effect ($p < 0.001$). In the face-to-face and hybrid models, students' GE were more moderate in these dimensions. All EER models can generate positive emotions with moderate negative effects, aligning with the goals of EERs as educational games. Further research is needed to identify the most effective EER model for different areas of nursing education.

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Background

Today, most higher-education students grow up in digitised environments and use dynamic and interactive digital information daily [1,2]. Therefore, their concept of learning and effective educational environments have changed significantly compared to traditional ones [2]. Moreover, in contemporary society, there is a trend toward devoting increasing importance to recreational activities, which has contributed to the fact that games and their elements usually overflow into almost all everyday life [3]. A common term for this trend is gamification, which [4] defined as 'the use of game design elements in non-game contexts.' Gamification can be viewed as a general concept that utilises gaming elements in a real environment. In the educational context, this relates to serious games and game-based learning [5]. Integrating gamification into education through innovative teaching methods can increase student interaction, motivation, and engagement in the learning process through purposeful applications [6]. In addition, in nursing education, using gamification elements allows teachers to reduce students' monotony and passivity and hasten the achievement of professional skills [7].

The effectiveness of gamification is determined by user experience [8]. Landers et al. [9] defined gameful experience (GE) as a psychological state created by interacting with three characteristics: the perception of goal attainability, motivation to achieve goals under certain imposed conditions, and the experience of willingness to participate in the game under those conditions. Gameful experiences indicate students' perceived emotional involvement from participating in a game [10]. Thus, GE is considered the primary goal of gamification [8] and a prerequisite for achieving the goals of its application [9]. The assessment of GE game users contributes to identifying the dimensions of GE

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that must be improved to adjust the effectiveness of interactive games [8].

Educational escape rooms (EERs) are innovative teaching methods that include gamification. Unlike many board games based on strategy and luck and screen-based games that rely primarily on hand-eye coordination, escape room activities are planned so that thinking activities are used to solve challenges [11]. The concept of an EER as an educational game includes many elements of an active learning strategy, combines learning based on problem-solving, and improves clinical skills, teamwork, communication skills, and critical thinking [12,13].

In general, EER activities are conceived as a team activity in which students 'lock themselves in a room,' where they receive a scenario according to which they must solve puzzles in order to 'escape the room' [14]. All activities within EERs are called puzzles, and the 'room' is the space in which the activities are carried out [1, 11, 15]). The room could be a physical space, and the EER is usually organised according to a face-to-face or virtual model (in the case of an online EER) [16]. However, with the development of digital technologies, the distinctions between virtual and physical spaces have been erased, and the concept of hybrid EER has been introduced [17].

Educational escape rooms (EERs) designed for healthcare students have primarily been conducted face-to-face [18,19]. However, the COVID-19 pandemic forced a shift to online education, a change neither teachers nor students initially chose [20]. The pandemic's increased reliance on digital tools encouraged educators to incorporate them into EER design, leading to a rise in online and hybrid EER formats [19,21]. Despite this shift, few studies have directly compared different EER models. López-Pernas et al. [22] were among the first to evaluate the effectiveness of face-to-face versus online EERs with Telecommunications Engineering students. While students found programming equally engaging in both formats, learning efficiency was slightly lower in the online model (López-Pernas et al. [22]). Ang et al. [23] outlined the implementation of face-to-face and online EERs in a chemistry course focused on chemical bonding, finding that both models fostered motivation, critical thinking, and problem-solving. However, the face-to-face model offered a more immersive experience, which students preferred [23]. In another study, Pozo-Sánchez et al. [2] compared the gamified experiences of secondary education master's students in face-to-face and online EERs. Both formats produced high levels of engagement and minimal negative effects, though face-to-face participants reported being more active and enjoying the experience more, while online participants demonstrated higher levels of creative thinking [2].

A recent integrative review of EERs showed that this innovative teaching and learning strategy has improved the knowledge of different nursing areas and is well accepted by nursing students [24]. In nursing education, EERs have been applied in the course of Adult Nursing 1 [25], Fundamentals of Nursing [20,26], Community Care [27,28], Anatomy [29], Pediatric Care [30], Reproductive Health Care [31], Cardiovascular Care [32], Emergency Care – Urosepsis [33] and Clinical Care of Older Patients with Acute Kidney Injury [13].

Implementing EERs in nursing education has resulted in many positive outcomes, including GE [14]. In studies with different designs, students' GE in EERs have indicated a high level of enjoyment, immersion, creative thinking, and activation, with the absence of or very few negative effects, which also contribute to effective learning [14,27,34].

However, most studies have focused on assessing nursing student GEs using only one EER model [7,12–14,20,25,27,31,32,34,35]. The analysis of GE can indicate the advantages and disadvantages of certain models of EERs that can be significant for the design and implementation of EER in nursing education. Given that EER can be carried out using different models, this study aimed to compare Serbian undergraduate nursing students' GE while utilising three different models of EERs (face-to-face escape room, hybrid, and online models). In addition, we aimed to determine the moderating roles of gender and previous participation in recreational escape rooms (ERs) in the ER models and students' experiences in different dimensions of GEs.

Methods

Study design and setting

This comparative cross-sectional study was conducted at the Faculty of Medicine, University of Novi Sad. It involved first-year nursing students during the summer semesters of the 2021/2022 and 2022/2023 academic years. The reporting of this study adhered to the STROBE guidelines [36].

Study procedures

The process of creating each EER model consisted of several steps based on the general principles of educational simulations [37] EERs [11,15], and medical EERs [12,25,27,38]. All three models of EERs had the same narrative, which included several topics of the Fundamentals of Nursing course and were created at the end of the course, a few weeks before the exam. Educational topics, skills, and puzzle tasks for face-to-face EER and hybrid and online EER models are presented in Appendix 1.

The first EER model was designed and implemented as a face-to-face EER using equipment in the faculty skill laboratory. The time limit of the EERs was one class hour (45 min). The content and types of puzzles were categorised under the narrative, learning objectives, and available skills laboratory resources. For additional equipment, it was necessary to purchase picture frames, boxes, keys, and padlocks with a total value of around 60 euros. Only theoretical knowledge was essential to solve the first and last puzzles; practical knowledge related to problems from a natural clinical environment was required for others.

There were seven puzzles in total, and they were presented in a linear sequence; thus, solving one problem unlocked the next. The puzzles were designed such that the first was the simplest, the next more complex, and the last the most difficult. The complexity of these puzzles was primarily in line with the educational goals of ERs and the achievement of a compromise between boredom and frustration [39].

Each puzzle was tested separately in the skill laboratory, and a panel of experts, consisting of five nurse educators from the Fundamentals of Nursing course, analysed the content, design, and resources of the EER. After reaching a consensus, a pilot study was conducted to test all the EERs.

The pilot study was conducted two weeks prior to the final study. In addition to voluntary consent, the criterion for participation in the pilot study was that the student passed the Fundamentals of Nursing course exam. Ten students were divided into two groups of four and six students. The pilot study identified the specific weaknesses of the initial puzzles. In both groups, one puzzle took almost half the planned time and caused frustration. The students cited unclear written directions and confusing clues as potential causes. Redesigning the EERs involved technical modifications based on received suggestions.

The final face-to-face EER model, involving 15 groups of students, was conducted over one working week. Following the recommendation by Veldkamp et al. [15], each group comprised four to six students. They were awarded extra pre-examination points to encourage their participation in the EERs and prevent the sharing of information or codes with other groups. These points were allocated based on performance: the most successful group earned 1 of the 10 maximum pre-examination points, the second-place group received 0.5 points, and the third-place group earned 0.25 points.

Before starting the EER activities, all students received a brief written and verbal description of the importance and methods of conducting the activities. When the students entered the skill laboratory, a timer animation was activated on the LCD screen installed on the wall, counting down the time. During the EER implementation, the nurse educator was also present in the skill laboratory, and the students had permission to consult him only once without stopping the timer.

All puzzles were created in digital format for the hybrid and online EER models. Various digital tools were used for their creation, ranging from simple audio recordings and text converted to a PDF format to complex interactive animated content. Interactive content was created using tools within the Genially® web platform to represent the clinical environment as realistically as possible. Subsequently, all puzzles were uploaded to the university's e-platform based on the Moodle™ learning management system. The option chosen on this platform for the opening instructions and six puzzles was a lesson module and a crossword game for the final seventh puzzle.

The opening instructions were in written and audio forms. Clicking the start button began the EER activities and the countdown timer. The answer to the first puzzle required choosing the correct option and entering a numeric-letter code for all others. An incorrect student's answer took the student a step back. The student received additional instructions by going back, reading the text and/or listening to the audio, and trying to solve the puzzle again. The number of attempts was not limited; however, the countdown did not stop.

For these EER models, a faculty computer technician and an instructional designer from the university's e-learning platform were added to the expert panel. After reaching a consensus, a pilot study was conducted using the same criteria as the first EER model. Ten students who had not participated in the previous pilot study or the face-to-face EER participated in this digital format pilot. They were divided into two groups, one with four students and the other with six. Following the pilot study, students provided suggestions, including feedback on the text font size in two animated documents.

The hybrid and online models were conducted in distinct formative environments. The hybrid model took place in two adjoining faculty skills laboratories, where the space allowed students to use equipment while maintaining physical distancing. Students were divided into nine groups, each provided with a laptop, and one group member used their access code to unlock the EERs. In contrast, the online model was conducted via the Zoom® platform. After logging in, students were organised into five groups of four to six using the breakout room feature, with group leaders receiving access links to complete the tasks. As in the first model, all students were given basic information and technical

instructions about the EERs and were awarded additional pre-examination points based on their performance.

Participants and study location

A total of 136 students enrolled in the nursing program at the Faculty of Medicine of the University of Novi Sad, the second-largest university in Serbia, participated in the study. The nursing program is a four-year academic curriculum, and all three EER models were integrated into the Fundamentals of Nursing course. The practical lectures for this course take place in well-equipped faculty skills laboratories, which are suitable for Serbia as a middle-income country. Notably, all students participating in the three EER models underwent this course for the first time.

The face-to-face EER sample comprised all first-year nursing students in the 2021/2022 academic year ($n = 90$). Of these students, 19 declared they did not want to participate in the study. The final sample comprised 71 students. The hybrid and online EER activities were conducted in the 2022/2023 academic year and comprised 89 students. Twenty-four students declared they did not want to participate in any EER model, so the final sample consisted of 65 students. In order to motivate them to participate and prevent further attrition of participants in the study, these students were allowed to choose between participation in a hybrid or online model. So, 42 students chose the hybrid model, and 23 chose the online EER model (Figure 1). A relatively small number of students within the groups determined further use of non-parametric statistical analyses to ensure the analyses were robust.

Instruments

The Gameful Experience Scale (GAMEX) and a general questionnaire served as the research instruments for this study. Eppmann et al. [8] developed GAMEX to evaluate students' game experiences (GE) across all EER models. The scale comprises 27 items categorised into six dimensions of GE. The first dimension, Enjoyment (items 1 to 6), assesses students' overall enjoyment of the games, determining whether their experience is fun, pleasant, and entertaining. The Absorption dimension (items 7 to 12) gauges students' immersion in the game and ability to avoid distractions. Creative Thinking (items 13 to 16) evaluates the level of creativity stimulated during gameplay, encouraging imaginative and adventurous thought. The fourth dimension, Activation (items 17 to 20), measures the sense of activity during the game. The Absence of Negative Effects (items 21 to 23) assesses any adverse feelings, such as annoys, hostility, or frustration. Lastly, the Dominance dimension (items 24 to 27) evaluates how influential, autonomous, and in charge students felt during the game. Each item is rated on a five-point Likert scale, ranging from 1 (never) to 5 (always), with 'game' referring to the playful activities engaged in during class. In this study, Cronbach's alpha was found to be

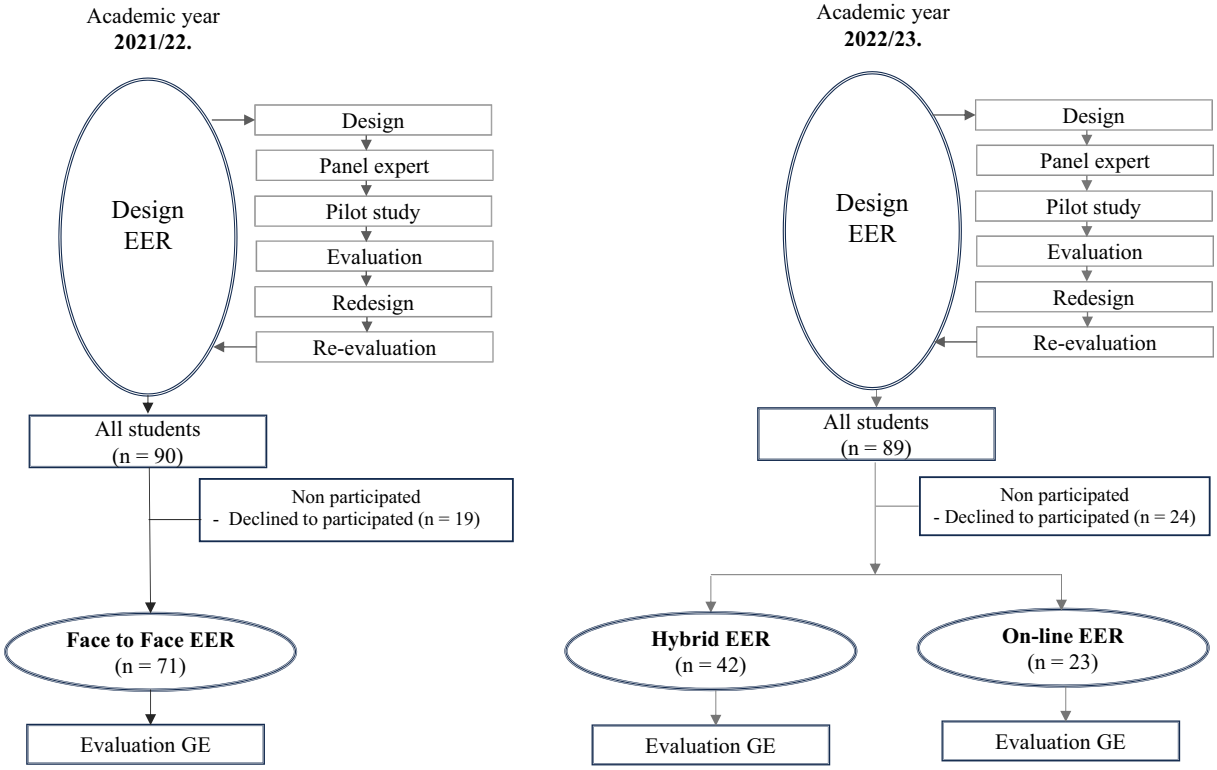

Figure 1. Flow chart study design and student selection.

0.88 (95% CI: 0.83–0.91) for the face-to-face EER model, 0.85 (95% CI: 0.78–0.91) for the hybrid model, and 0.95 (95% CI: 0.91–0.96) for the online model.

A general questionnaire designed to obtain sociodemographic characteristics included data on sex, age, and previous recreational experience with ERs.

Both instruments were created using the Moodle questionnaire module within the course's Moodle platform. Immediately following the EER activity, all students, regardless of the EER model, completed the online questionnaire. To ensure integrity, the settings allowed only one response per student, preventing multiple submissions.

Data analysis

The statistical software (IBM SPSS Statistics 26) was used for statistical data analysis. Cronbach's alpha was calculated to assess the internal consistency of the GAMEX scale. Descriptive analysis was performed using the mean (M), standard deviation (SD), mean rank (MR), median (Med), and interquartile range (IQR). Before conducting comparative statistical analyses, the normality of data distribution was checked. As the distribution deviates from normal for each of the six dimensions and the number of students within one of the groups is less than 30, we used the Kruskal – Wallis test to test the differences between the GEs of the students while participating in the three different models of EERs. In the options dialogue, we specified a 95% confidence interval. For the exact location of the observed intergroup differences, we used the Dwass-Steel-Critchlow-Fligner pairwise post hoc comparison. The analysis of moderation, in which categorical variables were coded into dummy variables and models were tested in a two-step procedure, was used to test the moderating role of gender and previous experience with participating in recreational ER activities regarding the EER models and achievement on the dimensions of the GAMEX scale. The level of statistical significance was set at $p < 0.05$.

Ethical consideration

This study was approved by the Ethics Committee of the Faculty of Medicine at the University of Novi Sad (reference number: 01–39/35/1). The students involved in this study provided informed consent following the Declaration of Helsinki. Before consent, the students received information regarding the research, noting that (non)participation in the study would not affect their success in any subject or further education.

Results

As presented in Table 1, 136 students participated in the study. Most participants were female (90.4%), with an average age of 19.7 (SD = 2.2) years. Eighteen students (13.3%) had experienced recreational ER activities in the past, and no student had participated in EER activities before the study.

In all three EER models, students successfully 'escaped the room' within the allotted time (Appendix 2). The median time to 'escape the room' for the face-to-face EERs was 39.2 (IQR = 2.1) minutes, followed by the online EERs at 37.4 (IQR = 4.1) minutes, and the hybrid EERs at 37.2 (IQR = 3.5). There were no notable differences in the time to solve all puzzles across the different EER models based on group size. Namely in face-to-face EERs $p = 0.19$ ($\chi^2_{(df=2,\ n=15)} = 3.32$), in hybrid EERs $p = 0.75$ ($\chi^2_{(df=2,\ n=9)} = 0.57$) and online EERs $p = 0.67$ ($\chi^2_{(df=2,\ n=5)} = 0.80$)

Details regarding students' GEs in all three EER models are presented in Table 2, while Appendix 3 provides the average score for each GAMEX dimension, categorised by group size. According to the GAMEX scale, scores ranged from 1 to 5, with lower scores indicating that GEs were 'never' present and higher scores indicating they were 'always' present. Notably, all three EER models achieved an average score above four in the Enjoyment dimension. Furthermore, Appendix 4 shows that students' GEs remained consistent across all three EER models, regardless of group size.

Table 1. Sociodemographic characteristics of the students.

	Model EERs			
Variable	Face-to-face ($n = 71$) n (%)	Hybrid ($n = 42$) n (%)	Online ($n = 23$) n (%)	All students ($n = 136$) n (%)
Gender				
Male	6 (9.2)	4 (9.5)	3 (13.0)	13 (9.6)
Female	65 (92.3)	38 (90.5)	20 (87.0)	123 (90.4)
Previous recreational ER activity				
Yes	6 (9.2)	7 (16.7)	5 (21.7)	18 (13.3)
No	65 (92.3)	35 (85.7)	18 (78.3)	118 (86.7)
Mean age (SD)	19.88 (2.5)	19.67 (2.3)	19.71 (2.1)	19.70 (2.2)

Table 2. Means and standard deviations of each GAMEX dimension for all three EER models.

GAMEX dimensions	Model EERs Face-to-face M (SD)	Hybrid M (SD)	Online M (SD)
Enjoyment	4.79 (0.40)	4.56 (0.50)	4.32 (0.59)
Absorption	3.68 (1.00)	3.58 (0.95)	3.35 (1.40)
Creative thinking	4.53 (0.58)	4.23 (0.57)	3.77 (0.90)
Activation	3.17 (0.58)	3.50 (0.60)	3.80 (0.78)
Absence of negative effects	1.27 (0.58)	1.86 (0.92)	2.27 (1.27)
Dominance	2.67 (0.83)	2.86 (0.74)	3.49 (0.77)

The results in Table 3 indicate that the students' GE during activities in all three models did not differ only in content absorption during EER ($\chi^2 = 0.681$, $p = 0.711$). The results of the Dwass-Steel-Critchlow-Fligner pairwise post hoc comparison showed that students in face-to-face EER enjoyed significantly more ($\chi^2 = 16.203$, $p < 0.001$) and thought more creatively ($\chi^2 = 20.966$, $p < 0.001$), compared to students who participated in hybrid and online EER. In contrast, GE students in face-to-face EER show that they felt significantly less active compared to the other two groups of students ($\chi^2 = 15.134$, $p < 0.001$).

A higher score in the Absence of negative effects dimension on the GAMEX scale indicates that the students had a more intense feeling of annoyance, hostility, or frustration [8]. Data analysis in this dimension indicates significant differences in the GE of students who participated in different EER models ($\chi^2 = 32.293$, $p < 0.001$). More precisely, students in the online EER had the highest score, students in the hybrid one had a slightly higher score, and students in the face-to-face EER had the lowest score. Also, students in the online EER had significantly higher levels of dominance. When we assessed the Dominance dimension, we found that students who participated in online EERs had significantly higher scores than others ($\chi^2 = 32.293$, $p < 0.001$). The effect size for all GE dimensions where a significant difference was observed was small and ranged from 0.11 (Activation) to 0.23 (Absence of negative effects).

To assess the moderating role of gender in the relationship between the dimensions of the GAMEX scale and the EER models, a moderation analysis was conducted through hierarchical regression analysis in two blocks. In the first block, predictor values (GAMEX dimensions) and moderator values (gender) were entered. In the second block, their interaction was introduced. In this study, sex was coded as a dummy variable, with 0 signifying male and 1 signifying female. After introducing the interaction in the second block, the main effect of the EER models remained significant in five dimensions (Enjoyment, Creative thinking, Activation, Absence of negative effects, and Dominance). A significant main effect of gender and the interaction effect of the model EERs and gender were not observed (Table 4). These results support that the GE of all students did not differ significantly, only in the absorption dimension of the GAMEX scale. Students had a similar sense of immersion regardless of the EER model in which they participated. In contrast, the moderation analysis confirmed that different models of EER contribute to the GE students' significantly differing enjoyment, creative thinking, activation, dominance, and absence of negative effects. The assumption that students of different genders are differently receptive to a certain EER model, that is, that they prefer different EER models, was not confirmed. Namely, the GE experiences of male and female students were equally affected by the activities of all three EER models. A moderation analysis was conducted through hierarchical regression analysis in two blocks to assess the moderating role of previous experience with ERs in the relationship between the dimensions from the GAMEX questionnaire and the EER models. In the first block, predictor values (GAMEX dimensions) and moderator values (previous experience with ERs) were entered. In the second block, their interaction was introduced. Previous experience with ERs was coded as a dummy variable, where 0 signified no experience and 1 signified experience. After introducing the interaction in the second block, the main effect of the EER model remained significant in five dimensions (Enjoyment, Creative thinking, Activation, Absence of negative

Table 3. Differences in the scores of each GAMEX dimension related to the EER models.

GAMEX dimensions	EER model Face-to-face[1] MR	Hybrid[2] MR	Online[3] MR	$\chi^2_{(df)}$	p	η^2
Enjoyment	80.23	63.58	46.23	$16.203_{(2)}$	<0.001 **1 > 2,3**	0.118
Absorption	72.05	67.44	65.17	$0.681_{(2)}$	0.711	0.004
Creative thinking	82.68	61.24	42.74	$20.966_{(2)}$	<0.001 **1 > 2,3**	0.153
Activation	57.66	78.65	90.35	$15.134_{(2)}$	<0.001 **1 < 2,3**	0.110
Absence of negative effects	52.69	84.35	95.74	$32.293_{(2)}$	<0.001 **1 < 2,3**	0.235
Dominance	60.38	69.60	98.28	$15.889_{(2)}$	<0.001 **3 > 1,2**	0.115

MR = mean rank; χ^2 = Kruskal Wallis test; df = degrees of freedom; p – values; η^2 = eta squared.

Table 4. Moderation effects of gender in the relationship between the GAMEX scores and the EER models.

	Estimate	SE	Z	p
Enjoyment				
Model EERs	−0.2308	0.0523	−4.415	<.001
Gender	−0.0373	0.1299	−0.287	0.774
EER model ✻ gender	0.1739	0.1639	1.061	0.289
Absorption				
Model EERs	−0.140	0.118	−1.189	0.234
Gender	0.185	0.292	0.633	0.527
EER model ✻ gender	0.574	0.369	1.558	0.119
Creative thinking				
Model EERs	−0.3596	0.0716	−5.021	<.001
Gender	0.0629	0.1780	0.354	0.724
EER model ✻ gender	0.2460	0.2246	1.095	0.273
Activation				
Model EERs	0.327	0.0684	4.777	<.001
Gender	0.116	0.1702	0.684	0.494
EER model ✻ gender	0.481	0.2147	1.228	0.064
Absence of negative effects				
Model EERs	0.51867	0.0940	5.51525	<.001
Gender	0.01945	0.2338	0.08319	0.934
EER model ✻ gender	0.00282	0.2949	0.00957	0.992
Dominance				
Model EERs	0.366	0.0894	4.094	<.001
Gender	0.274	0.2222	1.232	0.218
EER model ✻ gender	−0.239	0.2803	−0.852	0.394

SE = standard error; Z – values; p – values.

effects, and Dominance). A significant main effect of previous experience with recreational ERs was observed in only two dimensions: Absence of negative effects and Dominance. Students with previous GE in ERs had lower scores in these dimensions than those without such an experience. These results suggest that regardless of whether students had GE experiences participating in recreational ER, GE scores in the dimensions of Enjoyment, Creative Thinking, and Activation depend only on the model of EER in which they participated. Namely, the assumption that students with and without previous ER experience will have different results in these GE dimensions was not confirmed. In contrast, in the dimensions of Absence of negative effect and Dominance, it was observed that there are two main effects and that differences exist concerning previous experience with ER and the EER model. No interaction effects were observed for any of the dimensions (Table 5).

Discussion

Escape rooms as an innovative educational method are becoming increasingly popular because active learning aligns with the principles and concepts of gamification [2]. Although EERs can be implemented in different learning environments, most studies have focused on assessing GEs in one environment [14,20,27,31,34,35]. This study focused on GEs regarding nursing students using different EER models. All three EER models had the same narrative, content, number of puzzles, time limit, design steps, criteria for including students in the study, number of students in the group, and, depending on success, number of additional pre-examination points.

Although the time limit of the initial version of the face-to-face EERs in the pilot study proved inadequate, the redesigned version allowed all students to finish the game within the allotted time. A short time limit can cause students to feel frustrated, give up, or make futile attempts to solve puzzles, thereby failing to achieve the educational goals of EERs [40]. In addition, students' success in escaping in less than 45 min may have contributed to the awards for the best groups and the number of students in the group. The awards aimed to motivate students to participate

Table 5. Moderation effects of the previous experience with recreative ERs in the relationship between GAMEX scores and the EER models.

	Estimate	SE	Z	p
Enjoyment				
Model EERs	−0.2317	0.0526	−4.40687	<.001
Previous experience with ER	4.05e-4	0.1119	0.00362	0.997
EER model ✻ Previous experience of ER	0.0319	0.1395	0.22857	0.819
Absorption				
Model EERs	−0.1517	0.119	−1.275	0.202
Previous experience with ER	−0.0831	0.253	−0.328	0.743
EER model ✻ Previous experience of ER	0.1005	0.316	0.318	0.750
Creative thinking				
Model EERs	−0.3545	0.0718	−4.935	<.001
Previous experience with ER	0.1352	0.1529	0.884	0.377
EER model ✻ Previous experience of ER	0.0665	0.1907	0.349	0.727
Activation				
Model EERs	0.313	0.0694	4.52	<.001
Previous experience with ER	−0.204	0.1476	−1.38	0.167
EER model ✻ Previous experience of ER	0.202	0.1841	1.10	0.272
Absence of negative effects				
Model EERs	0.4830	0.0908	5.322	<.001
Previous experience with ER	−0.6288	0.1932	−3.255	0.001
EER model ✻ Previous experience of ER	−0.0377	0.2409	−0.157	0.876
Dominance				
Model EERs	0.341	0.0887	3.847	<.001
Previous experience with ER	−0.393	0.1887	−2.081	0.037
EER model ✻ Previous experience of ER	−0.101	0.2353	−0.428	0.669

SE = standard error; Z – values; p – values.

in EERs and prevent the transfer of codes to other groups, but also gave our EER activities a competitive format.

The literature offers no consensus on the ideal group size for successfully solving tasks in EERs [24]. Eukel and Morrell [38] suggest that the optimal group size is 4 to 5 students, while Makri et al. [1] recommend a maximum of six students per group to enhance immersion and improve the organisation of group performance when solving puzzles. Based on these recommendations, our study utilised groups of four, five, or six students across all three EER models. However, regardless of group size, there were no significant differences in the time to solve the puzzles or the students' GE. This finding supports the perspective that group size, as a factor in group dynamics, does not significantly impact the effectiveness of escape rooms in an educational setting. Thus, group sizes can be determined per the above recommendations [1; 15]).

Our study and previous studies that used the GAMEX scale to evaluate the GEs of nursing students showed that regardless of the environment, the highest average score was observed in the Enjoyment dimension [14,20,27,31,35]. An intense enjoyment experience indicates that the EERs evoked positive emotions, which, according to the general premise, is a desirable outcome of GE [41]. However, students' enjoyment level in the hybrid and online EERs was moderate. This result is consistent with the findings of other authors who have applied EERs in an online environment [20,27]. Therefore, the more a student is exposed to a screen and the less realistic the environment, the lower the level of enjoyment [15].

Students who participated in face-to-face EERs enjoyed solving puzzles and significantly thought more creatively than students in hybrid and online EERs. This means the real learning environment was more stimulating for developing imagination, creativity, and research abilities [22]. Creative thinking is important for nurses to efficiently realize the daily, often time-limited task [25]; therefore, when creating new EERs, advantages would certainly be given first to face-to-face and then to hybrid EERs. However, following the educational goals and dimensions that must be developed during EER and in situations with limited spatial, temporal, and material resources, other models have equal importance [1,2].

Krath et al. [5] indicated that teachers who use gamification in learning environments must develop gamification literacy and abilities to enable all its benefits and specific goals to be realized in the application context. EERs are considered immersive learning environments that promote teamwork and problem-based learning [33]. The results of the Absorption dimension in all three models of EERs indicate that all the puzzles created a sense of immersion in the students. In addition, we attempted to be maximally consistent with the narrative in the design to prevent the emergence of cognitive dissonance. Simultaneously, after a pilot study of the redesigned EERs, all detected ambiguous traces were eliminated. Therefore, in all EERs, the students were 'distracted from everything' by solving puzzles. Despite the limited time, they lost track of time, indicating their focus on solving the given problem. This confirms that the EER content was appropriately selected and designed, which is a prerequisite for achieving the results of this educational strategy [15]. Moreover, the results were significant because they showed that the transformation from face-to-face EERs to the other two models did not affect the content absorption level. At the same time, the results can confirm the positive effects of applying the general principles of educational simulations [37] and the cyclic design process [38] when creating EER.

The Activation level among students in the online ERRs was significantly higher than that among hybrid and face-to-face models students. In an online environment, students may feel more active, as each student can use a computer to obtain answers as quickly as possible to help them solve puzzles. However, this is impossible in an onsite environment due to the teacher's presence [22]. Xu et al. [42] also concluded that online teaching has a greater potential to improve lower-order cognitive skills. In other words, students' increased engagement while working in an online environment can result in better performance, which requires memory. Thus, we assume that online teaching is more suitable for developing lower-order but not higher-order cognitive skills, primarily because teachers and students lack communication skills. This lack of communication could affect students' performance in memory-related areas through online classes, whereas face-to-face classes develop a firm understanding of their fundamental knowledge. Based on these predictions, we would prefer hybrid and face-to-face EERs. The content of our puzzles enabled students to consolidate their knowledge in several areas of Fundamentals of Nursing during one class a few weeks before the exam.

From the aspect of game design, individual elements, and the entire game can cause specific emotions and desired GE outcomes in players [41]. In order to achieve these outcomes in a gamified environment, the absence of negative effects is also necessary in addition to positive emotional qualities [8]. Frustrated students and those for whom puzzles are not sufficiently challenging are less engaged during the game, resulting in inferior learning outcomes [6]. In our study, the students in online EERs experienced stronger feelings of anxiety and frustration.

The negative effects were slightly more moderate among students in the hybrid group, and the lowest level of these effects was recorded in face-to-face EERs. López-Pernas et al. [22] suggested that students' concerns about potential technical difficulties during puzzle-solving were one possible reason for higher stress levels in online EERs. They also concluded that participating in EERs in the classroom, where students solve puzzles in groups, could reduce the negative effects. Potential methods for overcoming negative effects in an online environment and using digital tools familiar to students include enabling mutual online collaboration before playing EER [20].

In our study, the online EER students had a stronger sense of dominance. The feeling of dominance is related to the game's design. For example, a competitive game aimed at strengthening leadership should give students the feeling that they are in charge, influential, and independent [8]. In a previous study regarding nursing EERs that did not contain these elements, students described their experiences as collaborative and valuable for understanding teamwork [28]. Reed and Ferdig [43] considered social interaction, cooperation, and joint problem-solving crucial elements of EERs. They also found that of the seven constructs related to the enjoyment of EERs, the highest was social interaction. Therefore, in addition to the design of our EER, which promoted teamwork and more immediate social interaction in the skill laboratory, students in hybrid and face-to-face EERs had similar feelings of dominance, which were significantly more moderate than students in online EERs. These results must not be ignored and must be carefully considered in creating future EERs, both from the perspective of the narrative and the decision of which EER model to apply. This is especially important when the puzzles in nursing EER are related to the clinical environment where the student is expected to have, in addition to knowledge, the ability to clinical reasoning, communication, teamwork, helping, and seeking help [32].

In previous studies regarding several nursing EERs, male students were more dominant than females [14,27]. However, according to the moderation analysis, our results are consistent with the results of the author of the GAMEX scale, where it was confirmed that the gender of GE respondents did not differ in any dimension [8]. The same analysis also confirmed that negative effects and a sense of dominance were significantly more moderate in students who had previously participated in ERs recreationally. Antón-Solanas et al. [20] also found that students with previous GE in recreational ERs had significantly fewer negative effects but were more dominant. In their study, apart from students with previous experience in recreational ERs, they also included students with previous experience in EERs. A higher level of dominance was also observed among these students but with a lower negative effect. This means that the previous experience in EERs increased the students' sense of security and readiness to study in such educational environments.

Limitations

Despite its strengths, such as implementing EERs in three different models, this study had several limitations. First, to enhance student motivation by allowing them the freedom to choose their participation format, the number of students involved in the online and hybrid EERs during the 2022/23 academic year was uneven. With the population of enrolled students, the sample size within the online students group is not satisfactory. Although we have adapted further analyses to this limitation, it is important to consider this. Additionally, the gender distribution was imbalanced, with a higher number of female students, which reflects the typical composition of nursing programs. Second, although rewards were offered to the top-performing groups, we could not verify whether students shared information with other groups, particularly in the face-to-face EER model. Third, it is unclear whether the increased engagement observed in online EERs was due to the learning environment, the student's desire to find answers quickly using phones and computers, or the limited presence of instructors in the online setting. Lastly, since our study did not collect data on students' exam performance in the subject linked to the EER, the impact of the EER model on students' academic outcomes remains unknown. The question remains whether further follow-up of students in a longitudinal study would give better insight into the effects of this educational strategy.

Conclusion

Educational escape rooms are increasingly utilised in nursing education. This study demonstrated that all three EER models could elicit positive emotions in students, while negative effects remained moderate, aligning with the desired outcomes of GEs for educational games like EERs. Our findings indicate that transforming content from face-to-face to hybrid and online formats did not affect students' ability to absorb content, as absorption levels were consistent across all three models.

Although this study provided valuable insights, its limitations should be acknowledged. Continued investigation is necessary to fully understand the impact and effectiveness of different EER models in nursing education.

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CRediT authorship contribution statement

DS, conceptualization, methodology, investigation, formal analysis, writing original draft; **VD**, conceptualization, investigation, resources, writing review and editing; **NBJ**, formal analysis, writing review and editing, supervision; **BBS**, resources, writing review and editing; **DM**, conceptualization, methodology, formal analysis, writing original draft, supervision.

Data availability statement

The data from this study are available upon reasonable request.

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