ORIGINAL ARTICLE

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Design and Implementation of a Digital Escape Room Game for Teaching Pharmacy Students about Digoxin Toxicity and Its Comparison with Lecture-based Teaching Methods

Background: The aim of this study was to design and implement a web-based escape room game to teach pharmacy students about digoxin poisoning and to compare it with traditional lecture-based education in terms of learning and student interaction.
Method: This study was conducted at Mazandaran University of Medical Sciences in 2023. A virtual escape room game was designed, featuring puzzles such as crossword puzzles, Morse code, scrambled words, and other similar puzzles related to digoxin toxicity. Pharmacy students were divided into two groups: one group played the virtual escape room, and the other one received a typical lecture on the same topic. Pre- and post-tests were administered to both groups to assess knowledge gain. In addition, students in escape rooms completed a perception questionnaire to evaluate their satisfaction, motivation, and perceived value of the game.
Results: The digital escape room students (4.19 ± 1.3) showed a statistically significant ($p<0.05$) increase in knowledge scores compared to the lecture control group (3.68 ± 1.79). The perception survey recorded extremely high engagement and satisfaction scores, with students reporting that the game was an effective and enjoyable way to learn.
Conclusion: The virtual escape room was an innovative and effective pedagogical tool for teaching pharmacy students about digoxin toxicity. This teaching method presents a potential new option for teaching challenging clinical materials at pharmacy schools.
Keywords: Pharmacy education, Digoxin/toxicity, Escape room, Educational games

تصميم وتنفيذ لعبة غرفة الهروب الرقمية لتعليم طلاب الصيدلة حول تسمم الديجوكسين ومقارنتها مع طرق التدريس القائمة على المحاضرات

الخلفية: كان الهدف من هذه الدراسة هو تصميم وتنفيذ لعبة غرفة هروب قائمة على الويب لتعليم طلاب الصيدلة حول تسمم الديجوكسين ومقارنتها مع التعليم التقليدي القائم على المحاضرات من حيث التعلم وتفاعل الطلاب.
الطريقة: أجريت هذه الدراسة في جامعة مازندران للعلوم الطبية في عام ٢٠٢٣. تم تصميم لعبة غرفة هروب افتراضية، تتميز بألغاز مثل الكلمات المتقاطعة، شفرة مورس، الكلمات المبعثرة، وألغاز مماثلة أخرى تتعلق بتسمم الديجوكسين. تم تقسيم طلاب الصيدلة إلى مجموعتين: مجموعة واحدة لعبت غرفة الهروب الافتراضية، والأخرى تلقت محاضرة نموذجية حول نفس الموضوع. تم إجراء اختبارات قبلية وبعدية لكلا المجموعتين لتقييم اكتساب المعرفة. بالإضافة إلى ذلك، أكمل الطلاب في غرف الهروب استبياناً للإدراك لتقييم رضاهم، دوافعهم، والقيمة المدركة للعبة.
النتائج: أظهر طلاب غرفة الهروب الرقمية (٤.١٩ ± ١.٣) زيادة ذات دلالة إحصائية ($p<0.05$) في درجات المعرفة مقارنة بمجموعة المحاضرة الضابطة (٣.٦٨ ± ١.٧٩). سجل استطلاع الإدراك درجات عالية جداً في التفاعل والرضا، مع إفادة الطلاب بأن اللعبة كانت وسيلة فعالة وممتعة للتعلم.
الخلاصة: كانت غرفة الهروب الافتراضية أداة تربوية مبتكرة وفعالة لتعليم طلاب الصيدلة حول تسمم الديجوكسين. تقدم طريقة التدريس هذه خياراً جديداً محتملاً لتدريس المواد السريرية الصعبة في كليات الصيدلة.
الكلمات المفتاحية: تعليم الصيدلة، الديجوكسين/التسمم، غرفة الهروب، الألعاب التعليمية

طراحی و اجرای یک بازی دیجیتال اتاق فرار برای آموزش دانشجویان داروسازی درباره مسمومیت با دیگوکسین و مقایسه آن با روش تدریس مبتنی بر سخنرانی

زمینه و هدف: هدف از این مطالعه طراحی و اجرای یک بازی اتاق فرار مبتنی بر وب برای آموزش دانشجویان داروسازی در زمینه مسمومیت با دیگوکسین و مقایسه آن با آموزش سنتی مبتنی بر سخنرانی از نظر یادگیری و تعامل میان دانشجویان بود.
روش: این مطالعه در سال ۲۰۲۵ در دانشگاه علوم پزشکی مازندران انجام شد. یک بازی اتاق فرار مجازی طراحی شد که شامل معماهای مختلفی مانند جدول کلمات متقاطع، کد مورس، کلمات درهم‌ریخته و سایر موارد مرتبط با سمیت دیگوکسین بود. دانشجویان داروسازی به دو گروه تقسیم شدند: یک گروه در اتاق فرار مجازی شرکت کرد و گروه دیگر آموزش معمول به‌صورت سخنرانی در همان موضوع را دریافت نمود. پیش‌آزمون و پس‌آزمون برای هر دو گروه اجرا شد تا میزان افزایش دانش سنجیده شود. علاوه بر این، دانشجویان گروه اتاق فرار پرسشنامه‌ای را تکمیل کردند تا رضایت، انگیزه و ارزش ادراک‌شده بازی ارزیابی شود.
یافته‌ها: گروهی که در اتاق فرار دیجیتال شرکت کرده بودند، افزایش معنی‌داری ($p<0.05$) در نمرات دانش (۱/۳ ± ۴/۱۹) نسبت به گروه کنترل (سخنرانی) نشان دادند (۱/۷۹ ± ۳/۶۸). نظرسنجی ادراک نیز میزان بسیار بالایی از درگیری، رضایت و انگیزه را ثبت کرد و دانشجویان گزارش دادند که بازی روشی مؤثر و لذت‌بخش برای یادگیری بوده است.
نتیجه گیری: بازی اتاق فرار مجازی یک روش نوآورانه و اثربخش برای آموزش دانشجویان داروسازی در زمینه سمیت دیگوکسین بود. این روش آموزشی می‌تواند به‌عنوان یک گزینه جدید برای آموزش مطالب بالینی دشوار در دانشکده‌های داروسازی مورد استفاده قرار گیرد.
واژه های کلیدی: آموزش داروسازی، مسمومیت با دیگوکسین، اتاق فرار، بازی آموزشی

فارماسی کے طلباء کو ڈیگوکسین ٹوکسیسیٹی (Digoxin Toxicity) کے بارے میں پڑھانے کے لیے ایک ڈیجیٹل ایسکیپ روم گیم کا ڈیزائن اور نفاذ اور لکچر پر مبنی تدریسی طریقوں کے ساتھ اس کا موازنہ

پس منظر: اس مطالعہ کا مقصد فارماسی کے طلباء کو ڈیگوکسین زہر (Digoxin Poisoning) کے بارے میں سکھانے کے لیے ویب پر مبنی ایسکیپ روم گیم کو ڈیزائن اور نافذ کرنا تھا اور سیکھنے اور طلباء کے تعامل کے لحاظ سے روایتی لکچر پر مبنی تعلیم کے ساتھ اس کا موازنہ کرنا تھا۔
طریقہ: یہ مطالعہ ۲۰۲۳ میں مازندران یونیورسٹی آف میڈیکل سائنسز میں کیا گیا۔ ایک ورچوئل ایسکیپ روم گیم ڈیزائن کیا گیا تھا، جس میں کراس ورڈ پزل، مورس کوڈ، سکیمبلڈ الفاظ اور ڈیگوکسین ٹوکسیسیٹی سے متعلق دیگر اسی طرح کے پزل شامل تھے۔ فارماسی کے طلباء کو دو گروپوں میں تقسیم کیا گیا تھا: ایک گروپ نے ورچوئل ایسکیپ روم کھیلا، اور دوسرے گروپ نے اسی موضوع پر ایک عام لکچر حاصل کیا۔ علم کے حصول کا جائزہ لینے کے لیے دونوں گروپوں میں پری اور پوسٹ ٹیسٹ لیے گئے۔ مزید برآں، ایسکیپ رومز میں موجود طلباء نے اپنی اطمینان، حوصلہ افزائی اور گیم کی سمجھی گئی اہمیت کا جائزہ لینے کے لیے ایک پرسیپشن سوالنامہ (Perception Questionnaire) مکمل کیا۔
نتائج: ڈیجیٹل ایسکیپ روم کے طلباء (۴.۱۹ ± ۱.۳) نے لکچر کنٹرول گروپ (۳.۶۸ ± ۱.۷۹) کے مقابلے میں نالج اسکورز میں شماریاتی طور پر نمایاں ($p<0.05$) اضافہ دکھایا۔ پرسیپشن سروے میں شمولیت اور اطمینان کے انتہائی اعلیٰ اسکور ریکارڈ کیے گئے، جس میں طلباء نے یہ بتایا کہ یہ گیم سیکھنے کا ایک موثر اور پرلطف طریقہ تھا۔
نتیجہ: ورچوئل ایسکیپ روم فارماسی کے طلباء کو ڈیگوکسین ٹوکسیسیٹی کے بارے میں پڑھانے کے لیے ایک اختراعی اور موثر تدریسی ٹول تھا۔ یہ تدریسی طریقہ فارماسی اسکولوں میں مشکل کلینیکل مواد پڑھانے کے لیے ایک ممکنہ نیا آپشن پیش کرتا ہے۔
کلیدی الفاظ: فارماسی کی تعلیم، ڈیگوکسین/ٹاکسیسیٹی، ایسکیپ روم، تعلیمی گیمز۔

INTRODUCTION

Rapid technological advancements and constant changes across various fields make the need for innovative educational methods increasingly evident. This is particularly true in specialized fields like medical sciences, where a deep and practical understanding of complex scientific concepts is crucial. Traditional teaching methods may no longer be sufficient. Teaching and education in medical universities hold special significance, as these institutions are responsible for training healthcare professionals who directly interact with the public health sector (1, 2). The quality of education in this area affects students' knowledge and skills and can lead to improved healthcare services.

Given the rapid pace of scientific and technological progress, the educational systems at these universities must be continually updated to meetthe society's current needs. One factor that can improve the quality of education in medical universities and better prepare students for the job market and professional challenges is the use of innovative teaching methods (1, 3, 4). These methods can increase student motivation and engagement. Active learning strategies, such as case-based learning (CBL) and team-based learning (TBL), play a significant role in transforming learners from passive spectators into active participants in the educational process. Creating interactive and collaborative environments allows students to engage in learning and take responsibility for their learning directly (1, 5).

Many universities worldwide strive to find educational methods that enhance students' decision-making abilities and promote continuous, sustainable, and student-centered learning. There has always been a gap between theoretical and practical training in pharmacy, with students often unable to quickly and properly apply theoretical knowledge in practice. One way to bridge the gap between education and clinical application is to shift from traditional education systems to active, student-participation-based learning. By using diverse methods such as educational games, we can encourage greater student engagement and improve learning outcomes (6, 7).

Among innovative teaching methods, Educational Escape Rooms have emerged as an engaging tool for transforming students from passive observers into active participants (8). In this approach, learners engage in game-based activities designed for knowledge acquisition or skill development. They solve puzzles related to educational goals within a limited time frame, such as escaping a physical room or unlocking a box. Several studies have utilized escape room games in pharmacy education, including teaching diabetes management to third-year pharmacy students, assessing pharmacy students' readiness for comprehensive practical exams, and evaluating students' knowledge of medicinal chemistry, pharmacology, and clinical heart failure (9).

However, this method has some limitations, such as the need for ample space to play or to modify the traditional game format in educational contexts. To address these challenges, educational escape rooms are now being adapted to analog or digital formats, creating hybrid learning environments. Recently, mainly due to the global COVID-19 pandemic, fully digital escape room games have been designed, allowing learners to participate from home (10, 11).

The "Poisoning Control" course introduces pharmacy students to concepts such as poisoning, types of antidotes, toxidromes, adverse effects of drug and chemical exposure, and the diagnosis and treatment of poisonings. These topics are crucial for students to understand the mechanisms of toxicity and how to diagnose and treat toxic effects. Lecture-based teaching in this course often results in the one-way transfer of a large amount of information, leading to rapid forgetting, low student participation, passive attendance, fatigue, and superficial learning (11, 12).

Digoxin toxicity was chosen as the educational focus of this study because of its clinical importance and high-risk nature. Digoxin remains a vital medication with a narrow therapeutic window, making misuse or overdose a common cause of poisoning incidents. The condition requires knowledge of pharmacology, toxicology, and clinical decision-making, offering a multidisciplinary learning experience. Additionally, its clearly defined clinical signs and management strategies make it suitable for a puzzle-based approach, making digoxin toxicity an ideal and effective subject for a digital escape room. Notably, although escape rooms have been used in pharmacy education for topics like diabetes management and medicinal chemistry, their application in toxicology has been limited. This study, therefore, fills an educational gap by focusing on digoxin poisoning.

This study aims to apply the escape room-based teaching method to enhance learning and satisfaction among general pharmacy students in the "Poisoning Control" course at Mazandaran University of Medical Sciences. Given the positive impact of game-based learning on students' education, this study seeks to explore the potential of this method to enhance learning quality, retention, motivation, and class engagement. If escape-room-based learning proves more effective than traditional lecture-based methods, it could be adopted as a key strategy in pharmacy students' educational programs.

Given the limited research on the use of innovative educational methods to teach toxicology topics to

pharmacy students, this study aims to assess the impact of digital escape-room-based learning on pharmacy students' academic performance in the "Poisoning Control" course at Mazandaran University of Medical Sciences.

METHODS

A This study consists of two phases. In the first phase, a digital educational escape room game was designed. In the second phase, the designed game was implemented in a learning environment to evaluate its effectiveness on pharmacy students' learning performance in the "Poisoning Control" course, focusing on the treatment of drug poisoning. The first phase of the study is considered a production-based research phase. In contrast, based on its application and implementation methods, the second phase falls under the category of semi-experimental studies, with a pre-test and post-test design and a control group. This part of the study assesses the impact of digital escape room-based learning on the performance of pharmacy students in the "Poisoning Control" course at Mazandaran University of Medical Sciences during the second semester of the 2023 academic year.

In the first phase, the design and development of the digital educational escape room game began with an extensive literature review on educational escape rooms from reputable national and international sources. To determine educational priorities and design the scenarios, puzzles, and content of the digital escape room, input was sought from toxicology and pharmacology faculty members and experts from the Toxicology Department at Razi Hospital. The educational content and scenarios were then developed, culminating in the creation of the digital escape room game focused on digoxin poisoning. Various puzzles, such as crossword puzzles, Morse code, scrambled words, and some other similar materials, enhanced engagement and learning. The game was designed in five stages as follows:

Stage 1: Students used their prior knowledge to answer questions about general poisoning principles in a crossword puzzle, which led to a code representing the drug's name.

Stage 2: Students watched an educational video on the mechanism of digoxin poisoning and answered related questions. Correct answers allowed them to progress, and they eventually solved a puzzle about the symptoms of digoxin poisoning, leading to a code representing the most critical cardiac side effect of digoxin.

Stage 3: Based on the video from the previous stage, students solved a series of riddles. Correct answers revealed the toxic dose of the drug, which they needed to remember. Solving all the puzzles correctly led them to the code representing the digoxin concentration in the patient's blood.

Stage 4: This stage focused on treating poisoning. Students were given scrambled letters that, when arranged correctly, revealed the therapy for each poisoning symptom. Correct answers provided a Morse code, which led to the antidote for digoxin poisoning, when coded.

Stage 5: Students solved a series of riddles with the help of hints provided, learning about the indications and administration of the antidote.

After the game design was completed, the second phase of the study began. Participants were assigned to the experimental (escape room) or control (lecture) groups based on their student identification numbers: even numbers were allocated to the experimental group and odd numbers to the control group. Then, a pre-test was administered to both the experimental and control groups. The experimental group was taught using the digital escape room, while the control group received lecture-based instruction. Immediately after the educational intervention, a post-test was conducted for both groups. To implement the digital escape room game, students were divided into three groups, each seated at a computer in separate spaces in the pharmacy faculty's library and computer lab. Each group followed the game's scenarios, solving puzzles and answering questions related to the diagnosis and treatment of drug poisoning. Correct answers allowed them to progress to the next stage. Verbal instructions were provided to participants before the game started.

The study population comprised all pharmacy students at Mazandaran University of Medical Sciences. Inclusion criteria were all students who had completed Pharmacology 1 and 2 and Toxicology courses, knew about drugs and poisoning principles, but had not yet taken the "Poisoning Control" course, which they were enrolled in for the current semester. Exclusion criteria included absence from the educational process due to illness or other reasons, unwillingness to continue participation, withdrawal from the course, or having previously taken the "Poisoning Control" course without passing it.

An exam was administered to evaluate the effectiveness of the digital escape room game on students' learning performance. The exam presented a poisoning case including several stages, each with multiple-choice questions. At each stage, students were required to diagnose the cause and severity of the poisoning and, later, to make decisions about treatment and resistant cases, assessing their knowledge and performance. Five faculty members from Mazandaran University of Medical Sciences, who were experts in poisoning treatment, reviewed the content validity of the exam questions.

The researchers created the knowledge test based on the learning objectives of the 'Poisoning Control' course. To ensure content validity, five faculty experts in toxicology and pharmacology

reviewed and approved the items. The perception questionnaire was designed to assess students' satisfaction, motivation, and perceived value of the game, with items adapted from themes used in previous educational escape room studies. The content validity of the questionnaire was evaluated by three experts in pharmacy and medical education. Internal consistency reliability was tested, with a Cronbach's alpha of 0.82, indicating a strong reliability estimate.

A researcher-made questionnaire containing demographic information and satisfaction-related questions was used to assess students' satisfaction with digital escape-room-based learning.

Statistical Analysis :

Data were analyzed using GraphPad Prism (version 8). Descriptive statistics (mean, standard deviation, and frequency) were used to summarize demographic characteristics and questionnaire responses. Paired t-tests were applied to compare pre- and post-test scores within groups, and independent t-tests were used to compare differences between groups. Statistical significance was set at $p < 0.05$.

RESULTS

In this study, 47 students were initially evaluated. Due to the absence, two students were excluded, leaving 45 participants. Of these, 23 were in the escape-room-based learning group and 22 in the lecture-based control group. The demographic data (age, gender, and academic semester) of the two groups showed no significant differences ($P < 0.05$), indicating homogeneity between the groups (Table 1).

The evaluation results showed that most students were delighted with participating in the digital escape room game and considered it a practical, innovative teaching method (Table 2). They expressed a desire for this method to continue in the faculty. Most students found the escape room experience educational and beneficial (Figure 1).

The satisfaction rates were as follows:

- Overall satisfaction with the escape room: 88%
- Satisfaction with the storyline and its appeal: 88%
- Perceived educational value of the escape room: 90%
- Satisfaction with the location where the game was held: 76%
- Satisfaction with the duration of the game: 84%
- Willingness to participate in future escape room games: 84%
- Overall student satisfaction with the game: 89%

Additionally, 89% of the participants believed that periodic escape room sessions could provide valuable learning opportunities for students.

Out of the 45 students who participated in the study, 40 (89%) completed pre- and post-class evaluations (Table 3). The average pre-test scores were 3.68 ± 1.79 for the lecture-based teaching group and 4.19 ± 1.3 for the escape room-based group, with no statistically significant difference between the two groups ($p < 0.05$).

Both teaching methods showed significant improvement in post-test scores compared to pre-test scores, indicating that both effectively increased students' knowledge levels. However, a comparison of the post-test scores revealed that the escape room group (7.3 ± 1.59) scored higher than the lecture group (5.36 ± 2.3), and this difference was statistically significant ($p < 0.05$) (Table 3).

DISCUSSION

Digital escape rooms, as an innovative educational method in the pharmacy field, particularly in teaching drug poisoning, serve as an effective tool for enhancing active learning. Utilizing these games in drug and toxin poisoning education provides opportunities for deep learning by enabling students

Table 1. The demographic characteristics of students in two groups: game-based learning through escape rooms and lecture-based learning

Demographic variable		Game method		Lecture method		Significance level
		Mean (SD)	Frequency (Percentage)	Mean (SD)	Frequency (Percentage)	
Age (Years)		22.45 (1.1)	-	22 (0.78)	-	P > 0.05
Gender	Boy	-	14 (62.5)	-	12 (54.5)	P > 0.05
	Girl	-	9 (37.5)	-	10 (45.5)	
Academic term	9	-	20 (87.5)	-	21 (95.5)	P > 0.05
	10	-	3 (12.5)	-	1 (4.5)	

Values are expressed as mean (SD) (age) or frequency (percentage) (gender and academic term). Comparisons between groups were performed using independent t-test for age and chi-square test for categorical variables. No statistically significant differences were found ($p > 0.05$ for all comparisons)

Table 2. Digoxin poisoning escape room perception scale

		Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
1	Organization of the escape room	56.5	30.4	13.0	0	0
2	Engaging scenario	56.5	34.7	8.7	0	0
3	Acquisition of new knowledge	60.8	30.4	8.7	0	0
4	Suitability of the venue	26.1	39.1	30.4	0	4.3
5	Adequacy of the duration	47.8	34.8	8.7	8.7	0
6	Willingness to participate again	56.5	21.7	13.0	4.3	4.3
7	Overall enjoyment of the escape room experience	69.5	13	13	4.3	0
8	Opportunity for learning	60.8	26.1	13	0	0

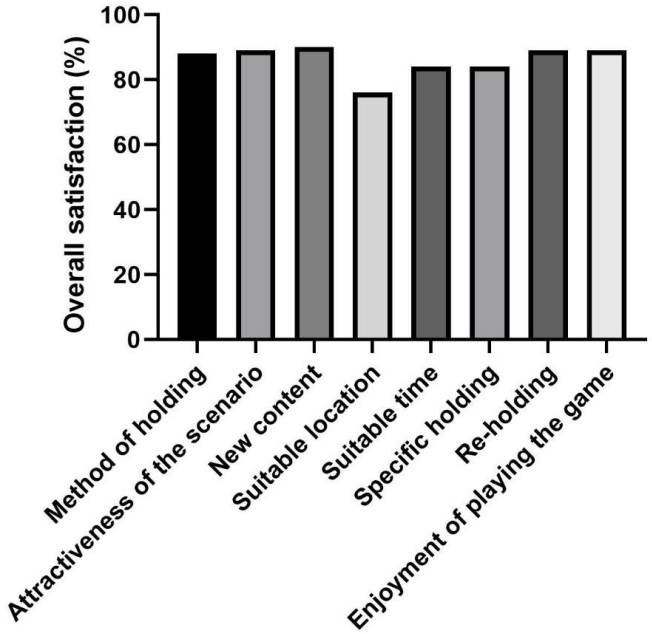

Figure 1. Overall satisfaction percentage of pharmacy students regarding implementing the digital escape room game

to improve their critical thinking skills and clinical data analysis in a simulated environment. In this approach, students face a series of challenges and problems related to a poisoning scenario interactively and practically. This allows them to gain a more profound understanding of drug toxicity mechanisms, the identification of poisoning symptoms, and appropriate management strategies.

Recent studies indicate that active learning methods, such as digital escape rooms, are significantly more effective than passive learning methods (such as traditional lectures) in improving student knowledge. Using digital and simulated teaching methods represents a powerful approach that can strengthen learning, increase engagement, and create more enjoyable learning experiences. These methods provide students with the necessary skills and place them in an interactive, challenging environment, which can lead to deeper, more lasting knowledge retention. Particularly in topics like digoxin poisoning carrying significant clinical

Table 3. The test scores, along with the mean and standard deviation for the game-based learning through escape rooms and lecture-based learning groups

Group	Test Scores		Paired T-Test
	Before Intervention	After Intervention	
	Mean (SD)	Mean (SD)	
Game-Based Learning (Digital Escape Room)	4.19 (1.3)	7.3 (1.59)	t = 6.36
			p < 0.0001
Lecture Method	3.68 (1.79)	5.36 (2.38)	t = 2.33
			p < 0.0314
Independent T-Test	t = 1.009	t = 3.092	
	p = 3.19	p = 0.0037	

Values are expressed as mean (SD). Within-group comparisons (before and after intervention) were conducted using paired t-test, while between-group comparisons were analyzed using independent t-test.

risks this type of learning moves students from theoretical knowledge to its practical application.

A study by Eukel et al. (2017) evaluated the impact of an escape room game on third-year pharmacy students' knowledge regarding diabetes management. Pre- and post-tests were used to assess the educational game's effect, and students completed puzzles related to diabetes treatment. The results showed a statistically significant increase in students' knowledge following the game completion (4). Similarly, in our study, improvements in students' knowledge were observed in both the lecture and escape room groups. Still, the post-test scores in the escape room group were significantly higher than those in the lecture group, demonstrating the escape room method's superior effectiveness compared to the traditional lectures.

However, in another study by Clauson et al. (2019) that examined pharmacy students' readiness for a comprehensive practical exam using an escape room system, the average post-test scores were three points lower than the pre-test scores. Despite this, 95% of the students reported that their clinical skills had improved and that their learning had accelerated (13).

Additionally, in a study conducted by Kinio et al. (2019), a vascular surgery escape room was designed, where 76% of the participants reported enjoying the game, and 53% agreed that escape rooms should be utilized in education (14).

Another study by Plakogiannis et al. (2020) evaluated the effectiveness of an escape room in teaching pharmaceutical chemistry, pharmacology, and clinical heart failure to second-year pharmacy students. The results demonstrated a positive impact of the method, showing increased learning and student interest immediately after completing the game (3). In our study, student satisfaction surveys revealed that most students enjoyed the escape room game, found it effective in enhancing their learning, and expressed a desire to continue using it in educational settings.

A systematic review has shown that most escape room studies target higher education institutions. Most escape rooms focus on health and safety topics, particularly in nursing and medicine. Moreover, the games are typically conducted in groups, with the average number of participants per team ranging between 2 and 14 individuals (11).

Thus, one key feature of digital escape rooms is their ability to foster interactive, collaborative learning experiences among students. In this method, students work in small groups and collaborate to solve problems, which enhances teamwork skills, encourages creativity, and improves interpersonal communication. In contrast to traditional methods focusing on individual learning and assessment through written exams, digital escape rooms emphasize collaboration, and team-based or problem-solving learning.

This study has several limitations. First, the quasi-experimental design with group assignment based on student identification numbers rather than full randomization may limit causal inference. Second, the relatively small sample size and single-institution setting restrict the generalizability of the findings to other student populations or universities. Third, although the knowledge test was reviewed by experts for content validity, its reliability (e.g., test–retest or internal consistency) was not fully assessed due to the limited sample size. Fourth, while the perception questionnaire showed acceptable internal consistency (Cronbach's alpha = 0.82), further psychometric validation with larger, more diverse groups is needed. Fifth, the intervention only covered one toxicology topic, digoxin toxicity, which limits the scope of applicability. Finally, the study measured short-term knowledge gains but did not evaluate long-term retention or how well the knowledge transfers into clinical practice. Future research with larger,

multi-center cohorts, broader toxicology topics, and long-term follow-up is recommended.

CONCLUSION

This study showed that a digital escape room game is an innovative and effective teaching method for pharmacy students learning about digoxin toxicity. Compared to traditional lecture-based methods, the escape room significantly boosted knowledge scores and resulted in high levels of student engagement and satisfaction. These results indicate that digital escape rooms can be a useful addition to traditional teaching in pharmacy education, especially for complex clinical topics. Future research should explore applying this method to other areas of toxicology and pharmacy education, include larger and more diverse student groups, and assess its long-term effects on learning outcomes and clinical decision-making skills.

Ethical Considerations:
Ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc., have been completely observed by the authors. This study was approved by the ethics committee of Mazandaran University of Medical Sciences, Sari, Iran, ethical code : IR.MAZUMS.REC.1403.488.

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