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Creation and evaluation of an educational escape room in paediatric dentistry

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Abstract

Background Several studies have suggested the benefits of pedagogical escape games for dental students but most have involved a limited number of participants and none was conducted in paediatric dentistry. This study aims to explore dental students' perceptions of the role of an escape room as an innovative pedagogical tool for enhancing motivation and consolidating learning in paediatric dentistry.

Methods This study was conducted in April 2023 with all fifth-year dental students (*n* = 183), who were divided into 5–6 student groups to simulate the conditions of an escape room. Prior to entering the room, each student completed a 16-question true/false knowledge test to assess their general knowledge. Upon exiting the escape room, participants completed a 14-question appreciation survey. A descriptive analysis of the responses was performed, with results presented as percentages or means (and standard deviations) when appropriate, using R (version 3.6.1; R Foundation for Statistical Computing, Vienna, Austria).

Results The 177 students reported being motivated to review their coursework in preparation for the escape game (4.3 \pm 1) and truly enjoyed the experience (4.8 \pm 0.4]). Immersive learning was found to be helpful (4.3 \pm 0.8]), and the escape game was rated as effective in consolidating paediatric dentistry knowledge (4.6 \pm 0.6]).

Conclusions This study highlights the potential of educational escape games as an innovative and effective pedagogical tool in paediatric dentistry, serving as a valuable supplementary strategy to diversify instruction and enhance active learning in dental education.

Keywords Paediatric dentistry, Education, Dental, Gamification, Teaching, Students, Dental

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Background

Motivation is one of the strongest predictors of academic success [1]. The more interested students are in activities, the more they persevere and engage [2]. Lecturing is the most common method of teaching in postsecondary education [3], but relying on a single strategy can produce a saturation effect among learners [4]. Diversifying pedagogical strategies enhances success in higher education [5]. Besides, students in lecture-based classes are 1.5 times more likely to fail than students in active learning environments are [6]. Active teaching focuses on learner-centred approaches that promote participation. Gamification, which incorporates game elements into nongame contexts, is popular among undergraduate and postgraduate students and serves as an excellent training and evaluation tool [7–10]. Games allow for errors and retries [11, 12] and help students test themselves and obtain individual feedback [13]. Additionally, team-based learning fosters critical thinking skills [14]. Most studies on active learning in higher education were conducted in the context of medical school [15].

An escape game involves solving puzzles to escape a critical situation or an enclosed space, whether real or virtual, within a limited time. A game master monitors progress and provides hints when needed, allowing for a multidisciplinary approach through various puzzles. Dentistry, as a medical and surgical specialty, requires considerable equipment manipulation, manual training and diagnostic procedures. It lends itself well to the use of escape games as a learning tool. Although the current educational games for dental students are often limited to quizzes or board games [16-18], the benefits of pedagogical escape games for dental students have been suggested by several studies [19–22]. However, most of those studies included a limited number of participants [23, 24], except one recent large-sample study which was not in paediatric dentistry [20].

The null hypothesis is that the integration of an escape game into the paediatric dentistry curriculum dental students will not be perceived by dental students as a relevant tool to enhance their learning motivation or consolidation.

The aim of this study was to explore dental students' perceptions of the value of an escape game as an innovative pedagogical tool for consolidating learning and enhancing motivation in paediatric dentistry.

Methods

Population

The population for this study consisted of fifth-year dental students enrolled in the Faculty of Dental Surgery at Paris City University during the 2023–2024 academic year (n = 183). A convenience sampling approach was employed. The entire cohort of fifth-year dental students (n = 183) was initially considered for participation, and the final sample included those who voluntarily agreed to participate in the study. Students were informed about the study's objectives and procedures. All students included in the study had similar levels of theoretical knowledge, as paediatric dentistry is consistently taught in the fourth and fifth years of the curriculum (with an optional in-depth study available in the sixth year). This homogeneity minimizes variability related to prior knowledge among participants.

Ethics approval and consent to participate

This study adheres to the principles outlined in the Declaration of Helsinki. As no information related to the health of the respondents was collected, this study did not require ethical approval according to French legislation (Articles L1121-1 to L1121-3 of the French Public Health Code). However, the respondents were informed of ethical considerations, including voluntary participation, anonymity, and data usage. These considerations were approved by the CNIL (National Commission on Informatics and Liberty) (No. 2236471).

The population for this study consisted of fifth-year dental students enrolled in the Faculty of Dental Surgery at Paris City University during the 2023–2024 academic year (n = 183). Participation in the escape game was mandatory, as it was a formal component of their university curriculum. However, participation in the accompanying study - designed to evaluate the game - was entirely voluntary. Students were invited to complete two questionnaires: one before and one after the activity. Only those who provided informed consent were included in the study. Students were explicitly informed beforehand that students were assured that their participation in the study was independent of their academic performance or assessments.

In the preparation room, the student volunteers completed the consent form to take part in the study. Informed consent was obtained from all participants before the study commenced. Participants were informed of their right to withdraw from the study at any time without penalty. The questionnaires were pseudoanonymous ensuring that participants could retract their responses if necessary: the data analyst cannot identify individuals, but students can be traced if necessary, using their initials and class number. They were assured that their identity would remain confidential and that the results would be anonymous.

Conception and test phase *Calendar*

The creation and implementation of the game lasted seven months, from the beginning of September 2023 to the end of March 2024. The material orders were placed in mid-February, and the β tests were carried out in mid-March. All the teachers of the discipline took part in the first test, and five sixth-year volunteer students took part in the second test. All fifth-year students took part in the escape game between April 2 and 5, 2024.

Team

The team consisted of three sixth-year students, two post-graduates, one teaching assistant and two permanent teachers. Two team members had already participated in the design of a pedagogic escape game. The inclusion of final-year students and recent graduates in the team encouraged exchange [25, 26]. The escape game was created and set up in 50 h.

Pedagogical objectives

The pedagogical objectives were defined by senior teachers. The tests focused on basic and fundamental concepts.

Theme

The chosen theme was the funfair. The puzzles were designed to withstand handling, be easily set up, be storable between teams and dismountable, have clear instructions, be accessible by six participants at the same time, and be amenable to modification over time (as the aim is for the puzzle to last several years).

Escape room

Game progress

The sessions took place over four days and included all 183 fifth-year students. Each session accommodated 22 to 28 students per half-day, who were divided into groups of four to six students. Thus, there were five sessions per half-day.

Each session proceeded as follows:

- reception in a first room adjacent to the escape room (10 min).
- **participation** in the immersive escape room game(40 min).
- debriefing in a second adjacent room (to prevent overlap between students from different sessions).

The next session's students were welcomed into the first room as the current session was concluding. The debriefing for the current session took place in the second adjacent room as the new session began.

Game objectives and steps

The objective was to complete the escape game as quickly as possible with minimal errors.

In the preparation room, students received additional information about the study and had the opportunity to complete and sign the consent form. Then, they answered a preescape game questionnaire containing 16 true/false questions (Table 1). Finally, a brief video described the scenario and main instructions, which were as follows: "the students were tasked with supervising their teachers' children, who had gone missing, and were given 40 minutes to find them".

In the escape room, all stages were numbered and needed to be resolved in order. Three supervisors were present: One acting like a game master, guiding the team and providing clues as necessary; the other 2 alternatively, received new groups in the first room, cleaned up the main room and debriefed the groups after the escape game. Throughout the week, the same teacher acted as a game master and completed a standardized evaluation grid for each team (Fig. 2). During the debriefing, teachers and students reviewed the key points of each stage



Fig. 1 Transformation of the room before and after setting up the escape game. Figure 1a shows the room as it is for teaching purposes, and Fig. 1b shows it transformed for the escape game

Table 1 Escape game perception scale results (N = 177)

Questionnaire	Mean (SD)	Strong- ly dis- agree (%)	Dis- agree (%)	Neu- tral (%)	Agree (%)	Strong- ly agree (%)	An- swers (No answer)
The idea of participating in an escape game has motivated me to revise my courses/could motivate me to attend meeting and train myself.	4.3±1	6	5	11	60	94	176 (1)
I find it useful to combine several learning methods to assimilate knowledge (lectures, e-learning, tutorials, serious game).	4.8±0.5	0	1	2	36	138	177 (0)
Team deliberation has helped me acquire new knowledge.	4.4 ± 0.7	1	1	19	63	93	177 (0)
Learning seemed easier in the immersive context.	4.3 ± 0.8	0	6	20	62	89	177 (0)
I found the escape game relevant in consolidating and reviewing my knowledge of paediatric dentistry.	4.6±0.6	0	2	8	46	120	176 (1)
I found it easier to apply the concepts covered in a clinical activity after this escape game.	4.3±0.8	0	5	22	70	80	177 (0)
My experience could motivate me to organize a serious game, even on another subject, to teach or learn an idea.	4.2±0.8	1	4	32	67	73	177 (0)
I was motivated by the fact that I was competing with other groups.	4.0 ± 1.1	6	14	35	49	73	177 (0)
The size of the group enabled me to participate actively and express myself.	4.2±0.9	0	14	17	68	78	177 (0)
I found that the level of difficulty of the stations was in line with the training objective.	4.5 ± 0.6	0	1	10	58	108	177 (0)
I felt immersed in the proposed themes.	4.7 ± 0.5	0	0	5	42	130	177 (0)
I'd like to take part in another escape game on another learning topic.	4.7 ± 0.5	0	0	6	44	127	177 (0)
The duration of the escape game seemed appropriate for learning without get- ting bored.	4.7 ± 0.6	1	0	4	44	128	177 (0)

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and then discussed any errors reported in the evaluation grid before answering questions.

In the main hall, the session went as follows:

Overall, I'm satisfied with the experience.

Stage 1- Cognitive-behavioural care and anaesthesia (Fig. 3): Choose positive terms, select anaesthesia technique sequences, identify injection points, and practice slowly administering the anesthesia.

Stage 2- Global questions (Fig. 4): Answer questions using stuffed animals, catching ducks in a pool, and gathering letters to unlock a cryptex.

Stage 3–Traumatology (Fig. 5): Using tarot-style cards, answer questions about the short-, medium-, and longterm care of a child.

Stage 4- Prescriptions (Fig. 6): Analyse a backpack's contents, including an X-ray and health records, to determine the correct medication, correct dosages, and correct galenic forms and to verify the tooth needing extraction.

Stage 5- Sugars and food (Fig. 7): Identify the least cariogenic foods in colour-coded boxes.

Data collection tools and outcome measures

The first outcome was student satisfaction and learning experience which were evaluated with a researcherdeveloped questionnaire specifically designed for this study consisting of 14 items adapted from the literature (Table 1) [20]. The questionnaire was divided into four aspects: motivation (questions 1, 7 and 8), learning experience (questions 2, 3, 4, 5 and 6), quality of experience (questions 9, 10, 11, 12 and 13) and global satisfaction (question 14). Each question included five response options: strongly disagree, disagree, neutral, agree, and strongly agree (questions and results are shown in Table 1). This post-escape game questionnaire was completed after the session.

3

23

151

177 (0)

0

The second outcome was to assess students' knowledge of key aspects of paediatric dentistry. This was evaluated:

- with a researcher-developed questionnaire consisting of 16 true/false questions, also developed for this study and adapted from the literature (questions and results are shown in Table 2) [20]. This preescape game questionnaire was completed in the preparation room.
- with a score reflecting time required to complete the escape game and number of errors made. The objective was to complete the escape game as quickly as possible and with minimal errors. Success is defined as a total time of less than 35 min, calculated by adding the completion time to one minute for each correction needed. To ensure that all students benefited from the same learning experience, they were not allowed to progress after making a mistake. The game master indicated the location of the error without providing the answer, except after three repeated mistakes, at which point the correct answer and explanations were given. The team with the best time won a prize.

Date, time, class number :

Index sheet

The index sheet allows us to assess students. There are two types of indices:

- Environment-related indices: Provide these liberally whenever necessary.
- Knowledge-related indices: Provide these in case of error.

Station 1

Theme	Mark one cross for each error	Total
Students did not select the correct words (on the first try)		
Students did not select the correct anesthesia sequence (on the		
first try)		
Students did not scratch the correct injection site (on the first try)		
Students did not understand the principle of controlled injection		
(even after multiple attempts)		
Other (to be noted) <u>:</u>		

Station 2

Theme	Mark one cross for each error	Total
Nolla Stage		
MIH Tooth		
Inferior Alveolar Nerve Block		
Long question on ICDAS 4 carious lesion		
Long question on temporization or extraction of tooth 6		
On-demand breastfeeding and high caries risk (RCI)		
Other (to be noted) <u>:</u>		

Station 3

Mark one cross for each error	Total

Other (to be noted) :

Station 4

Theme	Mark one cross for each error	Total
Choice of drugs		
Choice of dosages		
Choice of pharmaceutical forms		
Choice of the correct tooth for extraction		
Other (to be noted) :		

Station 5

Mark one cross for each error	Total

Other (to be noted) :

Total Duration (min) :

Score = Total Duration + Total Errors =

Fig. 2 Standardized evaluation grid



Fig. 3 This figure shows stage 1 of the escape game, which deals with anesthesia



Fig. 4 This figure shows stage 2 of the escape game, which includes a number of general questions on patient management in pediatric dentistry. Figure 4a shows fluffy toys with different response options, while Fig. 4b is a duck fishery with different response options



Fig. 5 This figure shows stage 3 of the escape game, which deals with dental traumatology



Fig. 6 This figure shows stage 4 of the escape game, which deals with drugs prescription. Figure 6a shows the stage upon the arrival of the teams, while Fig. 6b shows it after the teams have played



Fig. 7 This figure shows stage 5 of the escape game, which deals with nutrition

To ensure the reliability of the two researcher-developed questionnaires, a panel of six experts in dentistry and/or statistics independently assessed each item for relevance and clarity. This expert review process ensures that the questions would be consistently interpreted and understood by participants. Additionally, the pre- and postescape game questionnaires were administered under consistent conditions across all sessions, which further supports the reliability of the data collected. The validity of the questionnaires was addressed in two key ways:

 content validity: items in both questionnaires were carefully adapted from the literature and reviewed by the panel of experts to ensure their relevant to

Table 2 True/False test results (n = 180)

Questionnaire	Test
	correct
	answers
	(%)
I. Nolla classification concerns primary and permanent teeth.	87.8
2. Teeth generally begins eruption at Nolla stage 5.	83.9
3. Apexogenesis ends approximately 5 years after tooth eruption.	93.9
4. The first teeth to erupt are usually the maxillary molars.	73.3
5. Aesthetic treatment of demineralization stains on permanent incisors is not recommended before the end of apexogenesis.	68.9
6. MIH* has a well-defined aetiology and is best treated dur- ing pregnancy.	97.2
7. MIH is progressive: if left untreated, superficial MIH will spread and become severe.	66.7
8. HSPM** is hypomineralization of the first primary molars, often affecting the primary canines as well and foreshadow- ing MIH.	54.4
9. Before the eruption of the permanent molars, the bone cortex is loose, so para-apical anaesthesia is usually sufficient, as the anaesthetic diffuses easily.	87.2
10. Nitrous oxide/oxygen mixture has a longer half-life than hydroxyzine or diazepam	93.3
11. Avulsed teeth must always be reimplanted, whether as a permanent or primary teeth	99.4
12. It is forbidden to use an electric toothbrush before the age of 6.	96.1
13. Breastfeeding should be stopped as soon as the first tooth appears.	85
14. When MIH is severe, the tooth can be considered to exhibit chronic pulpitis.	70.6
15. Prolonged finger sucking maintains lingual malposition, at rest and during functions.	97.2
16. My patient has experienced a shock to the chin; on panoramic examination, I'm looking specifically for a fracture of the mandibular angle.	71.7
*MIH: Molar Incisor Hypomineralization	

**HSPM: Hypomineralized Second Primary Molars

the study's objectives, including measuring student motivation, learning experience, and knowledge of key aspects of paediatric dentistry.

 construct validity: the pre-escape game questionnaire assessed the students' baseline knowledge, while the post-escape game questionnaire evaluated their satisfaction and learning experience, confirming that both questionnaires were valid tools for measuring the intended constructs.

Data availability

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

Statistical analysis

A descriptive analysis of the responses to the test and the appreciation survey was performed. The results were expressed as percentages or means (and standard deviations) when appropriate. The statistics of the results were based on all the students who completed the escape game and consented to participate in the study. Data analysis was conducted using R (version 3.6.1; R Foundation for Statistical Computing, Vienna, Austria).

Results

Student satisfaction

Three students did not complete the satisfaction survey, leaving 177 respondents. The validity rate was 96,7%. Overall, the satisfaction score was 4.8 $[\pm 0.4]$, The students found the session well designed, with an appropriate level of difficulty (4.5 ± 0.6) and duration (4.7 ± 0.6) . The group size was considered suitable at 4.2 $[\pm 0.9]$. Immersion in the escape room theme was well rated, with a score of 4.7 $[\pm 0.5]$. The students were motivated to review the course material (4.3 $[\pm 1]$), with competition increasing motivation (4 $[\pm 1.1]$). They appreciated the combination of teaching methods (4.8 ± 0.5) and expressed a desire to participate in another escape room (4.7 ± 0.5)). The game was effective in consolidating paediatric dentistry knowledge (4.6 [±0.6]) and had a positive clinical impact (4.3 [±0.8]). Immersive learning was also helpful (4.3 $[\pm 0.8]$). Thus, the null hypothesis was rejected. The results are shown in Table 1.

Assessment of the initial knowledge level

Three students did not attend the practical session, but all the present students agreed to participate, resulting in 180 students being included in the study. The validity rate was 98,4%. The lower the total score was, the better the performance was, with an average completion time of 38.5 min (\pm 9.4). The best group finished in 23.6 min, while the worst group took 62.3 min. Half of the groups finished the game in 31.6 to 43.8 min, with 35% (*n* = 15 groups out of 38) succeeding overall (less than 35 min). The debriefing lasted from 20 to 50 min, depending on the group.

The average percentage of correct answers on the test was 82.5%. Only 1.7% (n=3) of the students answered all the questions correctly, while 72.2% (n=130) scored 80% or higher. The least correctly answered question was related to the diagnostic criteria of HSPM (54.4%), whereas the most correctly answered question was about the emergency management of avulsed teeth, with 99.4% correct answers. The results are shown in Table 2.

Discussion

To our knowledge, this is the first escape game designed specifically for paediatric dentistry. Students positively assessed the game's design and implementation, with the majority expressing enthusiasm for participating in future escape games, in consistence with previous studies [22, 27-30].

In recent years, escape games have gained popularity in medical and dental curricula to foster teamwork [31]. Despite proven benefits in terms of learner satisfaction [22, 27], serious games remain underutilized [7, 9, 21, 32–34], as highlighted in a recent systematic review [22]. Previous studies [20, 23, 24, 35] have shown the effectiveness of these games for dental students. Most samples were small (n = 18, n = 24, n = 56), except for one (n = 212). None focused on paediatric dentistry. Other studies highlighted the negative impact of student stress during formal conventional simulations and revealed that learners who participated in escape games experienced lower levels of anxiety than did those who engaged in conventional simulations [28-30]. This finding reinforces the importance of alternative methods in reducing anxiety and promoting a more supportive learning atmosphere. Yet, paediatric dentistry is often regarded by students as one of the most stressful and challenging disciplines to practice [36].

This study assessed the value of escape games in this field with a substantial student cohort. The results indicated that fifth-year dental students at Paris-Cité University positively evaluated the game's design and execution. Students' overall satisfaction reached a score of 4.8 $[\pm 0.4]$, with participants expressing a desire to engage in future escape room activities (4.7 [±0.5]). El Tantawi et al. [37] reported that gamification significantly enhanced dental students' academic writing scores, although their satisfaction levels were modest, possibly due to the mandatory nature of their participation in those activities. In the present study, as in Caussin et al. [20], while participation in the escape game was mandatory, students reported high satisfaction levels. Unlike Caussin et al. [20], the present escape game incorporates a cross-disciplinary assessment within the subject area, which requires a longer development process. Decision was made to penalize mistakes, a feature that was not included in their design. A recent qualitative study identified the key elements of effective games from medical students' perspectives, which included integration with instructional objectives, game rules, and rapid feedback [38]. The themes in this escape game were selected by the head of the department and validated by the teaching team, as well as by 6th-year students involved in a preliminary test. The participants found the escape game relevant for consolidating their knowledge of paediatric dentistry, with a score of 4.6 (± 0.6). The statements were tested, validated and improved by the teaching team and the 6th year students during the B test. Immediate feedback on answers allowed students to assess their progress, and postsession debriefing facilitated further learning. Thus, the high degree of student satisfaction with this escape game may be attributed to the incorporation of key gamification elements in the game design.

The percentage of correct answers in the initial knowledge assessment was 82.9%, which is considered high. Zaug et al. [24] and Caussin et al. [20] reported similar results (80% and 72.1%, respectively). Note that since this is a true/false questionnaire with 16 questions, the median would be 50% if the answers were given randomly. In addition, the preescape game questions focused on topics that were largely failed by previous cohorts in the exams. Research indicates that escape rooms can intrinsically motivate students to learn [39, 40]. In the present study, the students were motivated to review their material (4.8 $[\pm 0.5]$), partly because of the prospect of winning a prize (score of 4 4 [±1.1]). While only three students achieved a perfect score, 71.8% scored 80% or higher, indicating that students generally mastered the key knowledge expected by the end of their 5th year.

Each group consisted of four to six students, an optimal size for engaging with various hints and challenges [41, 42]. Eukel et al. [41] noted communication issues in teams larger than six. This group size seemed to facilitate active participation and self-expression (4.2 [±0.9]). The students valued the collaborative discussions within their teams, which was reflected in a satisfaction score of 4.4 [±0.7]. These findings align with those of Caussin et al. [20] (who reported a satisfaction score of 4.2 [±0.9]). Similarly, Aubeux et al. [23] reported that 66.6% of students agreed that teamwork helped them assimilate new knowledge.

The level of difficulty and duration of the session are important parameters [1, 20, 21]. The total time included both the escape game duration and additional minutes for each correction needed from the game master. Success was defined as completing the escape game in under 35 min. The average completion time was 38.5 min (± 9.4) , with the best group finishing it in 23.6 min and the worst group completing it in 62.3 min. 35% of the teams (n = 15 groups out of 38) succeeding overall. These results differed from those of Caussin et al. [20], who reported a 100% success rate. This difference may be due to the different definitions of success. They defined success as finishing the escape game, whereas in this study, it was defined as a score, considering time and errors, under 35 min [20]. Although there is no clear justification for setting a specific time limit, achieving the learning goals within a reasonable timeframe is considered an important factor in preventing learners from feeling frustrated and eventually dropping out [43]. Testing the

duration required to complete the learning activities is crucial in determining the appropriate time limit for the escape game [44]. Quek et al. [45] reported the students' negative reactions to the escape game regarding time constraints, lack of guidance, and absence of useful cues, highlighting the crucial role of the facilitator in ensuring team progression in the game, intervening only when necessary to promote more autonomous learners [44], and conducting debriefing sessions to foster learning through reflection [46]. Moreover, it seemed important for all the students to complete the escape game to ensure uniform learning experiences. Hence, in this study, they received guidance after mistakes; errors were identified without providing answers, except after three repeated mistakes, at which point explanations were given.

The students rated the difficulty level as suitable, with a score of 4.5 [\pm 0.6]. Regarding duration, Aubeux et al. [23] reported a mean escape time of 55 min, while Zaug et al. [24] reported a mean of approximately 60 min—closer to typical escape games but impractical with a cohort of 183 students. On the other hand, Caussin et al. [20], who had a sample size of 212 students, close to ours, reported a mean time of 17 min, which seems too brief to complete the experience. An educational escape room cannot follow all recreational conventions [47] while also achieving the learning objectives, therefore, the duration was extended to accommodate smaller groups while allowing participation from all students over four days. Overall, the students expressed satisfaction with the session duration, with a score of 4.7 [\pm 0.6].

The current investigation has several limitations. First, the logistics of the activity are time-consuming and require careful organization [25, 26]. This escape game was created and set up by an 8-person team in 50 h, which is almost twice the time reported by Caussin et al. [20]. Recognizing the importance of thorough testing [43, 48], two β tests were conducted: one with discipline teachers who did not participate in the creation phase and another with sixth-year students who volunteered. A 3-person team was needed to supervise each session. The presence of supervisors did not hinder the students' immersion in the game [47]. Second, the findings may not be generalizable because they focus on one faculty member, but the large sample size (n = 180) strengthens the results and offers insight into this specific context. Like many gamification studies, the focus was on student perceptions, with limited exploration of instructors' views. Third, the study lacks a control group, which limits the ability to make direct causal inferences about the unique educational value of the escape game, particularly regarding knowledge retention and engagement. This absence of comparison makes it difficult to assess how the escape room measures up against traditional teaching methods or other active learning strategies. The decision to provide the escape room experience to all students in the cohort was guided by ethical considerations, as it would be unfair to deprive some students of the complete educational experience, including the serious game and the debriefing in small groups. Thus, while the study does not directly compare the escape room with traditional teaching methods, it aims to evaluate its impact on engagement and satisfaction across all students. Fourth, the study primarily relied on immediate feedback metrics, such as student satisfaction and enjoyment, which, although valuable, do not necessarily correlate with longterm knowledge retention. Moreover the absence of longterm follow-up data prevents the assessment of whether the knowledge gained from the escape room is retained beyond the short term. Only one study reported knowledge retention for up to three months [49]. These limitations highlight the need for ongoing and future research, including studies that incorporate control groups and long-term follow-up, to more comprehensively assess the effectiveness of gamified learning in paediatric dentistry.

Further studies will be necessary for evaluating the escape room's impact on knowledge retention, clinical competence, and overall pedagogical value in this field.

Lastly, it is important to emphasize that the escape room is a supplementary educational activity, not a replacement for traditional teaching methods. While the escape room is an engaging and interactive tool, it is not intended to substitute the rigorous traditional curriculum designed to provide students with essential clinical skills. The one-hour escape game is incorporated into the existing curriculum, and the focus remains on preparing students for real-world, clinical practice through a combination of traditional and innovative teaching strategies.

Conclusions

Active teaching methods are recommended to increase students' motivation and success, and they can also help reduce anxiety. This study suggests that the escape game significantly enhanced learning and motivation in paediatric dentistry, as perceived by the students. Furthermore, competition with peers provided greater motivation to engage with the learning content.

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Author contributions

ED chose the thematic focus of the project and was a major contributor in writing the manuscript. PF contributed expertise in escape games, designed Station 2 and was a major contributor in writing the manuscript. JPA provided expertise in innovant pedagogic. AA was responsible for distributing questionnaires, collecting data, designing the tarot cards, procuring materials, and developing Station 1. AS designed Station 5. JG created the tarot card illustrations and designed Station 3. AL developed Station 4. YS was responsible for configuring the box settings. SH supervised the entire project, oversaw each station, coordinated the team, performed the statistical

analysis and was the main author of this manustricpt. VSF and MI reviewed the manuscript. All authors read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

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