1   TITLE

2   The impact of using an "Anatomy Escape Room" on nursing students: a comparative
3   study

4   ABSTRACT

5   *Background:* Anatomy is an important part of health science education. In teaching
6   anatomy, new teaching strategies have been studied in comparison with traditional-based
7   approaches. In this manner, strategies such as the escape room-based approach have been
8   used as an innovative learning approach in nursing education, but little is known about
9   its application in an Anatomy module.

10   *Objective:* To evaluate the effectiveness of the escape room for anatomy-related
11   knowledge retention in nursing and the perceived value of the game.

12   *Design:* In the first semesters of the academic years 2017-2018 and 2018-2019, a
13   comparative cross-sectional study was conducted.

14   *Settings:* This study took place at [*Hidden for blinding purposes*] with students enrolled
15   in the Anatomy module.

16   *Participants:* A total of 248 first-year nursing students took part in the study.

17   *Methods:* The study included two groups: an experimental group (EG) that participated
18   in an escape room in the final session of their Anatomy module, and a control group (CG)
19   that received a traditional-based teaching approach in their final lesson.

20   *Results:* Students enrolled in the Anatomy module were randomly assigned to either the
21   experimental (EG, n=128) or control groups (CG, n=120). The escape room was
22   conducted in groups of four and lasted no more than 15 minutes. In terms of satisfaction
23   with the escape room, EG scored above the mean. The item "I enjoyed playing" received
24   the highest score (4.88 ± 0.35). Taking the final scores of each group into account, the
25   EG had a final average score of 8.94 ± 0.96, while the CG had a final average score of
26   7.70 ± 1.25 ($p = 0.001$).

27 *Conclusions:* According to the findings, the "Anatomy Escape Room" is a game-based
28 approach that motivates students and constitutes a down-to-earth resource for anatomy
29 learning in healthcare students.

32   BACKGROUND

33 In healthcare degree programmes, anatomy modules are generally taught at the beginning
34 as an essential component of health education in order to ground basic knowledge in areas
35 such as histology and gross anatomy, among others (Brown et al., 2017; Reinke, 2019).
36 Indeed, without this knowledge, healthcare providers may be unable to effectively
37 develop their clinical practice (Lewis et al., 2016). Although some anatomy-related
38 teaching approaches have traditionally included various strategies such as cadaver
39 dissection or the use of anatomical models (Choi-Lundberg et al., 2016; Ghosh, 2017;
40 Pais et al., 2017), new teaching approaches have recently been studied, including
41 prosected specimens (Mitrousias et al., 2020), computer-aided instruction (Wilson et al.,
42 2019), educational websites (Natsis et al., 2021); bodypainting (Diaz and Woolley, 2021),
43 integrated problem-based learning cases (Doomernik et al., 2017), brainstorming
44 (Goswami et al., 2017), and even effective use of the museum (Kim et al., 2017; Memon
45 et al., 2020). Likewise, attitudes toward assorted teaching approaches have been explored
46 in a number of studies (Abdullah et al., 2020; Estai and Bunt, 2016; Pruitt et al., 2021).
47 The main purpose of these educational approaches is to foster a positive environment, in
48 which students can use their natural learning skills to understand complex concepts and
49 maintain anatomical awareness through study, emulation, and clinical practice (Khalil et
50 al., 2018).

51 In this vein, Estai and Bunt (2016) found that the importance of teaching modern anatomy
52 is to use a wide selection of pedagogical methods, though more research is needed to
53 investigate this transition to new methodologies. Game-based teaching models that use
54 both visual and auditory stimuli to benefit different learning styles while also encouraging
55 group discussion and participation are among the most recent approaches used (Gallegos
56 et al., 2017), whereas others such as an interactive atlas (Guy et al., 2018), virtual reality
57 (Fenesi et al., 2016; Moro et al., 2017) or even comics (Kim et al., 2017) are also used.

58　All of these active learning approaches involve a process of instruction, practice, and
59　assessment, which traditionally existed separately (Ambrosio-Mawhirter and Ford-
60　Garofalo, 2016), but now occur concurrently when game-based models are used, allowing
61　students to learn in more natural conditions (Havola et al., 2020). This is the case for
62　escape room-based teaching approaches, which have yielded promising results in
63　previous studies on healthcare students (Morrell and Ball, 2019; Rosenkrantz et al., 2019).
64　The term "escape room" refers to environments wherein the participants must work in
65　teams to solve specific topic-related puzzles and riddles in a limited amount of time to
66　achieve set objectives (Gordon et al., 2019; Guckian et al., 2020). These activities are
67　defined as experimental in nature, but they also appeal to players looking for new
68　experiences (Rosenkrantz et al., 2019). This game-based practice has proven popular
69　among students, and more evidence is emerging demonstrating that these approaches are
70　being used effectively in medical education (Kinio et al., 2019). Despite knowing that
71　most escape rooms are inherently recreational and are influenced by video games, they
72　are becoming more popular in educational learning. In this scenario, escape rooms have
73　been shown to promote collaboration and social skill development while also increasing
74　student engagement with their learning environment (Kinio et al., 2019). The escape
75　room-based model not only combines three types of active learning: gamification, flipped
76　learning, and problem-based learning (López-Belmonte et al., 2020), but it also
77　strengthens other characteristics required in realistic professional teams, such as critical
78　thinking and teamwork-based skills (Adams et al., 2018; Friedrich et al., 2018). As a side
79　benefit of these features, students can engage in meaningful learning through sequential
80　tasks and immediate feedback, while also actively participating and promoting interaction
81　in near real-time scenarios (Morrell and Ball, 2019; Zhang et al., 2019).

82　Overall, escape room-based teaching strategies have shown to be effective in terms of
83　satisfaction and motivation for healthcare students (Adams et al., 2018; Gómez-Urquiza
84　et al., 2019; Roman et al., 2020), such as surgical and dermatology students or radiology
85　residents (Guckian et al., 2020; Jambhekar et al., 2019; Kinio et al., 2019). To the best of
86　our knowledge, no study has yet integrated an escape room-based teaching strategy into
87　an Anatomy module in a healthcare degree program.

METHODS

89   Aim

90   The purpose of this study was to evaluate the effectiveness of the escape room for

91   anatomy-related knowledge retention in nursing, as well as the perceived value of the

92   game.

93   Design

94   In the first semesters of the academic years 2017-2018 and 2018-2019, a comparative

95   cross-sectional study was conducted to answer the following research question: "How

96   effective is a game-like design such as escape room to engage nursing students and

97   promote anatomy-related knowledge retention?". The study included two groups: an

98   experimental group (EG) that participated in an escape room in the formative final session

99   of their Anatomy module, and a control group (CG) that received a traditional-based

100   teaching approach, a passive learning method such as an expositive class session, in their

101   formative final lesson.

102   Participants

103   All participants were nursing students from [*Hidden for blinding purposes*]. A total of

104   248 first-year nursing students (193 females and 55 males) took part in the study after

105   enrolling in the Anatomy module. The selection criteria included those students who were

106   (i) enrolled in the anatomy module, (ii) 18 or older, (iii) not exchange students, and (iv)

107   willing to provide written informed consent prior to participating in the study. In the EG,

108   128 students experienced an escape room-based teaching approach, while 120 students in

109   the CG received a traditional-based teaching approach. Each EG group was assigned at

110   random (see Figure 1).

111   *[INSERT FIGURE 1 ABOUT HERE]*

112   Procedure

113   The "Anatomy Escape Room" was designed to be performed in the final session of the

114   Anatomy module. This is a mandatory module in the first year of a nursing degree that is

115   developed over a 15-week period and includes both theory and practice classes.

116   Participants were divided into groups of four, and each group had a maximum time limit
117   of 15 minutes in the escape room. After completing the escape room and receiving
118   feedback, participants completed a self-administered satisfaction in-person questionnaire.

119   <u>Escape Room</u>

120   The escape room was designed to be used in the same classroom where the Anatomy
121   classes were developed. This game-based session was titled "The Mystery of the Two
122   Bodies", and the aim of the players was to locate 10 clues using their anatomy-related
123   knowledge, with the ultimate intention of finding a key to escape the room and save the
124   injured bodies inside (see Figure 2 and 3).

125   *[INSERT FIGURE 2 AND FIGURE 3 ABOUT HERE]*

126   Students were required to use their knowledge and abilities from previous anatomy
127   classes to solve the topic-related puzzles and riddles and, ultimately, unlock the padlock.
128   The riddles were concealed in anatomical models, and students had to use different
129   materials, such as ultraviolet LED flashlights, to locate numbers or words in the correct
130   location of bones, joints, muscles, abdominal region divisions, heart valves, or brain
131   lobes. For example, in order to find the correct clue to open the padlock, students needed
132   to know and locate the main inspiratory muscle innervated by the phrenic nerve. Each
133   successful solution to a clue was considered a hit, and solving all ten problems allowed
134   them to leave the room. These clues were designed to prevent bias in assessing students'
135   knowledge and to only provide information for the next clue. Rather than including
136   anatomy module knowledge that would lead to the correct answer, their purpose was
137   merely for game dynamics. Thus, one of the clues could be as follows: "to continue with
138   the game, you must introduce a four-digit code that can be found in the main inspiratory
139   muscle innervated by the phrenic nerve". Meanwhile, the CG was subjected to the same
140   ten questions that were traditionally evaluated by a multiple-choice test (e.g., What is the
141   main inspiratory muscle innervated by the phrenic nerve?).

142   <u>Final session</u>

143   The CG was evaluated using a traditional method, in which an educator asked students to
144   locate specific topic-related concepts in anatomical models (for a maximum of 15
145   minutes). Students were evaluated in groups by the same educator, and the same ten

5

146 questions as in the EG were used, albeit worded differently and with no hints. The EG,

147 on the other hand, was evaluated throughout the escape room-based model, and the same

148 ten questions were adapted using clues and topic-related puzzles, with the solutions

149 located in the correct anatomical location. The final puzzle contained the answers to the

150 ten questions, as well as the final hint to open the padlock. If students were unable to

151 correctly answer some questions, they could seek support (up to three times) in order to

152 solve the puzzle, even though their score was based on their first answers. In both cases,

153 the time spent by each group was recorded.

154 Data collection

155 "Sex" and "Age" were collected as sociodemographic variables. A questionnaire from a

156 previous study was retrieved from institutional repository to evaluate the satisfaction of

157 nursing students with the escape room designed (Gómez-Urquiza et al., 2019). Questions

158 were rephrased to include the name of the activity for the proposed game-like design. The

159 answers to the six questions were ranked on a 5-point Likert-type scale ranging from 1 to

160 5, with 1 being strongly disagree and 5 being strongly agree:

161 1) Participating in the "Anatomy Escape Room" enabled me to see the value of
162   anatomy in nursing.
163 2) Participating in the "Anatomy Escape Room" helped me bolster module-related
164   fundamental concepts.
165 3) I enjoyed playing.
166 4) I reckon the escape room will help me solidify the module-related concepts for
167   the theory exam.
168 5) In the escape room, I remembered and applied what I had learned during the
169   Anatomy module.
170 6) More game-like models of this type should be included in the nursing degree.

171 Data analysis

172 The data was analysed using the statistical program SPSS version 22 for Windows. First,

173 a descriptive analysis of the data was performed. Later, the central tendency and

174 dispersion of quantitative variables were measured, while the frequency and percentage

175 of categorical variables were analysed. Each question of the questionnaire was analysed.

176 The Student's t-test was used for independent samples after the data distribution was
177 evaluated using the Kolmogorov Smirnov test, which revealed a normal distribution of
178 the same.

179 Ethical considerations

180 Approval was obtained from the Ethics Committee of the [*Hidden for blinding purposes*]
181 (UALBIO2017/023). All participants were informed about the purpose of the study, the
182 anonymity and confidentiality of their results, and provided informed consent prior to
183 participation. The ethical principles of the Declaration of Helsinki and subsequent
184 amendments were always followed.

185   FINDINGS

186 The socio-demographic characteristics of the participants

187 The sample size included 248 first-year nursing students from the [*Hidden for blinding*
188 *purposes*], with 51.6% (n=128) belonging to the EG and 48.4% (n=120) belonging to the
189 CG. These groups were comprised of 77.8% (n=193) females and 22.2% (n=55) males,
190 with a mean age of 19.59±4.70 (ranged from 18 to 51 years old). In terms of the EG,
191 76.6% (n=98) were females, while 23.4% (n=30) were males. Similarly, females
192 composed 79.2% (n=95) of the population in the CG, while males constituted 20.8%
193 (n=25).

194 The outcome of the final session evaluation

195 Both groups completed the evaluation within the estimated time frame, with no
196 significant differences (p>0.05). For the EG and CG, the mean time to escape or complete
197 the evaluation was 870 s (14 min and 5 s) and 855 s (14 min and 25 s), respectively.
198 Considering the final scores for each group, the average final score in the EG was
199 8.94±0.96 points, with a minimum of 7.5 and a maximum of 10, while in the CG it was
200 7.70±1.25 points, with a minimum of 5 and a maximum of 10. There were statistically
201 significant differences in the final scores of both groups (p = 0.001).

Satisfaction with the escape room-based model

203 In terms of satisfaction with the escape room-based approach, all participants scored

204 higher than average (Table 1). The items with the highest scores were "More game-like

205 models of this type should be included in the nursing degree" (4.94±0.24), "I enjoyed

206 playing" (4.88±0.35) and "Participating in the "Anatomy Escape Room" enabled me to

207 see the value of anatomy in nursing" (4.67±0.57).

208   *[INSERT TABLE 1 ABOUT HERE]*

209   DISCUSSION

210 The purpose of this study was to evaluate the effectiveness of the escape room for

211 anatomy-related knowledge retention in nursing, as well as the perceived value of the

212 game. Our findings revealed that students who participated in the escape room for the

213 final evaluation outperformed those who used a traditional-based evaluation. Despite the

214 fact that different anatomy-related teaching approaches have been used, to the best of our

215 knowledge, this is the first study to use the escape room as an innovative learning

216 approach in an Anatomy module. According to the review of Estai and Bunt (2016),

217 combining multiple pedagogical resources is an effective approach to teaching and

218 learning modern anatomy, emphasizing the importance of evaluating these new

219 approaches. In this context, the use of simulated scenarios as a complement to traditional

220 gross anatomy teaching approaches appears to be interestingly useful (Deng et al., 2018),

221 which concurs with our study on the usefulness of the escape room-based model as an

222 down-to-earth educational resource for Anatomy modules.

223 Despite the fact that this method has been used in other disciplines of health sciences

224 (Eukel et al., 2017; Guckian et al., 2020) and that a number of studies have used it as an

225 innovative method of learning (Adams et al., 2018; Gómez-Urquiza et al., 2019; Guckian

226 et al., 2020; Jambhekar et al., 2019; Kinio et al., 2019), only a recent study has used the

227 escape room as an evaluation method in another nursing module (Roman et al., 2020).

228 Having said that, our findings, as well as those of Roman and collaborators (2020), point

229 to the escape room-based approach as a useful anatomy evaluation system, increasing

230 students' interest in improving teamwork and communication skills, both of which are

231 required for a high-quality professional care delivery. Based on the current students

232 consulted for this study, this educational game-based model helps students see the value
233 of the "Anatomy Escape Room" in their healthcare practice, which is supported by other
234 authors who demonstrated that the escape room experience also prepares students to work
235 on rapid team-made groups and are therefore, particularly helpful for their future clinical
236 practice (Friedrich et al., 2018). Interestingly, subjects who participated in the escape
237 room also stated that this type of activity bolstered them in their daily practice of critical
238 thinking (Gómez-Urquiza et al., 2019), as they gained significant insights by debating the
239 correct answers and reasoning while using this learning strategy (Gallegos et al., 2017).
240 One possible explanation for this could be that they had to think about each task in order
241 to escape, which improved their decision-making process (Mullins and Sabherwal, 2018)
242 and supported them in reinforcing basic module-related concepts and preparing for the
243 theory exam (Candida-Castro and Schleder-Gonçalves, 2018). In other words, this type
244 of game-based strategy improves the teaching-learning process while allowing nursing
245 students to acquire anatomy-related knowledge and develop other nursing competencies.

246 Numerous studies have shown that these methods benefit students by improving
247 conceptual understanding (Cleveland et al., 2017) and increasing positive student
248 perceptions of learning new concepts (Tharayil et al., 2018), as well as increasing student
249 motivation and interest while promoting active student-centred learning (Reed, 2020).
250 Consequently, this type of teaching approach constitutes a valid resource to support other
251 teaching strategies in a nursing degree program, such as simulation, fellowship,
252 encouraging collaboration, and enhancing learning (Ambrosio-Mawhirter and Ford-
253 Garofalo, 2016), with research indicating that knowledge retention improves even one
254 month later (Berthod et al., 2020). Our research found that students did remember and
255 apply module-related content during the game session, suggesting that more game-like
256 models of this type, in their opinion, should be included in the nursing degree. In a similar
257 vein, Adams and collaborators (2018) found that participants considered the escape room
258 to be remarkably interesting and entertaining, providing interactive and positive reports
259 to support the use of game-based learning and its use as an evaluation strategy for
260 experienced nurses. The general reaction to the use of escape rooms as a complementary
261 learning approach has always been very positive (Morrell and Ball, 2019), even when
262 commercial escape room models are used (Zhang et al., 2018). Some studies have shown
263 that escape rooms may be an effective method of integrating clinical and lecture-based
264 teaching without requiring a large number of resources (Guckian et al., 2020), optimising

their potential use for motivating healthcare students to pursue their profession (Connelly et al., 2018). Overall, enjoyment and gamification are powerful aspects of the escape room as a learning resource and teaching strategy, facilitating learning by increasing motivation and perseverance toward the task (Aubeux et al., 2020; Berthod et al., 2020). In our study, the escape room strategy benefited and enhanced knowledge retention in the Anatomy module, as students perceived, they put their previous specific topic-related knowledge into practice in a much more natural manner, although more research is needed to scrutinize the long-term memory effectiveness of these escape game-based models (Jaramillo-Rincón and Trujillo-Mejia, 2020).

Limitations of this study

However, the findings of this study are subjected to a number of limitations that need to be considered. First, a prior evaluation in both groups, as well as a subsequent long-term evaluation, would have provided more information. Second, there is scant evidence analysing the use of escape rooms in anatomy-related learning and as an evaluation method, which limits the discussion of our findings. And at last, the level of satisfaction and usefulness of the educators who took part in the activity was not assessed, which would have allowed us to delve deeper into the level of satisfaction with this teaching-learning resource.

CONCLUSIONS

For healthcare students, the escape room-based approach is a down-to-earth resource for learning and evaluating anatomy. This strategy has been demonstrated to be a motivating learning experience that supports students in recalling and applying what they have previously learned in class. In short, further exercises alike should be incorporated into anatomy learning and evaluation. The current study confirms that the use of this game-based method can be considered as a captivating and creative approach that can be used as a complement to traditional-based methods in healthcare teaching and evaluation while also increasing knowledge among university students.

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