Design and Evaluation of an Athletic Training Educational Escape Room

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Context: The educational escape room is an innovative teaching strategy, and the use of this technique is gaining popularity in some health care disciplines. It is believed to promote acquisition of knowledge and skills, increase motivation, and encourage engagement, critical thinking, collaboration, and problem-solving.

Objective: To describe the use of an innovative educational escape room in a master's-level athletic training course and to examine learning effectiveness and students' perceptions.

Design: Quasi-experimental.

Setting: A Commission on Accreditation of Athletic Training Education–accredited master's-level athletic training program.

Patients or Other Participants: A convenience sample of 14 students enrolled in a master's-level professional athletic training program participated.

Intervention(s): Educational escape room.

Main Outcome Measures(s): A paired-samples *t* test was used to determine differences between preactivity and postactivity knowledge-assessment scores. Measures of central tendency were used for survey questions related to student perceptions of the activity. Student perceptions were assessed after the intervention.

Results: All participants completed the preactivity and postactivity knowledge assessments. The difference in scores was found to be statistically significant ($t_{13} = -4.502$, P = .001), with a large effect size (Cohen d = 1.32). Participants thought the escape room was an effective way to improve their knowledge of course materials (mean \pm SD = 5.0 \pm 0.0) and encouraged them to apply course material in a new way (mean \pm SD = 4.9 \pm 0.27). Participants reported that they had fun (mean \pm SD = 5.0 \pm 0.0) and felt that the activity was immersive (mean \pm SD = 5.0 \pm 0.00). Qualitative elements from the postactivity survey corroborated the data.

Conclusions: The education escape room described in this study promoted learning while providing a fun and engaging learning experience with positive perceived value.

Key Words: educational gaming, active learning, engagement, teamwork

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KEY POINTS

- Educational escape rooms are an innovative teaching technique that can be used by instructors to help achieve course objectives.
- Graduate athletic training students perceived participation in an educational escape room to be an engaging and effective way to learn.
- Educational escape rooms incorporate multiple brainbased, student-centered teaching and learning strategies that can help promote learning.

Escape rooms are team-based, live-action games that require players to solve puzzles, find clues, and accomplish tasks.¹ The educational escape room is an innovative teaching strategy that combines learning design, game mechanics, and logic.² Educational escape rooms have been used in higher education in a variety of disciplines, such as pharmacology,³ nursing,^{4–6} physical therapy,⁷ medicine,⁸ and computer programming.^{9,10} They have also been used outside the classroom. For example, Connelly et al¹¹ used an escape room for a nursing school recruiting event.

Most educational escape rooms require students to work with a partner or as part of a small team.¹² They often have a linear storyline or a sequential path, where a series of puzzles are linked. When one puzzle is completed, it provides a clue to the next puzzle. This ensures that students cannot "escape" without solving all the puzzles.¹ Educational escape rooms have been designed to be played in physical rooms (ie, classrooms or simulation labs), in an online digital setting, and in a combination of physical and digital settings.¹² The goals of the activity and various constraints (eg, the size of the room, number of students participating) often dictate the choices made by instructors.

A variety of educational escape room puzzles have been reported in the literature. For example, Caldas et al³ created an escape room to teach pharmacology students about compounding medications. Puzzles included word locks, cryptograms, coded messages, a directional lock, and more. To solve the puzzles, students needed to apply the course content. Barker et al⁴ created an escape room for nursing students to increase comprehension and retention of material related to fluid and electrolyte imbalance. One of their puzzles required participants to correctly determine the infusion rate. This answer was then used to open a combination lockbox, reinforcing learning.

Several benefits are associated with educational escape rooms, including improving knowledge and skills and increasing motivation and engagement, as well as facilitating problemsolving, critical thinking, and collaboration.^{8,13–24} There are also several challenges to designing and implementing educational escape rooms. First, creating an educational escape room is time-consuming.^{13,17,20–22,25} It takes time to choose the appropriate learning objectives to be incorporated into the educational escape room, design the puzzles, devise clues, and run a pilot test. However, once the activity has been created and tested, it can be used repeatedly with less preparation time. Few studies have quantified the time required to create a successful escape room. However, Eukel et al¹⁷ estimated that creation of puzzles and materials for a diabetes management-themed escape room took approximately 20 hours. Hawkins et al²⁶ noted that it took a year for nursing faculty to design and implement a simulation-style safe-medication escape room.

Creating puzzles that cover course content, fit the narrative of the escape room, and are at the appropriate level of difficulty is complex and requires innovative thinking. Puzzles that are too easy will likely not help instructors meet the educational goals of the task. However, overly difficult puzzles can be frustrating and stressful.²¹ Constraints such as classroom size, number of students, time frame, and budget are other factors that must be considered to successfully implement an escape room.

Despite the challenges, this educational technique is viewed very positively in the literature. Finding effective ways to facilitate learning, critical thinking, and collaboration is important and can add value to students' educational experiences. Use of educational escape rooms is gaining popularity, but it is still a new teaching technique for most educators. Additional research is needed to help instructors determine if the time, effort, and resources required are worth the intended or achieved outcomes. There is also a need to evaluate the effectiveness of this innovative teaching method with adult graduate students. The purpose of this paper is to describe the use of an innovative educational escape room in a master's-level athletic training course and to report on learning effectiveness and student perceptions.

METHODOLOGY

Design and Setting

I used a quasi-experimental approach for this study. The findings presented in this article are focused on participants' knowledge scores preactivity and postactivity and their perceptions of the experience. The education escape room activity took place in an athletic training orthopedic injuries course. This course is a comprehensive study of the head, spine, and thorax, with attention to the prevention, assessment, evaluation, and recognition of common injuries to these areas. Students take this course in their first year of a professional level master's in science in athletic training program at a private Midwestern university. There was no grade associated with this activity. The findings are reported using the Transparent Reporting of Evaluations with Nonrandomized Designs guidelines.²⁷ The research design is summarized in Figure 1.

Participants

Participants included a convenience sample of 14 students enrolled in a master's-level professional athletic training

Figure 1. Research design.



program. The study took place near the end of the students' first year in their academic program. All students voluntarily agreed to participate in the study. Of the 14 participants, the age range was 22 to 26 years (23.43 ± 1.34 years); 8 were female, 6 were male; and the ethnic group distribution was 86% Caucasian and 14% Hispanic.

Data Collection

To examine the effectiveness of the escape room and investigate students' perceptions of the activity, 2 instruments were used: (1) a pretest and a posttest to examine changes in student knowledge, and (2) a postexperience survey to collect student perceptions of the activity. This research was approved by an institutional review board. All students in the course engaged in the escape room and the preactivity and postactivity quiz as part of a regular class activity. Completion of the postexperience survey about the activity and use of their data for research purposes was optional. At the beginning of the postexperience survey, students were provided with an informed-consent statement that covered the study in its entirety.

Students completed a 37-question knowledge assessment on the material associated with the activity 1 week before participation in the escape room and again immediately after the escape room. This method has been used in similar studies.^{3,17,18} The knowledge-assessment test used all fill-inthe-blank–type questions. The format was the same for both tests, but the order of the questions varied. Students were provided with the correct answers after each test. The pretest and posttest were considered class activities, and no points were awarded toward students' course grade. Validity was established through a panel of experts.

The 33-question student-perception survey was modified from the educational escape room questionnaire used by Lopez-Pernas et al¹⁰ for a computer programming escape-room experience. The questions were aimed at assessing students' perceptions toward the use of the education escape room as a learning activity and the students' thoughts on the design of the escape room. Students provided an overall rating for the experience using a 5-point scale (1 = *poor* to 5 = *excellent*), 25 questions were evaluated using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*), and 4 questions had *yes* or *no* options. At the end of the survey, there were 3 openended questions, where students could indicate their most favorite and least favorite parts of the activity. They could also leave additional comments or suggestions. The survey was administered using Qualtrics. Validity was established through a panel of experts. No modifications were deemed necessary based on the feedback.

Intervention: Educational Escape Room

Planning. The goals for this learning activity were to reinforce course content using a fun and engaging method that required problem-solving and collaboration. Students who participated in this activity were first-year master's-level students enrolled in an orthopedic injury evaluation course focused on the head, spine, and thorax. The escape room puzzles required knowledge of cranial nerves and nerve roots. The escape room learning activity was scheduled for the end of the term to ensure students had an opportunity to be familiar with the content required to be successful at solving the puzzles. Specific learning objectives included (1) link cranial nerve numbers and names, (2) identify the function of each cranial nerve, and (3) identify the myotomes, dermatomes, and reflexes associated with nerve roots.

I considered several factors while designing the escape room. First, each puzzle needed to be created with the learning outcomes in mind. Second, each team of students needed to complete each puzzle. I chose a linear design approach because it ensures that students complete each puzzle before starting the next puzzle.¹ Location and social distance constraints were also factors, because of completion of this activity during the COVID-19 pandemic. The escape room took place in an athletic training lab/classroom. A combination of university social distancing guidelines and a desire to have each student get as much experience with the puzzles as possible limited each group size to pairs. To accommodate 7 pairs of students, 7 sets of puzzles were created (1 complete set for each pair). For organizational purposes, each set was color coded. Equipment was another consideration. Escape rooms often include ciphers, lock boxes, various types of locks (combination, direction, or key entry), UV light to see invisible ink messages, and more. For this activity I wanted to incorporate some of the common escape room equipment.

Most puzzles needed to be created so that students would know they had the correct outcome without needing to be told if they were right or wrong. For example, if the answer to a puzzle was associated with a combination lock, and the lock opened, then students would know they were correct. If the lock did not open, they could work through the puzzle again and make another attempt. Eight puzzles were created for the educational escape room activity. Inspiration was found from a variety of sources. The internet was particularly helpful in providing ideas on how to use common resources in uncommon ways (such as layering transparent plastic to reveal clues).

As part of the planning process, a pilot test was conducted with 2 teams of students in their second year in the athletic training program. This was needed to ensure the directions were adequate, and the puzzle difficulty was appropriate. In recognition that students in the first year of the program were just learning the content required to complete the puzzles (as opposed to the second-year students who participated in the pilot test), a system for providing hints was created. If students struggled with a particular puzzle, they could earn a hint by taking a short course content-related quiz. There was a different quiz for each main puzzle.

The teams participating in the pilot test of the educational escape room took 30 to 40 minutes from start to escape. Although most educational escape rooms include a time limit,¹² one was not used in this activity. To downplay competition between teams, students were told that all teams needed to successfully complete each puzzle so that all students could escape together. These choices were made to decrease anxiety and allow students to take the time they needed to fully engage in the puzzles.

Puzzles and Implementation. *Puzzle 1.* Students started the escape room activity with an envelope containing directions and game pieces. The goal of the puzzle was to correctly match cranial nerve names with their numbers. Each student in a team received their own set of triangular game pieces. If done correctly, the puzzle would create the shape of an elongated rhombus (Figure 2). Once each team member completed their puzzle, they were given a second envelope with a new puzzle.

Puzzle 2. Students were provided with 3 cards, each with a different math problem using cranial nerves (eg, Hypoglossal – Trigeminal =?). Students were instructed to keep these cards for later. Unknown to the students at the time, the 3 numbers would be used to open a combination lock. When students completed this puzzle, they received an envelope with the third puzzle.

Puzzle 3. Students used a cipher wheel to reveal a code word. Cranial nerve functions were located on the outside of the wheel. Cranial nerve numbers were printed on the movable inside of the wheel. When the number and the function were aligned, students could see a letter. Students recorded each letter in order of the cranial nerves (ie, the first letter in the code corresponded with cranial nerve 1, and so on). A 12-letter code was revealed when this puzzle was correctly completed. This code was used to help solve the next puzzle. If the letters did not create a recognizable word, students knew they had to try again.

Puzzle 4. After solving the cipher puzzle, students were given 12 strips of paper. Using the code word from the previous puzzle, they put the paper strips in order to get their next clue. This clue led the students to find a notebook hidden somewhere in the classroom. Notebooks were in a different location for each team.

Puzzle 5. Each notebook was "locked" with a string wound around it and held together with a lock. To open the notebook, students needed to use a 3-digit code. The answers to the cranial nerve math problems from puzzle 2 opened the lock. The order of the numbers was identified on the back of each puzzle card using invisible ink. Attached to each notebook was a UV light pen. Students could shine the UV light on the cards to learn the order of the numbers.

Puzzle 6. Inside the notebook were puzzle directions and a bag full of small blocks. Each block had a single myotome, dermatome, or reflex printed on it for nerve roots C3–T1. Students were also provided with a game board where each block had a designated spot. The goal of the game was to match each myotome, dermatome, and reflex block with the associated nerve root. Once all the blocks were placed on the

game board, students could check the results. If 1 block was out of place, they were instructed to mix the blocks up and replay the game until they were all correct. Once this puzzle was completed, students were provided with instructions and puzzle pieces for the final 2 puzzles.

Puzzle 7. Students were provided with a folder containing small square game pieces made of transparent plastic. Each square provided 1 piece of information (myotome, dermatome, or reflex for nerve roots L1–2 to S2). Each square also provided part of a symbol. The game board had a spot for each nerve root where students could place the game pieces. When all the squares were piled up for the correct associated nerve root, a complete symbol was revealed in the lower right corner. If the puzzle was done correctly, students had 6 symbols.

Puzzle 8. Students were provided with a paper containing 18 symbols linked with words. Students located the 6 symbols from the previous puzzle to create a sentence. Once correct, the sentence revealed the location of a key that would let them "escape." Keys were in a different location for each team.

Data Analysis

Data analysis was conducted using SPSS version 26 (IBM Corp). Descriptive statistics including mean, median, mode, and standard deviation values were analyzed. The Shapiro-Wilk test was conducted to verify the assumption of normality. A 2-tailed, matched-pairs *t* test was used to evaluate the differences between pretest and posttest, with the effect size (*d*) calculated to determine the magnitude of difference (small = 0.2, medium = 0.5, large = 0.8).²⁸ Reliability of the survey was established by Cronbach α (0.80). To assess interrater reliability with respect to grading the pretest and posttest, all exams were graded independently by the researcher and an assistant. Only 1 question on 1 exam was inconsistently graded. The question was examined and regraded and the dispute resolved by consensus.

RESULTS

Students indicated an overall rating of the escape room as excellent (mean \pm SD = 5.0 \pm 0.0). Half of the students (50%) indicated they had participated in an escape room (for entertainment). None of the students had participated in an educational escape room before this activity. Each team completed the escape room. One team requested hints for the first 2 puzzles; another team requested a hint only for the first puzzle. Five teams did not request hints. All teams completed the activity in under 40 minutes.

All participants completed the preactivity and postactivity knowledge assessments. The average score for the pretest was 26.2 ± 4.0 (on a scale of 0–37). The average score for the posttest was 31.5 ± 4.0 . Table 1 includes the mean, median, and SD for each test. The average increase in scores was 5.3 ± 4.5 , which implies a mean learning gain of 21%. All data were normally distributed, as assessed by the Shapiro-Wilk test. The difference in scores was found to be statistically significant ($t_{13} = -4.502$, P = .001) when a paired-samples t test was performed, indicating an increase in student knowledge. Additionally, a large effect size was found (Cohen d = 1.32).

Figure 2. Puzzle 1.



Table 1. Results of the Pretest and the Posttest ($N = 1$

Pretest		Posttest		Cohon d	D Value (2 Tailed)
Mean ± SD	Median	Mean ± SD	Median	Effect Size	Paired-Samples <i>t</i> Test
26.2 ± 4.0	25.5	31.5 ± 4.0	32.0	1.32	<.001

^a Scores could range from 0 to 37.

Table 2. Results of the Educational Escape Room Perception Survey (N = 14)

Question	Value
5-point scale questions, mean \pm SD (mode)	
What was your general impression of the escape room? (1 very poor-5 excellent)	5.0 ± 0.00 (5)
Please state your level of agreement with the following statements. (1 strongly disagree–5 strongly agree)	
The escape room was an effective way to improve my knowledge of the course material.	5.0 ± 0.00 (5)
The escape room was an effective way to review the content.	$5.0 \pm 0.00(5)$
The escape room encouraged me to apply course material in a new way.	4.9 ± 0.27 (5)
I learned more with the escape room than I would have with a regular class session.	4.5 ± 0.76 (5)
I learned more with the escape room than I would have with a normal study session on my own.	4.5 ± 0.65 (5)
The escape room was fun for me.	5.0 ± 0.00 (5)
The escape room was an immersive experience.	5.0 ± 0.00 (5)
The escape room was a stressful experience.	1.5 ± 1.13 (1)
It was difficult for me to focus on learning because I was feeling stressed or overwhelmed.	1.6 ± 0.94 (1)
The escape room was too hard.	1.2 ± 0.43 (1)
The difficulty of the escape room lies in mastering the course material.	4.4 ± 0.65 (5)
I think I was prepared enough to succeed in the escape room.	4.6 ± 0.74 (5)
The escape room was well organized.	5.0 ± 0.00 (5)
The initial guidance provided was enough.	4.9 ± 0.27 (5)
The duration of the escape room was adequate.	4.9 ± 0.27 (5)
The hint approach was adequate.	4.9 ± 0.27 (5)
I wish I received more help during the escape room.	1.7 ± 0.91 (1)
The supervision of the activity was adequate.	4.9 ± 0.27 (5)
I liked the fact that the escape room combined a variety of puzzles.	5.0 ± 0.00 (5)
I liked participating in the escape room with a classmate.	4.4 ± 1.09 (5)
I would have rather participated on my own.	2.3 ± 1.20 (1)
I would rather have been part of a larger team.	1.5 ± 0.76 (1)
All the members of the team weare equally involved in solving the different puzzles.	4.4 ± 1.16 (5)
In general, I enjoy playing games (video games, board games, social media games, etc).	4.6 ± 0.74 (5)
Yes or no questions, % yes	100
Would you recommend other students to participate in the escape room?	100
Would you like other courses to include activities like this?	100
Was this your first experience with any time of escape room?	50
Was this your first experience with an educational escape room in a class?	100

Participants indicated they thought the escape room was an effective way to improve their knowledge of course materials (mean \pm SD = 5.0 \pm 0.0) and an effective way to review the content (mean \pm SD = 5.0 \pm 0.0). They also agreed or strongly agreed that the escape room encouraged them to apply course material in a new way (mean \pm SD = 4.9 \pm 0.27) and that they learned more than they would have with a regular class session (mean \pm SD = 4.5 \pm 0.76) or a normal study session on their own (mean \pm SD = 4.5 \pm 0.65). See Table 2 for complete results of the postactivity survey.

Results indicated that students had fun (mean \pm SD = 5.0 \pm 0.0) and enjoyed the variety of puzzles (mean \pm SD = 5.0 \pm 0.0). Students were asked to indicate their favorite puzzle or favorite part of the escape room. All puzzles were mentioned by at least 1 student with the exception of puzzle 6 (small blocks with myotomes, dermatomes, and reflexes written on them for nerve roots C3-T1). Puzzle 5 (the "locked" notebook) was mentioned by multiple students. One participant wrote: "I thought the lock around the binder was cool because you had to go back and use your other previous answers to continue forward." Puzzle 1 (triangular game pieces used to match cranial nerves) and puzzle 7 (transparent plastic squares with myotomes, dermatomes, and reflexes layered to create symbols to decipher) were also popular. One participant wrote, "I liked the decoding puzzles, geometric shape puzzle (matching the nerves), finding the binder, and

figuring out the 3-digit code." Another participant wrote, "I enjoyed the one where we had to layer pieces to get a shape that corresponded to a cipher."

Most of the students felt that the activity was immersive (mean \pm SD = 5.0 \pm 0.00) and did not feel the escape room was stressful (mean \pm SD = 1.5 \pm 1.13) or overwhelming (mean \pm SD = 1.6 \pm 0.94). All of the participants indicated that they would recommend other students participate in the educational escape room and would like other courses to include such activities.

Organization and difficulty of the escape room was viewed positively. Participants did not think the escape room was too difficult (mean \pm SD = 1.2 \pm 0.43), and they all strongly agreed the escape room was well organized (mean \pm SD = 5.0 \pm 0.0). Results also indicate that students felt the initial guidance they received was sufficient (mean \pm SD = 4.9 \pm 0.27), the duration was adequate (mean \pm SD = 1.7 \pm 0.91). They also somewhat or strongly agreed that the hint approach was adequate (mean \pm SD = 4.9 \pm 0.27). Although most students indicated that they liked participating with a classmate (mean \pm SD = 4.4 \pm 1.09), a few participants (n = 3) would have preferred to complete the activity on their own (mean \pm SD = 2.3 \pm 1.2).

Overall participants viewed the educational escape room experience very positively. Additionally, participants seemed to appreciate the effort required to create the escape room. One participant shared: "So fun! Thank you for setting aside so much of your time to create all of that." Another participant felt similarly and wrote, "Honestly, I was just amazed by how much work you put into making fun learning experiences for us. It shows how much you care about us and the program."

DISCUSSION

The present study examined the pedagogical value of an educational escape room designed to reinforce material in a master's-level athletic training course. Participants in this study felt that the educational escape room was an effective way to improve their knowledge of course material, and knowledge-assessment scores increased after completion of the activity. These finding are consistent with previous studies using a variety of escape room themes and designs.^{3,8–10,13,17–20,22} Educational escape rooms may assist learning by incorporating multiple brain-based, student-centered teaching and learning strategies such as providing a safe environment, cooperative learning, movement, active/experiential learning, and critical thinking.²⁹ By combining multiple evidence-based education practices into a single learning activity, education escape rooms could be a useful and effective instructional method to help students improve knowledge.

Participants indicated that the escape room encouraged them to apply course material in a new way. Similar results were found by Woodworth,³⁰ who designed an escape room activity for nursing students focused on the topic of acute myocardial infarction. Most students (77%) in that study indicated that this class activity made them think about the topic in a unique way. According to Schomaker and Meeter,³¹ novel experiences can increase motivation and promote learning. Therefore, constructing puzzles that students had not experienced before was a priority. It was equally important that puzzle solutions require students to recall course content. Active recall of course material can improve the ability to remember this material again later, thus promoting retention.^{32–34} Retention may also be improved if the way students are asked to apply content knowledge is also novel. Research has shown that engaging in material under different conditions than what is "normal" for a student may help students retain the information more effectively because it encourages deeper processing of materials.³⁵ Therefore, solving novel puzzles created to address specific learning objectives could be an effective mechanism to improve retention.

One component common to many in-person escape rooms is the use of movement. Physical movement can increase energy and engagement and help learners to be more attentive.^{36–38} It also allows the brain to make better connections and improve memory.^{29,37} Planned movement during the educational escape room described in this study was an intentional part of the design. Students searched for hidden objects twice during the activity, once in the middle and once at the end. The search for the locked notebook (puzzle 4 of 8) did not take much time, but it did provide an opportunity for a burst of physical activity, which allowed a small cognitive break before working to solve the next puzzle. Many educational

escape rooms described in the literature use a scenario-based approach in which movement is integral throughout the activity.^{16,26,39,40} If the escape room is designed to be completed in a didactic class, instructors should consider the benefits of incorporating movement into the activity.

Results of the present study indicate that students felt that the activity was immersive and enjoyable. Clauson et al¹⁵ found similar results using an in-person escape room, noting high engagement among participants. Student engagement is a common strength in educational escape room literature.^{14,15,21,23} For example, Cain and Piascik¹⁴ found that compared with a typical classroom experience, students participating in a blended-format educational escape room activity showed more engagement in thinking about the problems and more involvement in discussing course material. Additionally, Peleg et al²³ noted that students thought time flew by during a chemistry-themed escape room, indicating a level of engagement that demonstrates high intrinsic motivation and the type of environment that promotes personal growth and learning.

Escape room puzzles require teamwork, concentration, critical thinking, and cooperation.⁴¹ Students must use their knowledge and available resources to work through problems, solve puzzles, and "escape."^{15,22,25,40} In most escape room activities, students work with a partner or as part of a team. Thus, there is opportunity for students to collaborate and practice effective communication.^{6,13,21,22,41} Students can learn from their peers while working together to solve puzzles.³⁰ Teamwork allows students to share ideas and information to spark connections and help each other learn.²¹ In the present study, most of the participants (86%) liked working with a classmate. This aligns with other education escape room research that has found positive results from students working in pairs or small teams.^{3,9}

Lastly, participants thought this activity was fun. Multiple studies have found similar results, noting that students find the escape rooms to be fun and enjoyable.^{13,14,20,22,23,41} These emotions can positively impact learning by improving engagement and motivation.^{42,43} We can gain the interest of adult learners when they do not know what will happen next.⁴³ Fun learning experiences may also promote greater learning retention,⁴² thus creating a fun, unique learning activity for students can have positive benefits.

Application

When instructors consider adding a new activity to their courses, it can be helpful to understand if the effort is worth the potential gains in knowledge. Designing and creating the described educational escape room took considerable time. I did not keep a specific record of the time spent on this project, but I worked on it for 5 weeks before pilot testing. Although I enjoyed the challenge, creating unique puzzles to meet the learning objectives took some trial and error. The cost for the materials (ie, combination locks, key locks, invisible ink with UV lights) was less than \$40, but the materials can be reused.

Despite the challenges and costs, there were many rewards. One of the unexpected benefits was that students identified gaps in their knowledge. Several students commented after the activity about increased motivation to study the material they struggled with. This is consistent with research showing improved interest in studying after participation in an escape room activity.²⁰ I chose to keep the escape room activity a surprise. However, student motivation to learn may increase in anticipation of participating in an educational escape room. For example, Kinio et al⁸ created a vascular surgery–themed escape room for medical students requiring application of knowledge and skills. Many participants noted that anticipation of this experience motivated them to study and prepare for the escape room. Based on the goals of the activity, advance notice of the escape room activity might be a useful strategy for instructors to consider.

Limitations and Future Directions

The design of this study is subject to several limitations. The sample size is small because of the limited number of students enrolled in the course. The sample selection was intentional and not random. Participation in the study was voluntary. The findings may be restricted to the context of students who participated in this educational escape room. Caution should be used in interpreting the results of the knowledge assessment. Without a control group, the influence of other factors can't be determined. Additionally, a survey was used to determine student opinions on this specific escape room experience, and thus it is individualized for this purpose. This protocol has been used in similar studies.^{10,20,23}

Future research should include a larger sample with quantitative and qualitative methods and analysis. Validated survey instruments and use of a comparison group should also be considered, as well as a method to test long-term retention. There are few studies examining how active-learning strategies, such as escape rooms, affect learning outcomes and longterm knowledge gains in athletic training students. Despite this study being limited to first-year master's-level students in a professional athletic training program, it provides a solid foundation for future research.

Conclusions

Use of an innovative educational escape room in a master'slevel athletic training course revealed encouraging results. Although challenging to develop, educational escape rooms can provide a fun and engaging learning activity with positive perceived value. This study contributes to the literature of the didactic use of active learning techniques in athletic training education. Educational escape rooms are being used in allied health professions in a variety of modalities and covering a wide array of content. Athletic training educators should consider educational escape rooms as alternative teaching methodology to meet their course goals.

REFERENCES

- 1. Nicholson S. Peeking behind the locked door: a survey of escape room facilities. Published 2015. Accessed October 22, 2021. http://scottnicholson.com/pubs/erfacwhite.pdf
- Lameras P, Arnab S, Dunwell I, Stewart C, Clarke S, Petridis P. Essential features of serious games design in higher education: linking learning attributes to game mechanics. Br J Educ Technol. 2017;48(4):972–994. doi:10.1111/bjet.12467

- Caldas LM, Eukel HN, Matulewicz AT, Fernández EV, Donohoe KL. Applying educational gaming success to a nonsterile compounding escape room. *Curr Pharm Teach Learn*. 2019;11(10):1049–1054. doi:10.1016/j.cptl.2019.06.012
- Barker N, Kaulback M, Yocom D. Fluid and electrolyte escape room. J Nurs Educ. 2020;59(5):298. doi:10.3928/01484834-20200422-14
- Dacanay AP, Sibrian J, Wyllie C, Sorrentino E, Dunbar G. Can you escape sepsis? using a healthcare escape room as an innovative approach to nursing education. *Clin Nurse Spec*. 2021;35(2):65–72. doi:10.1097/NUR.00000000000578
- Haley B, Palmer J. Escape tasks: an innovative approach to nursing education. J Nurs Educ. 2020; 59(11):655–657. doi:10. 3928/01484834-20201020-11
- O'Brien JL. The use of escape rooms to develop critical thinking in physical therapy education. ELC 2020 Virtual Learning Conference; October 17, 2020. Conference abstract. Accessed October 22, 2021. https://apta.confex.com/apta/elc2020/ meetingapp.cgi/Session/9164
- Kinio AE, Dufresne L, Brandys T, Jetty P. Break out of the classroom: the use of escape rooms as an alternative teaching strategy in surgical education. *J Surg Educ.* 2018;76(1);134139. doi:10.1016/j.jsurg.2018.06.030
- López-Pernas S, Gordillo A, Barra E, Quemada J. Examining the use of an education escape room for programming in a higher education setting. *IEEE Access*. 2019;7:31732–31737. doi:10. 1109/ACCESS.2019.2902976
- López-Pernas S, Gordillo A, Barra E, Quemada J. Analyzing learning effectiveness and students' perceptions of an educational escape room in a programming course in higher education. *IEEE Access.* 2019;7:184221–184234. doi:10.1109/ACCESS.2019. 2960312
- Connelly L, Burbach BE, Kennedy C, Walters L. Escape room recruitment event: description and lessons learned. *J Nurs Educ*. 2018;57(3);184187. doi:10.3928/01484834-20180221-12
- Fotaris P, Mastoras T. Escape rooms for learning: a systematic review. In: *Proceedings of the European Conference on Games Based Learning*. Academic Conferences Ltd; 2019:235–243. doi:10.34190/GBL.19.179
- Blankenship A, Tyner R, Ferroni R, Schubert C. Using an escape box in continuing nursing education for multidisciplinary emergency preparedness. *J Contin Educ Nurs.* 2021;52(2):85–89. doi:10.3928/00220124-20210114-08
- Cain J, Piascik P. Are serious games a good strategy for pharmaceutical education? Am J Pharm Educ. 2015;79(4):47. doi:10.5688/ajpe79447
- Clauson A, Hahn L, Frame T, et al. An innovative escape room activity to assess student readiness for advanced pharmacy practice experiences (APPEs). *Curr Pharm Teach Learn*. 2019;11(7):723–728. doi:10.1016/j.cptl.2019.03.011
- Daniel L, Valko J, McAtee TJ, N-Wilfong D. Using an escape room modality to teach mock code essentials. J Contin Educ Nurs. 2021;52(3):118–122. doi:10.3928/00220124-20210216-05
- Eukel HN, Frenzel JE, Cernusca D. Educational gaming for pharmacy students: design and evaluation of a diabetes-themed escape room. *Am J Pharm Educ.* 2017;81(7):6265. doi:10.5688/ ajpe8176265
- Frenzel JE, Cernusca D, Marg C, Schotters B, Eukel HN. Design-based research: studying the effects of an escape room on students' knowledge and perceptions. *J Am Coll Clin Pharm.* 2020;3(7):1326–1332. doi:10.1002/jac5.1290

- Guckian J, Sridhar A, Meggitt SJ. Exploring the perspectives of dermatology undergraduates with an escape room game. *Clin Exp Dermatol.* 2019;45(2):153–158. doi:10.1111/ced.14039
- 20. Gómez-Urquiza JL, Gómez-Salgado J, Albendín-García L, Correa-Rodríguez M, González-Jiménez E, Cañadas-de la Fuente GA. The impact on nursing students' opinions and motivation of using a "nursing escape room" as a teaching game: a descriptive study. *Nurse Educ Today*. 2019;72:73–76. doi:10. 1016/j.nedt.2018.10.018
- Hermanns M, Deal B, Campbell AM, et al. Using an "escape room" toolbox approach to enhance pharmacology education. J Nurs Educ Pract. 2018;8(4):89–95. doi:10.5430/JNEP.V8N4P89
- Kubin L. Using an escape activity in the classroom to enhance nursing student learning. *Clin Simul Nurs.* 2020;47:52–56. doi:10. 1016/j.ecns.2020.07.007
- Peleg R, Yayon M, Katchevich D, Moria-Shipony M, Blonder R. A lab-based chemical escape room: educational, mobile, and fun! *J Chem Educ*. 2019;96(5):955–960. doi:10.1021/acs.jchemed. 8b00406
- Wynn L. An escape room simulation focused on renalimpairment for prelicensure nursing students. *Teach Learn Nurs*. 2021;16(1):95–99. doi:10.1016/j.teln.2020.09.006
- Adams V, Burger S, Crawford K, Setter R. Can you escape? creating an escape room to facilitate active learning. *J Nurses Prof Dev.* 2018;34(2):E1–E5. doi:10.1097/NND.00000000000433
- Hawkins JE, Wiles LL, Tremblay B, Thompson BA. Behind the scenes of an educational escape room. Am J Nurs. 2020;120(10):50-56. doi:10.1097/01.NAJ.0000718636.68938.bb
- Haynes AB, Haukoos JS, Dimick JB. TREND reporting guidelines for nonrandomized/quasi-experimental study designs. *JAMA Surg.* Published online April 7, 2021. doi:10.1001/ jamasurg.2021.0552
- Cohen J. A power primer. *Psychol Bull*. 1992;112(1):155–159. doi:10.1037//0033-2909.112.1.155
- 29. Freeman GG, Wash PD. You can lead students to the classroom, and you can make them think: ten brain-based strategies for college teaching and learning success. *J Excell Coll Teach*, 2013;24(3):99–120.
- Woodworth JA. Escape room teaching pedagogy in the didactic learning environment for nursing. *Nurse Educ*. 2021;46(1):39–42. doi:10.1097/NNE.00000000000847

- Schomaker J, Meeter M. Short- and long-lasting consequences of novelty, deviance and surprise on brain and cognition. *Neurosci Biobehav Rev.* 2015;55:268–279. doi:10.1016/j.neubiorev.2015.05. 002
- Bjork RA, Bjork EL. Desirable difficulties in theory and practice. J Appl Res Memory Cogn. 2020;9(4):475–479. doi:10. 1016/j.jarmac.2020.09.003
- Karpicke JD, Grimaldi PJ. Retrieval-based learning: a perspective for enhancing meaningful learning. *Educ Psychol Rev.* 2012;24(3):401–418. doi:10.1007/s10648-012-9202-2
- 34. Persellin DC, Daniels MB. A Concise Guide to Teaching with Desirable Difficulties. Stylus Publishing; 2018.
- 35. Bloom EM. Creating desirable difficulties: strategies for reshaping teaching and learning in the law school classroom. *Univ Detroit Mercy Law Rev.* 2018;95(2):115–152.
- Strean W. Creating student engagement? HMM: teaching and learning with humor, music, and movement. *Creat Educ*. 2011;2(3):189–192. doi:10.4236/ce.2011.23026
- 37. Pennington E. Brain-Based Learning Theory: The Incorporation of Movement to Increase the Learning of Grammar by High School Students. Dissertation. Liberty University; 2010.
- Wells S. Moving through the curriculum: the effect of movement on student learning, behavior, and attitude. *Rising Tide*. 2012;2:1–17.
- Edwards T, Boothby J, Succheralli L. Escape room: using an innovative teaching strategy for nursing students enrolled in a maternity clinical course. *Teach Learn Nurs*. 2019;14(4):251–253. doi:10.1016/j.teln.2019.05.001
- Gabriel PM, Lieg CL, Holland S, Ballinghoff J, Cacchione PZ, McPeake L. Teaching evidence-based sepsis care: a sepsis escape room. J Contin Educ Nurs. 2021;52(5):217–225. doi:10.3928/ 00220124-20210414-05
- Garwood, J. Escape to learn! an innovative approach to engage students in learning. J Nurs Educ. 2020; 9(5):278–282. doi:10. 3928/01484834-20200422-08
- Lucardie D. The impact of fun and enjoyment on adult's learning. *Procedia Soc Behav Sci.* 2014;142(1):439–446. doi:10. 1016/j.sbspro.2014.07.696
- 43. Wlodkowski R. Enhancing Adult Motivation to Learn: A Comprehensive Guide for Teaching All Adults. 3rd ed. Jossey-Bass; 2008.