

ESCAPE the Boring Lecture: Tips and Tricks on Building Puzzles for Medical Education Escape Rooms

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ABSTRACT: Escape rooms in medical education are a novel, game-based learning approach for teaching medical topics. In these escape rooms, learners complete a sequential series of medical-themed puzzles leading them to “escape” a specific story. Designing puzzles can be anxiety-provoking and may be the gatekeeper for educators in medicine to create their own escape rooms. Though there have been publications on the importance and methods of building a healthcare-themed-escape room, there is a gap in the literature on designing puzzles to teach specific learning objectives successfully. In this Scholarly Perspective, the authors share puzzle ideas and support tools and use Bloom's taxonomy as the framework to teach educators how to design challenging and engaging escape room puzzles.

KEYWORDS: Escape room, game-based learning, medical school education, residency education, fellowship education, gamification

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Introduction

Game-based learning (GBL) capitalizes on the learner-centered shift in medical education approaches to teach topics using game design principles.^{1,2} GBL is an engaging way to improve learning outcomes^{1,3} while creating an environment for active learning, social interaction, peer-to-peer education, and problem-solving.^{4,5} A recent trend in GBL in medical education is the use of escape rooms. In traditional escape rooms, teams solve a series of puzzles and gather clues to “escape” from an enclosed environment within a time limit.⁶ Creating multiple medical-themed puzzles linked together into one “mission” in the escape room format has translated well in medical education.⁷ For example, Zhang et al published an escape room they created to teach intern physicians their institutional patient safety priorities.⁸ Multiple nursing educators have shared their approach to using escape rooms to teach teamwork skills.^{9–12} Similarly, emergency medicine educators described their creation of escape rooms to teach teamwork and communication skills.⁸

Like other forms of GBL, learners consistently perceive escape rooms as effective ways to support team building and increase communication skills.^{13–16} Learners perceive knowledge gains following escape room games and significant increases in knowledge have been shown using pre-post testing.^{17,18} Improvement in critical thinking, problem-solving skills, and creativity are also reported.^{19,20} Through an engaging story discovered through sequential puzzles, escape rooms create environments that foster engagement and teamwork. Several examples in the literature discuss frameworks and tips on creating escape rooms for medical education. These examples tend to be holistic, discussing the overarching goals and theories behind using escape rooms in medical education without the granular details of specific puzzle design.^{7,21,22}

While these frameworks provide an excellent foundation justifying escape rooms as an education tool, there is a dearth of literature on practical “How To” advice for creating puzzles to reflect specific learning objectives. In our experience, this creative hurdle often presents a barrier to educators who might otherwise build their own escape rooms.

The authors all have created and used escape rooms successfully with learners across the continuum of medical education. Subsequently, we created and presented a workshop (*Escape from the Boring Lecture—How (and Why) to Design Educational Escape Rooms*) at a national meeting.²³ Participants described that having the replicable tools for creating different types of puzzles in an escape room and learning how to debrief and teach using puzzles was a particularly beneficial aspect of helping them overcome the anxiety and inertia of creating their own escape rooms.²³ In this article, we aim to empower educators to overcome the most common challenges with developing medical escape rooms—designing and debriefing the challenging and fun component puzzles that address learning objectives. We use the overarching structure of Bloom's taxonomy—a hierarchical ordering of cognitive skills used to help educators create specific and focused learning objectives^{24–26}—as scaffolding on which to organize and present tips on puzzle design.

Building an escape room

At their core, escape rooms rely on experiential learning, aiming to make memories instead of memorizing.⁴ Players complete a series of puzzles that follow a story plot within a time limit to win the game. Puzzles rely on a loop of (1) a challenge to overcome, (2) a concealed solution, and (3) a reward that leads to a new puzzle or ends the game.²⁷ A simple example is being locked in a room with a combination lock on the door. Using the framework: (1) the challenge is



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opening the combination lock, (2) the combination is the concealed solution, and (3) the reward is escaping into the next room. The answers to the concealed solution are where creativity is the only limit. Good puzzles are integrated into the plot of the story and are solvable with the information, logical clues, and equipment provided to the player.²⁷ The same structure is true for puzzles in educational escape rooms; however, a good escape room puzzle must also accomplish the learning objectives of the overall activity (Figure 1).

Bloom's taxonomy

In approaching effective puzzle design, Bloom's taxonomy creates an avenue for connecting puzzles with learning objectives. Bloom's taxonomy is a hierarchal framework for educators to create an interchange where teachers and students can understand the learning objectives for a given educational activity.²⁴⁻²⁶ Furthermore, well-defined learning objectives serve as the foundation for creating a learning activity. In escape rooms, educators should ask themselves "by the end of this escape room or puzzle, the learners will be able to..." filling in the end with the appropriate verb from Bloom's taxonomy.

Objective 1: Remember

In Bloom's Taxonomy, the "remember" objective is about retaining and learning basic facts or recalling events in a step-by-step procedure.²⁸ This cognitive skill is a necessity for nearly every topic in medicine. For example, medical students need to recall the basic structure of the heart before understanding the complexities of different congenital heart malformation physiology. Furthermore, during medical school, most students complete a dissection in an anatomy lab and memorize the different structures of the human body. Depending on the stage of learners and the topic, this objective may be necessary before advancing to more complex objectives.

Puzzle types

In education, crossword puzzles or word searches are an active way for learners to learn and recall content. Saxena et al created

a crossword puzzle to train undergraduate students in identifying key concepts and transferring content in a way that also promoted collaboration.²⁹ Mohan et al found that 85% of students reported that crossword puzzles enhanced their learning of microbiology and immunology and oriented them to the topic.³⁰ Word games can be useful in escape rooms to lead to further clues while teaching content. In our escape room workshop, we used a crossword puzzle with certain blocks highlighted in different colors to signal the importance of that specific letter. After completing the crossword puzzle, the letters were organized by the colors on a rainbow, leading to a new phrase "UNDER THE TABLE" which led the participants to look under the table where their next clue was hidden (Figure 2). Another example used by the authors in an infectious disease escape room is shown in Figure 3. Learners were expected to match the pathogen with its associated confirmatory testing and then place them in alphabetical order. Doing this would give them the vital signs for their patient, helping them move forward in to escape room puzzle. One of the authors helped create an escape room on nephrology topics for medical students. A puzzle in this escape room combined two different puzzles with one portion focused on "remembering." Learners were given 24 cards that contained either a disease name, etiology, histopathology image, and histopathology description. They were required to put them together in sets of 4 for the 6 different nephrology diseases. Once complete, looking at the back of the cards would give them the clues to the next puzzle which was a crossword (Figure 4).

Objective 2: Understand

The "understand" objective refers to comprehending a topic and presenting ideas. Explaining and describing the content is a keystone for this objective. It expands past the "remember" objective in that learners can recall information, paraphrase it into their own words, and explain it to others. The flipped classroom model in medicine utilizes this objective.³¹ Learners are

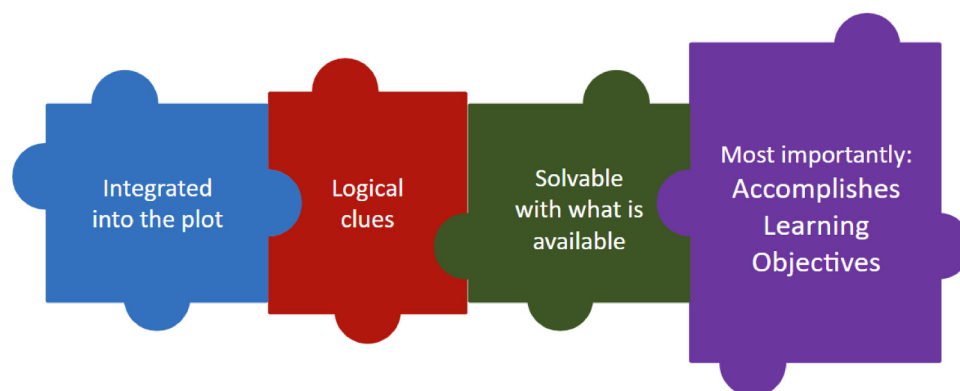


Figure 1. Principles of a good escape room puzzle, adapted from Weimker et al.²⁷

ESCAPE

The Boring Lecture

Task 1: Complete the puzzle
Task 2: Follow the rainbow!

DOWN

1. Weeks to be considered term
5. 5 letters, 6 words, New York Times puzzle game
6. The pediatrician's favorite antibiotic
8. F508 deletion
9. PAS 2023 location
10. When kids make block tower, in months
12. Newborn score in the delivery room
13. Hashtag us on _____
14. Test to find pyloric stenosis
15. PAS 2022 location
18. Best home suction device ever!
21. University of Minnesota Mascot
22. Bronchiolitis cause

ACROSS

2. This person's slap was heard around the world
3. PEM Docs favorite sedation medicine
4. When babies should regain their birthweight
7. Scary sounding, actually benign baby rash
11. Most common heart defect
12. FOAMED is Free Open _____ Medical Education
16. Breathing problem diagnosed at 5yrs of age
17. Most common childhood cancer
19. Jaundice caused by inadequate milk production
20. Common cause of forearm and wrist fractures in kids
23. Koplik spots

All answers are written out. And remember, cheating and looking it up is okay!

FOLLOW the RAINBOW!



Figure 2. Puzzle example using crossword puzzle with highlighted letters when ordered by the colors of the rainbow spelling “UNDER THE TABLE” leading to a subsequent clue.

expected to learn the facts independently and discuss and explain those concepts to each other during the in-class portion.

Puzzle types

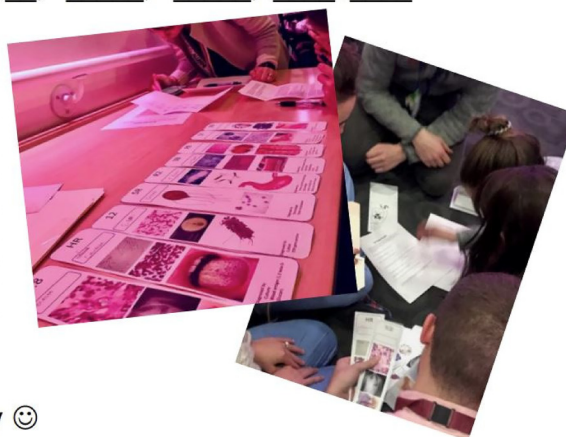
Memory-matching games can accomplish the “understand” objective in GBL. These types of games can be presented in multiple ways—with words, images, or both. An example of

this is creating a matching-memory game using different electrocardiogram (ECG) images that match their associated pathologies. Learners must understand the pathology and its associated ECG findings before putting them together. Other examples include radiological images, laboratory findings, medications, or pathology complications. In a nephrology escape room created by one of the authors, medical students matched nephrology medications with their known renal

Vitals are in **order** to get the diagnosis: _____, _____, _____, _____ / _____

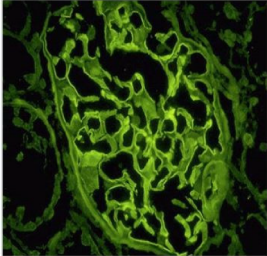
T-3	Aspergillus	Blood/Respiratory antigen (galactomannan), culture
9.8	Blastomyces	Urine antigen, culture
HR	Candida	Blood antigen (glucan), culture
12	ESBL	Culture, presence of <i>AmpC</i> gene
5R	Giardia	Stool antigen, direct visualization
R2	Helicobacter Pylori	Breath test, urine/blood antigen, serology.
3B	Mycobacterium tuberculosis	Interferone gamma releasing assay, histopathology, culture
P8	Neisseria meningitidis	Blood/CSF culture, CSF antigen by latex agglutination
1/	Rickettsia rickettsi	Blood PCR, serology.
39	Staphylococcus aureus	Blood, tissue, fluid culture

T39.8, HR:125, RR:23, BP:81/39



Hint: Sometimes bugs line up alphabetically 😊

Figure 3. Infectious disease escape room puzzle example.

<h2>Goodpasture Syndrome</h2> 	<p><u>Etiology/Associations</u></p> <ul style="list-style-type: none"> • Antibodies against alpha-3 chain of type IV collagen are found in GBM and alveoli • Results in hemoptysis & hematuria • Type I RPGN
	<ul style="list-style-type: none"> • LM: crescents (extracapillary cell proliferation) in Bowman's space • IF: diffuse, linear pattern • EM: GBM damage

7 Across: A 25yo woman presents with low-grade fever and right flank pain for 2 days. She also has mild dysuria and increased urinary frequency. Urine dipstick is positive for leukocyte esterase. What is the most likely diagnosis?

Figure 4. Puzzle example of 4 separate pieces (front) coming together to provide a clue to a crossword puzzle (back).

complications following a case presentation prompt. The back of each combined pair had words that, when put together in alphabetical order of the drug names, would give the clue to the location of the next puzzle.

Participants can also be provided cards that must go in a specific order, such as the vaccine schedule, developmental milestones, or as we did in our workshop, Kern's Six Steps of Curriculum Development. When participants successfully put the individual cards in order of the six steps, the bottoms of the cards spelled out a website that led to the next clue. We used a URL-shortening website (tiny.url.com) to make our own website name for a cloud-based folder which contained a sound file containing a morse code clue. Participants were then able to use a Morse code alphabet posted on the conference room wall to decode the word, which led to the next clue.

Objective 3: Apply

The third level of Bloom's Taxonomy is "apply." Here, learners take the knowledge and skills they attained and apply them to a given topic. Medical students are asked to apply their knowledge and skills in many different parts of their training. For example, applying their knowledge to a theoretical patient during case-based learning or their history-taking skills during communication skills sessions with simulated patients in Objective Structured Clinical Examinations. Furthermore, educating on the appropriate use of clinical guidelines relies on learners understanding information to apply it to a patient.

Puzzle types

Puzzles focused on physical tasks are an excellent way for learners to apply their skills. Different task trainers are commonly used in the simulation labs to apply and hone skills. One idea is utilizing an airway task trainer for learners to apply their airway skills. Puzzle designers can create a scenario in which

learners are required to apply their cognitive skills and identify a foreign body aspiration. A “foreign body” with a clue written on it can be hidden in the trachea of the airway task trainer and equipment such as forceps and a laryngoscope blade can be left out for learners to obtain the clue. The leads learners to apply cognitive and physical skills in one puzzle. Another example the authors have used is having a locked box where a part of the combination was the sum of the ultrasound-measured diameter of vessels in an intravenous (IV) access task trainer. Residents who had previously completed ultrasound training were left with an ultrasound machine and three different (IV) access task trainers. These specific learners had to rely on their previous knowledge and apply it to solve the puzzle.

Creating physical puzzles adds an additional layer and makes educational escape rooms more dynamic and interactive. During the pandemic, mastering donning and doffing personal protective equipment (PPE) became a priority. McLaughlin et al created an escape room puzzle that required participants to identify and don correct PPE per institutional standards before entering a room to find more clues and puzzles.³² Podlog et al created an “Escape the Trauma Room” where residents complete multiple small puzzles involving physical tasks such as arterial line transducer setup, using a cast cutter, and ventilator management.³³ The feedback they received from their learners was overwhelmingly positive, and it fostered team building.²⁸

Objective 4: Analyze

“Analysis” is commonly thought of as critical thinking and essential in medicine. Critical thinking is taught and evaluated in clinical, classroom, and simulation settings. Learners need to be able to break material down into its constituent parts to be able to fully analyze it.²⁴ Educators teach learners to analyze a specific aim and formulate a study design to answer a research question. Clinically, trainees formulate a differential diagnosis and decide between multiple patient scripts to develop an assessment and plan.

Puzzle types

Puzzles using simulated or described clinical cases allow learners to demonstrate critical thinking and analysis skills. One of the authors created a game that randomly generates clinical cases to facilitate case discussions with pediatric residents.⁴ Similar games could be used within an escape room format to stimulate critical thinking. Another example that could be used to meet the objective of the analysis is described by Kaul et al who created a puzzle that required learners to correctly turn multiple wheels to align clinical history, exposure, and imaging findings of interstitial lung disease.³⁴

Objective 5: Evaluate

A further domain of Bloom’s Taxonomy is “evaluation.” Learners commonly learn how to critique and evaluate research

during their training. Many programs have Journal Clubs or Journal Reviews where trainees appraise an article on its study design, research question, analysis, and impact on patient care. Furthermore, in the simulation environment, trainees are placed in settings where they assess simulated patients, make decisions, and reevaluate their management based on the scenario. Attending physicians also use the simulation center to self-evaluate their skills and hone their procedural and clinical acumen in a safe learning environment. To self-evaluate, the individual must have a baseline level of understanding and comfort in self-analysis.

Puzzle types

Using a high-fidelity mannequin in a simulation-based escape room allows for real-time changes in the game. Creating a mid-game change to a mannequin can be done remotely. Furthermore, embedded simulation personnel allow learners to do different evaluations of a situation. Sarage et al used a high-fidelity mannequin to simulate an 84-year-old patient and a confederate to play the family member in an escape room where participants evaluate the patient, identify hypertension, and administer the appropriate medication.³⁵ Another twist was the order they received was incorrect and the nursing students had to recognize the error and correct it.³⁵ In another example, during our escape room, participants had to evaluate an academic poster on clinical disease in long COVID to solve questions which gave them a portion of a clue. This type of puzzle is not limited to posters, and academic journal articles can serve as the venue for the answers.

Objective 6: Create

The top of the revised Bloom’s Taxonomy is “create.” The teach-the-teacher method relies on learners creating. Progression through medicine involves learning how not only to practise medicine but also to lead a team of learners, which is an additional skill. Facilitator training courses are commonplace in simulation, where trainees practise evidence-based debriefing techniques, learn scenario design, and mannequin operation.^{36,37} Also, trainees learn to manage an entire team, creating assessments and plans for each patient while balancing education and creating a safe learning environment. Engaging learners in puzzle design is another method for learners to “create.” Bakkum et al described an opioid escape room in which groups of third-year medical students were assigned to create a prototype escape room. Students appreciated the freedom and creative thinking the assignment provided, although most of the students felt the assignment was too much work.³⁸

Puzzle types

Building a specific puzzle in which learners complete Bloom’s objective of “create” is challenging. However, an escape room can have puzzle answers that combine to expose the principles

of a concept that lead to learners' ability to create something independently. During our *Escape the Boring Lecture* escape room, learners had to navigate a puzzle that involved exposing them to Kern's 6 Steps of Curriculum Development. This was reinforced with a part of the puzzle having the learner place cards with each step represented by an image in the correct order to obtain a URL that led to the next clue. The answer to this puzzle created an avenue for discussion on Kern's 6 Steps of Curriculum Development during the debriefing period. It allowed learners to understand the base concepts in a gamified manner with reinforcement and clarification of its use in future curriculum creation during the debrief. Although the puzzle itself was not directly teaching learners to create a curriculum, the debrief honed their understanding into a path to support future curriculum design.

Weaving together puzzles

Meta Puzzles are used commonly in escape rooms. These puzzles are solved by combining pieces and clues gathered from smaller puzzle solutions to find a final answer to a broader puzzle. For example, one of the authors created a toxicology escape room utilizing a simulation mannequin to mimic symptoms of organophosphate toxicity (wet bedding for excessive sweating, wetness around the mouth for salivation, mydriasis, and tachycardia). Learners were given minimal information and had to analyze clues to reach a definitive diagnosis and solve

the overall puzzle. The author used smaller puzzles to provide hints about what medication and dose were appropriate for the pediatric patient, with the correct dose being the exit to the room.

Identify Games™ created an escape room puzzle box board game (Figure 5a) that relies on finding the correct sequence of 12 physical keys based on a story and can be used to weave together multiple small puzzles. The game comes with multiple keys and for each unique escape room scenario, 12 correct keys need to be placed in the correct order within the 1-h timer. Each key has different designs, including the shape, internal cutout, roman numeral, letter, number, and arrows (Figure 5b). These allow a variety of "correct answers." For example, a letter from the key can be used in a word or multiple-choice question or certain shapes can represent times on a clock. Educators can design their own escape room where a series of puzzles leads to an individual key. During our workshop, we created four puzzles revolving around a story of a child swallowing a battery that used the puzzle box and keys to solve. Each solution would give a small portion of a larger answer.

Debriefing principles in escape rooms

In healthcare simulation, debriefing is just as or even more important than the simulation.³⁹ The same can be said in GBL, where learners must have an opportunity to process and discuss the learning that occurred.⁴ Facilitator-led



Figure 5. (a). Identify Game™ ESCAPE ROOM puzzle box. (b) Identify Game™ ESCAPE ROOM game keys.

postevent debriefing is the most common technique, where a facilitator positions themselves as the expert and guides the learners through their experience, expertise, and training.⁴⁰ Elements in healthcare simulation debriefing that can be used in debriefing an escape room are psychological safety, establishing rules for the debrief, establishing a shared mental model, asking open-ended questions and using silence, and addressing key learning objectives.⁴⁰

Psychological safety

Healthcare escape rooms can be challenging and, at times, anxiety-provoking. These escape rooms provide the opportunity to work through clinical scenarios and hone critical thinking skills under the pressure of a time limit and competition, without any risk to patients. Ensuring a sense of safety among participants is essential in the design of educational escape rooms. Psychological safety is the ability to “behave or perform without fear of negative consequences to self-image, social standing, or career trajectory.”⁴¹ It is the facilitator’s responsibility to create a safe learning environment, during both the pre- and postdebrief in healthcare escape rooms.

Establishing rules of the debrief

Rules can be laid out before the debriefing session to ensure facilitators and learners are on the same page. These rules help create a safe environment for the debrief.⁴² Rules such as confidentiality and validity of everyone’s feedback and the assertion that the focus is on education and not game performance is critical.

Establishing a shared mental model

A shared mental model is “the overlap of individuals’ set of knowledge and/or assumptions that act as the basis for understanding and decision making between individuals.”⁴³ Facilitating learners to review their experience in the escape room provides a shared understanding of the event and reinforces key learning points. In debriefing, it is used to get the participants and the facilitator on the same page.

Asking open-ended questions and using silence

Open-ended questions like “can you tell me about puzzle three” facilitate a better discussion than yes/no questions. Furthermore, it is the facilitator’s responsibility to foster discussion while answering the participant’s questions. Allowing for silence after asking open-ended questions creates space for learners to process their thoughts.

Addressing key learning objectives

Addressing learning objectives is a foundational aspect of the debriefing period. Frequently in escape rooms and serious

games debriefing, discussion on the game itself can overtake the more important elements of the learning objective. Having a specific phase during the debrief to address the learning objectives of the escape room is vital.⁴⁴ A technique is to start with a brief discussion of the puzzle, subsequently transitioning into the learning points of the puzzle.

Escape room puzzles are meant to be a fun and exciting modality to achieve the learning objective, however, without effective debriefing, the key learning points may be lost. Debriefing allows for reflection and self-assessment, clarifying and reinforcing the learning points, discussing team strategies, and an opportunity to provide feedback on the escape room. Escape room creators should focus just as much energy on their plan for debriefing as they do on developing fun and exciting games.

Conclusion

Escape rooms are an excellent adjunct to traditional teaching methods. They can involve little to no cost, can be easily administered to various students, and require a facilitator over an educator. Educational escape rooms provide nonthreatening, collaborative learning through teamwork and communication. Creating a game, let alone an entire escape room can be anxiety-

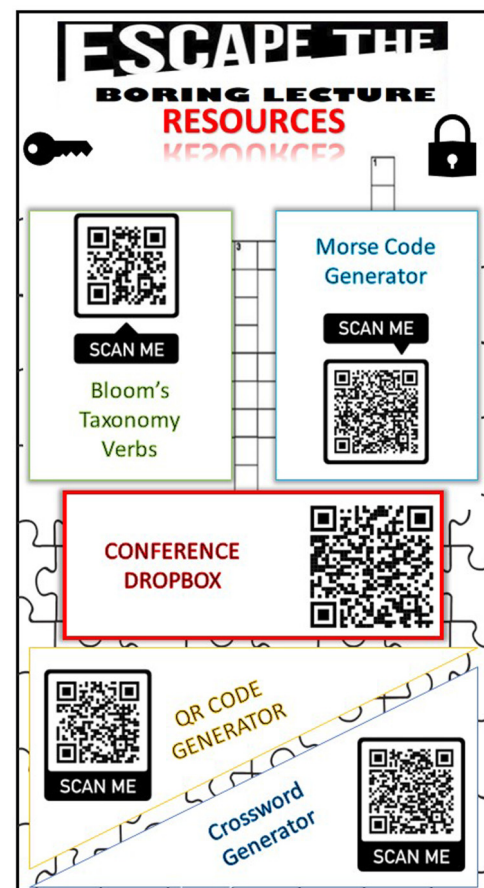


Figure 6. QR code resource flyer from ESCAPE the Boring Lecture Conference.

provoking and daunting for educators. As with conventional educational methods, focused learning objectives are necessary to create a successful educational escape room. A debriefing session is also imperative to clarify any misunderstanding and reinforce the educational objectives of the session. Developing puzzles to facilitate specific learning objectives and weaving the puzzles together using a story or metapuzzle is a method educators can use to design their own escape rooms. This framework for escape room creation with examples of game ideas and resources (Figure 6) provided in this paper should alleviate the initial hurdle to creating new and innovative educational escape rooms.

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