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# Delivering a Novel Medical Education “Escape Room” at a National Scientific Conference: First Live, Then Pivoting to Remote Learning Because of COVID-19

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Escape Rooms are gaining prominence as education modalities; the use of principles of game design have been shown to augment knowledge acquisition in a fun, team-based learning experience (“edutainment”). In this report, we outline some of the medical literature and then provide our step-by-step approach and lessons learned when building what was, to our knowledge, the first continuing medical education Escape Room at a national scientific meeting. We then comment on how this innovative educational offering was reimaged the following year for remote (virtual) learning because of the COVID-19 pandemic.

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**KEY WORDS:** development; education; escape room; gamification; game-based learning; interactive learning

Traditional forms of continuing medical education, including most programming at scientific conferences, are often unidirectional and predicated on passive acquisition of information rather than application of knowledge. Over the past decade, interest in innovative educational techniques has grown, with professional societies increasingly exploring ways to make conference learning more active and thereby add value to in-person attendance. One example is the use of gamification, the application of game design elements to nongame contexts.<sup>1,2</sup> Systematic reviews have shown that gamification seems to be an effective technique to enhance learning in many fields, including medical education.<sup>3,4</sup>

Escape rooms (ERs) are essentially live-action adventure games, popular social activities in which groups of players are “locked” into a purpose-built location to

solve a variety of puzzles along a theme or storyline under time pressure. Success ends the game, and the players “escape.” By definition, an ER is a participatory experience in which individuals are engaged in collaborative problem-solving. When the theme of the room is educational, participants are inherently active learners in a fun, stimulating environment that can enhance knowledge learning and retention.<sup>5-9</sup> Viewed through an educational theory lens, ER design amalgamates concepts of social constructivism, connectivism, emotional engagement, and self-directed learning elements of adult learning theory. These are core concepts of experiential learning,<sup>10</sup> and gamification is achieved by adding game elements of time pressure, strategy, challenge (risk), and payoff (rewards). Rewards can be extrinsic (such as a physical prize for best performance) or intrinsic (such as a sense of satisfaction) in nature. The ER also functions as

**ABBREVIATIONS:** CHEST = American College of Chest Physicians; ER = escape room; VER = virtual escape room

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psychologically “safe” space, in that players can make and learn from mistakes in a low-risk environment.<sup>11</sup>

Herein, we describe how we developed and implemented an ER educational activity at the American College of Chest Physicians (CHEST) 2019 CHEST annual scientific meeting. We then comment on how this was successfully reimaged for remote learning for the 2020 meeting because of the COVID-19 pandemic. Our goal is to provide a blueprint for similar activities so that readers can develop their own creative educational programs.

## Background Literature

ERs are a popular means of collegial team building and entertainment. They have been adapted for educational use in several disciplines that included pharmacy,<sup>5,6</sup> nursing,<sup>7,12-15</sup> and undergraduate education in a variety of fields.<sup>8</sup> Within health professions education, ERs have been used in several specialty applications.<sup>9,16-19</sup> The goals of ER activities vary but generally fall into three categories when used in a medical setting. First, they aim to enhance or reinforce knowledge.<sup>5-9</sup> Second, the collegial nature of the activity may be used to encourage a culture of safety<sup>16,20,21</sup> to promote teamwork<sup>22</sup> and interprofessional education,<sup>15,23</sup> or to foster wellness in a stressful setting such as residency recruitment or during orientation to new programs.<sup>13,19</sup> Third, ERs have been developed successfully for skills building<sup>11,24</sup> that include disaster preparedness,<sup>18</sup> chronic disease management,<sup>5</sup> and procedural training.<sup>10</sup>

ERs are both well-received and effective as an educational technique. In one study, participants changed how they viewed patient safety threats after an ER experience.<sup>16</sup> In a large pharmacy management course, 91% of participants indicated improved engagement in problem-based thinking in an ER format as opposed to a traditional classroom.<sup>6</sup> Other studies have demonstrated increases in participants’ desire to work in a team,<sup>25</sup> improved critical thinking and clinical communication skills,<sup>22</sup> and improved interprofessional teamwork.<sup>22</sup> Importantly, an ER need not have a medical theme to develop teamwork skills and attitudes in medical participants. Participants of one study that involved emergency medicine residents highlighted similarities between a nonmedical commercial ER experience and the ED and reported that the experience motivated them to learn more about overcoming barriers to teamwork, managing conflicting personalities and other personal differences, and multitasking.

Participants recommended additional ER activities with other medical professions and participants at various levels of training.<sup>16</sup>

## Case Example: CHEST 2019 ER

### *A Starship Experience*

One year before the meeting, two of the authors (V. Kaul and W.F. Kelly) conceived of the idea, created the theme and storyboard, and recruited the remaining authors and CHEST staff to collaborate on creating learning objectives, individual puzzles, physical props, and implementation. In “A Starship Experience,” players board a damaged spaceship and must use their pulmonary and critical care knowledge to save its crew and the lifesaving vaccine prototype it is transporting (Fig 1).<sup>26</sup> Five puzzles were built to cover a broad range of pulmonary topics and maximize the educational value. However, we also desired a high success rate (80%) during the relatively short play time. To achieve this ER success rate, based on pilot testing with a variety of learners, it was decided that players would be allowed to “escape” the room by successfully solving any three of these puzzles.

For the physical space, rooms at a hotel near the conference were reserved. Two identical ERs were planned to double learner throughput, with shared entrance and exit areas for learner orientation and debrief, respectively. Puzzles and props were purpose-built at the CHEST Headquarters (Chicago, IL) to be transported and reassembled at the conference. In the months leading up to the conference, full-scale assembly and pilot testing were performed; staff members with no knowledge of the project completed the experience from start to finish. These rehearsals identified several needed improvements to puzzles, props, and set game time. [Online supplemental materials](#) show images and links to videos, including use of social media to promote curiosity without revealing content (e-Figs 1 and 2).

The ER experience was included in the cost of conference registration, and both advance online and walk-up/standby registrations were encouraged. Event duration was set at 20 to 40 minutes per 6- to 8-person group. Thematic decorations in the rooms and waiting areas helped set the scene and build excitement. Before entering the ER, players watched an introductory video in the “player waiting area” (Fig 1) that revealed the game scenario and the objectives of the educational exercise (e-Fig 3). Authors acted as in-room guides, role-playing in costume to facilitate learning by pointing

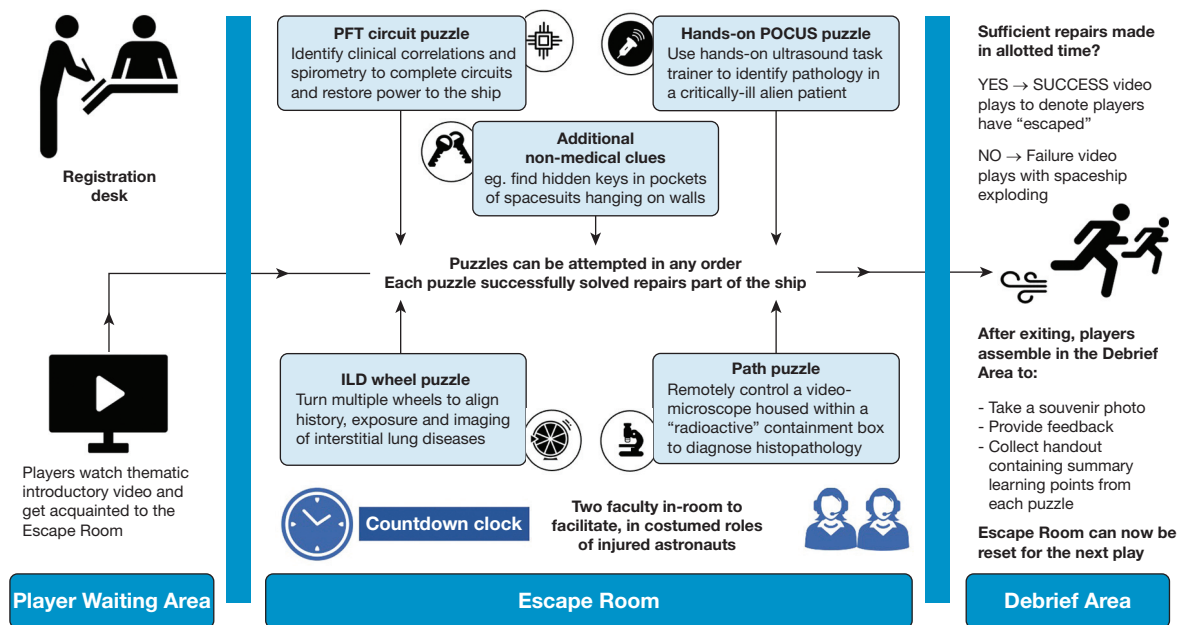


Figure 1 – CHEST 2019 Escape Room. ILD = interstitial lung disease; path = pathology; PFT = pulmonary function test; POCUS = point-of-care ultrasonography.

participants in the right direction if they were struggling, but they were deliberately unhelpful in solving the actual puzzles. A demonstrative set of sample prompts that can be used by moderators for an ultrasound-based puzzle can be reviewed in the e-Table 1. Some participants knew each other, but many were assigned randomly to groups; clinical expertise ranged from nonmedical guests to senior practicing physicians. A postgame “debrief area” (Fig 1) allowed players to take a souvenir picture, provide and receive feedback, and review learning points for the educational content (e-Fig 4).

## Approach to Creating an Educational ER

### Establish Learning Goals and Objectives

As with any educational experience, the first step when creating an educational ER is to identify an overarching goal for the activity. Ours was to engage learners in a team-based approach to the diagnosis of pulmonary and critical care disorders that included history and examination, radiology, and pathology. ER designers must define discrete learning objectives clearly with the use of the SMART (specific, measurable, attainable, relevant, and timely) framework.<sup>27</sup> Each individual puzzle or task should be connected to a learning objective while also advancing the theme. In our example, completing “circuits” on a spaceship control panel required participants to match classic high-resolution CT pattern images with lung histopathologic

findings. Solving this puzzle advanced the overall theme by restoring power to part of the ship. Specific objectives ensure a discrete, measurable gain in knowledge and are keys to the determination of “success” of the escape when providing post-activity feedback to learners.

Designers should ensure that learning objectives and puzzle solutions are attainable. Difficulty can be calibrated to intended participant experience and expertise, and although the activity should be challenging, success should be achievable by most learners (individually or as a group). We aimed to engage a wide range of players to stimulate interprofessional collaborative learning, so our puzzle solutions encompassed a range of clinical expertise. Finally, learning objectives should be timely, which means that the knowledge or skills are acquired, assessed, and/or used in an appropriate timeframe. The subjects of our puzzles were all common topics in pulmonary and critical care medicine that participants reasonably could expect to encounter on any given day in clinical practice. Ultimately, the discrete learning objectives associated with each puzzle should combine to meet the goals for the room as a whole. By completing the mission of saving the spaceship, for example, players get intrinsic rewards for having demonstrated this learning.

After establishing the scope of the project as defined by its learning goals and objectives, designers must develop

the theme or story of the room, determine the number of players and their flow through the experience, and create the constituent puzzles that players will have to solve. These elements will likely not occur sequentially but will overlap during the creative process. We have separated them here to explore key components of each element (Table 1).

### *Develop a Theme and Storyline*

Social diversion and a desire to solve puzzles may be adequate to drive engagement for some learners. However, player commitment to the theme or storyline can enhance the experience, sense of community among participants, and intrinsic reward on successful completion. A creative theme can also compensate for production shortcomings, such as scenery or props limited by budget constraints. The theme can be anything that resonates with the target audience: realistic (a bank vault), fantastic (medieval castle), or drawn from popular culture. A storyline related to one's conference location or current events may also drive participation and engagement. The chosen theme and storyline must provide ample opportunities for story elements to accommodate all the desired learning objectives in the form of individual puzzles. Player immersion into the theme allows for suspension of disbelief as in theatre or cinema and increases learner activation and attention by raising the stakes beyond failing or succeeding at the game itself. In our case, failure resulted in the explosion of the spaceship and loss of a vaccine prototype that could help billions of people. At the same time, designers must take care to balance even imaginary risk with a sense of fun or fantasy that allows players to tolerate a lack of success.<sup>28</sup> Some data suggest that learners can experience significant emotional distress in a simulated setting with a poor outcome.<sup>29,30</sup>

### *Determine an Appropriate Number of Participants*

When the number of participants is potentially large, such as at an international conference, designers should consider the size of groups per round of play. Groups of three to ten players work well for most ER experiences; play is influenced by the size of the room, the number of puzzles and complexity, whether players must complete the puzzles sequentially (vs individuals or subgroups working on different puzzles in parallel), and the total time available. Avoidance of overcrowding of the physical space is important because it can lead to learner disengagement or safety issues. For the CHEST 2019 ER, we estimated an approximate number of total players and assessed our resources (time, space, and staff

support) to group eight players in each 620 square foot space for up to 20 minutes with puzzles that could be solved in any order and could be played in parallel or in sequence. This allowed players to spread out and attempt multiple puzzles simultaneously but also get to try each puzzle. In this way, more individuals could contribute to the team's overall performance.

### *Create Individual Puzzles and Weave Them into a Complete Experience*

Designing the constituent puzzles of an ER can be the most rewarding and challenging part of the creative process. Classic games, brain teasers, and illusions can be repurposed into puzzles such as anagrams, riddles, hidden images, or objects to be reassembled. A single puzzle may incorporate several elements, such as the use of a black light to reveal an anagram or the use of a magnet, won from an earlier successful puzzle, to reach a distant object. An ideal ER experience includes puzzles that vary in topic, design, and method of play. Constructing a table with a list of puzzles with their integral elements, functional details, and story integration can help ensure that interactions within the game are feasible, interesting, and logical.

Designers should consider the number of players and time available in addition to the room's overall degree of difficulty and that of each individual puzzle. A puzzle with a 100% success rate may be inadequately challenging but could provide a boost of confidence to a learner who finds other puzzles impossible. A variety of difficulty levels can engage different learners and encourage teamwork. Similarly, designing multiple potential strategies or solutions for a particularly challenging puzzle can help mitigate frustration, foster player creativity, and allow for a broader range of players. For example, a puzzle that requires players to match the radiographic finding of a specific diagnosis with its pathologic correlate could have nonmedical clues embedded in the images, which would allow early trainees or nonmedical players to participate.

Puzzles can be linked such that individual solutions not only advance the story but also "unlock" new game elements. For example, a correct answer to one area of the room may reveal a tool elsewhere or knowledge required for a different puzzle. In this way, parallel or nonlinear play allows groups to divide their efforts and engage with several puzzles simultaneously, avoiding a bottleneck at a single location, yet assist each other and move the game forward as a whole. Puzzles that require cooperation can be designed specifically to meet learning objectives regarding communication, leadership, and teamwork.

**TABLE 1 ] Summary of Steps in Building an Escape Room Build With Challenges and Suggested Solutions**

Steps	Challenges	Considerations
Establish learning objectives	Wide range of training level and clinical experience at a national specialty conference	Use the SMART (specific, measurable, attainable, relevant, and timely) framework to define the goals for individual puzzles and overall room.
	Teaching time limited, often to an hour or less	Vary puzzle difficulty and type to accommodate different learners.
Develop a theme and a storyline	Identify a storyline that is engaging for the audience and practical for the build of the escape room	Limit number of learning objectives required to escape and refine based on rehearsals.
		Choose a theme that resonates with conference attendee demographics.
		Can be realistic or fantasy.
Determine number of participants	Smaller group sizes and/or longer play times for each group are beneficial, but this completes with “throughput” (number of total learners that can have experience)	Storyline related to the city, theme of the meeting, or specialty may resonate.
		Theme/story inspires individual puzzles and should tie them together.
		Number of participants per room is roughly four to ten but should be determined by the size of the room, by the ability of players to complete the puzzles sequentially or in parallel, and by the heterogeneity of player expertise.
		Faculty development and rehearsals help moderators facilitate rooms.
Create individual puzzles	Combine medical content with a physical puzzle that is engaging but feasible	Some individuals that sign up in advance will not show up
		On-site demand may be high as excitement builds: how will you deal with turning people away?
		Level of difficulty
		Remote (virtual) escape rooms are limited only by the number of trained moderators, but training is critical for a uniformly good experience.
		Avoiding bottlenecks
Solidify the build: equipment and resources	Available budget	Ensure puzzle types are varied to appeal to players with different strengths.
		Complicated is often not better; classic games, brain teasers, and illusions can be repurposed into puzzles such as anagrams, riddles, hidden images, or reassembling objects.
		Incorporate alternative potential solutions for the puzzles (ie, “an out”), which help mitigate frustration and foster player creativity.
Solidify the build: equipment and resources	Conference center rules (capacity, fire codes) and on-site resources	Peer review the puzzles ideas before build.
		Before your conference, pilot the physical puzzles and props with uninvolved people who will give you candid feedback on difficulty and enjoyment; be sure to time them and add 15% when you set time for actual event.
Solidify the build: equipment and resources	Conference center rules (capacity, fire codes) and on-site resources	Incorporation of parallel, nonlinear play in the room allows players to select puzzles that match their abilities and reduces bottlenecking of the entire group on one puzzle.
		Rooms can be subdivided via screens, curtains, or “doors” made of thin plywood or poster board into “zones” to allow work on different puzzles.
Solidify the build: equipment and resources	Conference center rules (capacity, fire codes) and on-site resources	Room size must take into account the number of simultaneous players and also allow the entire group to work on a single puzzle at the same time if they choose.

(Continued)

**TABLE 1 ] (Continued)**

Steps	Challenges	Considerations
	Solicit interested faculty volunteers for build and/or test subjects and/or moderators	Ensure the site has adequate, widely dispersed electrical outlets and the necessary power and surge protection to support all required electronics.
		Use props to create an environment that helps the learners buy into the theme and truly suspend reality but not be too distracting.
		Strategic use of lighting and shadows and inexpensive sensory devices, such as fog or white noise machines, can “hide” imperfections in stagecraft.
		Parts handled by multiple learners will break or go missing, so have spare supplies on hand.
		Rehearsals and having trusting relationship between faculty and staff to share feedback are essential.
Solidify learning: debrief and/or asynchronous materials	Effective feedback	Conduct in a separate space so the escape room can be “reset” and allow entry of new players.
	Retain educational content	Keep debrief area away from registration/ orientation zone to avoid giving answers/ surprises away.
	No delayed entry of next group of players	Bidirectional conversation that is structured and provides an avenue for the players to offer feedback.
		Provide durable material, such as a digital file accessed with a QR code, that highlights the major learning points of individual puzzles and scientific literature references.

One or more embedded facilitators are often helpful for game play and to monitor the safety of individuals and props in the room. They can exist as passive, disembodied voices from another room only responding as needed or active participants in the action. If the latter approach is used, other participants may be aware of their role, or they can be covert operatives. However they present themselves, moderators can supply hints if players are becoming frustrated, or if a group is moving along too quickly to feel they had an adequate challenge, by adding a cognitive load with intentional misdirection (e-Fig 5). Such faculty adaptation in real-time to maintain the learning environment during a simulated scenario is well-established in medical education.<sup>31</sup>

Moderators should practice in advance, ideally as both a learner (ignorant of the puzzle answers) and then with test players who are either new to the puzzles or can pretend to be so. These sessions allow puzzle designers and moderators to anticipate difficult points and practice guidance techniques and are particularly

important with potential for technology failures. For large programs with multiple moderators, designers may consider providing standardized prompts for moderators to use when needed.

Successful resolution of the game (ie, “escaping”) should require players to solve most, if not all, of the puzzles and lead to a thematic payout to cap a fulfilling experience. Failure, on the other hand, may occur due to running out of time or a misstep during a critical puzzle. Even participants who “fail” merit a fitting conclusion to the storyline, ideally one that is not too disastrous, as discussed earlier. All players should be debriefed or at least receive a summary of key learning points at the end of the experience to reinforce learning.

#### *Solidify the Build: Equipment and Resources*

By sharing this approach, we want to highlight that both in-person ERs and virtual/on-line ERs (VERs) can be designed feasibly by medical educators. We do recommend including team members with a breath of

expertise (such as audio/video editing, creating visuals, simulation, gamification, and question or puzzle creation). These attributes typically do not need specialized training. Our team of creators had no prior experience in the creation of ERs before creating this activity. In terms of the time commitment, the creators for CHEST 2019 ER first met about a year ahead of the conference. The initial weekly set of conference calls to decide on core concepts such as the theme, topic to be covered, type of puzzles to be included, and spatial organization were followed by monthly coordination calls to ensure ongoing productivity and planning. Between phone calls, faculty work on assigned puzzles individually (one puzzle per author). Just like any evolved educational activity, the preparation for ERs is an involved process.

It is possible to create an engaging ER experience on a limited budget. A single room can be divided into open “zones” for individual puzzles and allow pieces or solutions of individual puzzles to overlap in creating a final solution. Alternatively, single rooms can be subdivided via screens, curtains, or “doors” that are made of thin plywood or poster board. These dividers can be moved when a puzzle is solved, and the group is ready to move into the next “room.” The site should have adequate facilities to support any needed equipment, such as widely dispersed electrical outlets and surge protection. Depending on the intricacy of game design, this may include lighting, cameras, microphones, computer screens, and any electronic components of the puzzles themselves. Appropriate use of shadows can hide wires, camera equipment, or other logistical devices that may otherwise distract players. Creative lighting and ancillary inexpensive sensory obfuscation devices such as fog or white noise machines will also hide imperfections in stagecraft.

Puzzles can consist of or include elaborate physical elements, with flashing lights and working switches, buttons, and levers. But even simple props can augment the participant experience by providing physicality and a tactile sensory component. Solid shapes can be used for a matching game, like an advanced version of a child’s toy. A spinning wheel with images is constructed easily with a large piece of cardboard. A rudimentary tool that is won by solving one puzzle and is used to open a box or lift a weight in another could be made from a common household item wrapped in tin foil or otherwise simply adorned. Whatever is used, having spare parts for props is critical, because components handled by a large number of learners may break or get lost.

Once the learning objectives are established; the puzzles are designed, and at least a rough version of the physical elements are built, designers should leave adequate time to pilot the experience with novice players. This allows developers to gauge difficulty and acceptability of the components, to assess the size and design of the room as a whole, to estimate the completion time, and to identify points at which moderators may need to provide helpful hints. Many ER activities will require limited testing and refinement; however, for a large audience, such as a national conference, developers may need to conduct multiple iterations of testing before live operations. Finally, equipment will need to be transported safely and assembled on-site, which in our case required a dedicated team of professionals that included clinicians, educators, and technical staff. Because our team was working in-person at the CHEST Headquarters in Glenview, IL, before the conference, we built the puzzles in Illinois and had them transported to the conference site along with other equipment typically transported from the Headquarters for any annual Conference. However, for ERs designed in-situ at institutions such resources would not be needed and would make designing the activity significantly less resource intensive.

#### *Reinforce Learning: Debriefing the Learners and Solidifying Key Teaching Points*

After completion of the ER activity, regardless of the outcome (ie, “win” or “lose”), learners should have the opportunity to provide and receive feedback. We created a social atmosphere for team photos to encourage participation. The possibility of failure is essential and thrilling, but players who do not escape may face significant disappointment. Strategies for mitigating this disappointment and associated negative reinforcement in such learners include (1) emphasizing the medical knowledge gained and reinforced in a collaborative manner during the event and avoiding focusing on just the outcome, (2) sharing the ER failure rate (peer comparison), especially if it is significant, and (3) encouraging players to try the activity again at a later time. Another technique we use for one room only was a “twist” at the end of the story that minimizes the failure impact. Of course, as with all good storytelling, this must be believable to be satisfying, avoiding *deus ex machina*.

To solidify key learning points, designers could use any number of tools. In-person discussion may work well for small groups; the PEARLS (Promoting Excellence and Reflective Learning in Simulation) blended approach is



an effective tool for dedicated educational venues.<sup>32</sup> In addition or as an alternative for larger groups, asynchronous material that participants can review at their leisure may be more appropriate and reinforce learning with spaced repetition. For example, after the CHEST 2019 meeting ended, we sent players a packet of educational materials by email that covered the learning objectives of each puzzle.

With this 3-hour pilot project, approximately 100 physician learners in teams as small as two to three, along with many nonphysician guest observers, experienced the ER in an average of 20 minutes, with a success rate of >90%. High learner satisfaction with medium-to-low difficulty level was voiced during debriefs, with all participants reporting that they would very highly recommend the activity to colleagues. Ten participants also completed on-line surveys and agreed that the ER was “relevant” and “helpful” to their clinical practice (3.11 on scale of 1 to 4) and “preferred over traditional meeting lectures” (3.20 on a scale of 1 to 4). Free text comments reinforced the importance of keeping group size small, and some participants wanted the option of viewing videos of their own performance after the event.

### The COVID-19 Contingency: VER

When the CHEST 2020 annual meeting appropriately became remote (virtual) due to the pandemic, we piloted an online version of our ER. Although much of the clinical puzzle data (CT scans, pathology images, pulmonary function tests) could still be used, thematic immersion, delivery platform, and faculty development had to evolve considerably. Our group played commercial, nonmedical on-line ERs to get ideas for possible formats. Our recommended VER building considerations included the following questions: (1) Will the experience be autonomous and self-paced (like a video game) or live with a moderator? (2) Would the experience work better in a single player or small group format? (3) How can player registration and screening be performed efficiently? (4) How do we assess the need for any digital or physical materials to be sent to players ahead of time to help prepare for the VER? (5) How do we determine the appropriate use of technology (content display, broadcasting, security, and minimizing the inevitable technical difficulties)? (6) The all-important aspect: How do we ensure faculty development?

We chose a live, small group experience guided by a moderator to maximize engagement and sense of

community and with no player prework required. Players signed up individually and were grouped randomly, although we suggest allowing team sign-up and, when possible, the assignment of individuals deliberately to ensure diversity of medical expertise. The number of learners that register but do not attend an educational event varies but consider overbooking by 20%. In lieu of a physical ER, players were shown a hyperlinked, multimedia PowerPoint (Microsoft Corporation) file (e-Fig 6) over a Zoom (Zoom Video Communications, Inc) video call. Videos and images replaced the hands-on puzzles, which, along with thematic orientation materials, could be created by faculty (W.F. Kelly) at no or low cost that were enhanced by purchased on-line stock photos.<sup>30</sup> On game day, players joined a Zoom call and were placed in teams via breakout rooms, thus becoming passengers on a space shuttle headed to the CHEST 2120 meeting on Jupiter Station. A potential catastrophe ensues, and players must work together, vocalizing suggestions to identify solutions through consensus and resolve the crisis. Faculty moderators (e-Fig 7) who controlled this slide set were pulmonary, critical care, and sleep medicine physicians who played the role of the shuttle pilots (someone who could help but had no medical knowledge). A Zoom vendor managed breakout rooms and provided technical support.

A detailed script was provided to each moderator that contained puzzle answers and lists of responses to all anticipated player comments and questions along with supportive prompts to provide struggling teams contingencies in the event of technical problems and tips for handling quiet or disruptive learners. Each moderator had to be a player first and then serve as a moderator with other moderators as players. This took 2 to 3 hours per faculty member but allowed identification and correction of most technical difficulties, enhanced improvisation skills, and, we believe, ensured quality and reliability across player groups.

VERs improve access for international participants and are scalable, limited only by the number of moderators. A 1-hour slot per day for 4 days was offered, and there were >100 players across 20 different moderator groups. As per the completed post-event survey, players were split equally between physicians in practice and trainees. Average completion time of the activity was 47 minutes out of the maximum provided time of 60 minutes, with very high self-reported learner satisfaction on the post-activity survey. Our group currently is planning both additional live and virtual ER experiences for continuing medical education.

## Conclusion

In summary, a medical knowledge ER, although novel, is well-grounded in educational theory, is feasible in a live or remote format even for large groups of participants such as an international scientific meeting, and provides meaningful, engaging, small group learning with high learner and faculty satisfaction.

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**Additional information:** The e-Figures, e-Table, can be found in the Supplemental Materials section of the online article.

## References

1. Deterding S, Sicart M, Nacke L, O'Hara K, Dixon D. Gamification. using game-design elements in non-gaming contexts. In: CHI '11 Extended Abstracts on Human Factors in Computing Systems [Internet]. New York, NY, USA: Association for Computing Machinery; 2011. p. 2425-8. (CHI EA '11).<https://doi.org/10.1145/1979742.1979575>. Accessed February 15, 2021.
2. Rutledge C, Walsh CM, Swinger N, et al. Gamification in action: theoretical and practical considerations for medical educators. *Acad Med*. 2018;93(7):1014-1020.
3. Hamari J, Koivisto J, Sarsa H. Does gamification work? A literature review of empirical studies on gamification. In: Proceedings of the 47th Annual Hawaii International Conference on System Sciences. January 6-9, 2014; Article number 6758978.
4. Gentry SV, Gauthier A, Ehrstrom BL, et al. Serious gaming and gamification education in health professions: systematic review. *J Med Internet Res*. 2019;21(3):e12994.
5. 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.
6. Cain J. Exploratory implementation of a blended format escape room in a large enrollment pharmacy management class. *Curr Pharm Teach Learn*. 2019;11(1):44-50.
7. 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.
8. 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*. 2019;76(1):134-139.
9. Guckian J, Sridhar A, Meggitt SJ. Exploring the perspectives of dermatology undergraduates with an escape room game. *Clin Exp Dermatol*. 2020;45(2):153-158.
10. Rincón SXJ, Mejia AT. The learning behind the escape room. *Med Teach*. 2020;42(4):480-481.
11. Rosenkrantz O, Jensen TW, Sarmasoglu S, et al. Priming healthcare students on the importance of non-technical skills in healthcare: how to set up a medical escape room game experience. *Med Teach*. 2019;41(11):1285-1292.
12. 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.
13. Connelly L, Burbach BE, Kennedy C, Walters L. Escape room recruitment event: description and lessons learned. *J Nurs Educ*. 2018;57(3):184-187.
14. Morrell BLM, Ball HM. Can you escape nursing school? Educational escape room in nursing education. *Nurs Educ Perspect*. 2020;41(3):197-198.
15. Kutzin JM. Escape the Room: Innovative Approaches to Interprofessional Education. *J Nurs Educ*. 2019;58(8):474-480.
16. Zhang XC, Diemer G, Lee H, Jaffe R, Papanagnou D. Finding the 'QR' to patient safety: applying gamification to incorporate patient safety priorities through a simulated 'escape room' experience. *Cureus*. 2019;11(2):e4014.
17. Podlog M, Husain A, Greenstein J, Sanghvi S. Escape the trauma room. *EM Educ Train*. 2019;4(2):158-160.
18. Patineau A, Leonowics N, Mlynarek C. Escape Room: An Innovative Approach to Teaching Disaster Preparedness to Emergency Medicine Residents and Medical Students. The Western Journal of Emergency Medicine; Orange [Internet]. 2019;20(4). <https://search.proquest.com/docview/2270968668/citation/21505DF207F94491PQ/1>. Accessed February 3, 2021.
19. Jambhekar K, Pahls RP, Deloney LA. Benefits of an escape room as a novel educational activity for radiology residents. *Acad Radiol*. 2020;27(2):276-283.
20. Backhouse A, Malik M. Escape into patient safety: bringing human factors to life for medical students. *BMJ Open Qual*. 2019;8(1):e000548.
21. Diemer G, Jaffe R, Papanagnou D, Zhang X, Zavodnick J. Patient safety escape room: a graduate medical education simulation for event reporting. *MedEdPORTAL*. 2019;15:10868.
22. 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.
23. Friedrich C, Teaford H, Taubenheim A, Boland P, Sick B. Escaping the professional silo: an escape room implemented in an interprofessional education curriculum. *J Interprof Care*. 2019;33(5):573-575.
24. Terrasi B, Badoux L, Abou Arab O, et al. Escape game training to improve non-technical team skills in the operating room. *Med Teach*. 2020;42(4):482.
25. Gordon SK, Trovinger S, DeLellis T. Escape from the usual: development and implementation of an 'escape room' activity to assess team dynamics. *Curr Pharm Teach Learn*. 2019;11(8):818-824.
26. WFKfilms. Starship Escape Room [Internet]. 2019. [https://www.youtube.com/watch?v=XgNl\\_JCgHxA&feature=youtu.be](https://www.youtube.com/watch?v=XgNl_JCgHxA&feature=youtu.be). Accessed February 15, 2021.
27. Bjerke MB, Renger R. Being smart about writing SMART objectives. *Eval Program Plan*. 2017;61:125-127.
28. Corvetto MA, Taekman JM. To die or not to die? A review of simulated death. *Simul Healthc*. 2013;8(1):8-12.
29. Lateef F. Maximizing learning and creativity: understanding psychological safety in simulation-based learning. *J Emerg Trauma Shock*. 2020;13(1):5-14.
30. Henriksen JW, Altenburg C, Reeder RW. Operationalizing healthcare simulation psychological safety: a descriptive analysis of an intervention. *simulation in healthcare*. 2017;12(5):289-297.
31. Dieckmann P, Lippert A, Glavin R, Rall M. When things do not go as expected: scenario life savers. *Simul Healthc*. 2010;5(4):219-225.
32. Eppich W, Cheng A. Promoting excellence and reflective learning in simulation (PEARLS): development and rationale for a blended approach to health care simulation debriefing. *Simul Healthc*. 2015;10(2):106-115.