Creative Education, 2024, 15, 2099-2110
https://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

Case Study to Escape Room: The Design of a Parkinson's Disease Based Escape Room

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How to cite this paper: Slauson, S. R. (2024). Case Study to Escape Room: The Design of a Parkinson's Disease Based Escape Room. *Creative Education, 15,* 2099-2110.
https://doi.org/10.4236/ce.2024.1510129

Received: September 7, 2024
Accepted: October 25, 2024
Published: October 28, 2024

Abstract

Many active-learning and experiential pedagogies have been reported in recent years demonstrating increased engagement and student learning outcomes. These activities often enable higher Bloom's taxonomy questions to be employed while enabling collaboration and peer learning in addition to developing soft skills such as leadership and conflict resolution. Most of these pedagogies point to an increase in critical thinking, a difficult skill to teach and evaluate in a typical classroom setting yet one of the most referenced by employers. This article describes the conversion of a case study into an escape room activity which was utilized as a midterm exam in an upper-level neurochemistry elective course. As case studies are anchored in both active and experiential learning models, a more interactive activity such as an escape room reinforces those ideals with increased appeal from the student perspective.

Keywords

Active Learning, Case Study, Escape Room, Neurochemistry, Parkinson's Disease

1. Introduction and Literature Review

Active learning and experiential learning are certainly not new concepts in the perspective of human evolution yet have made an emergence as new pedagogies in education in the past few decades. Active learning is an instructional method that seeks to engage the student more actively than passive activities such as listening to lectures and taking notes (Brame, 2016). Experiential learning targets exercises that immerse the student in an experience typically followed by immediate reinforcement techniques such as reflection or questioning (Northern Illinois University Center for Innovative Teaching and Learning, 2012). Considering the active approach intersects cohesively with the experiential technique in as much as the activity demonstrates experience common to the subject, many activities belong to both, such as case studies (Atkinson et al., 2020).

A case study in its simplest form is a study of a specific person or situation (Toogood, 2023). These are often used in education to reinforce major learning objectives and reveal applications to students by describing a particular problem and asking a series of questions that lead students to the solution. When performed in a group format, they can also incorporate collaborative and metacognitive learning by allowing students the opportunity to discuss their view and support it with evidence (Mutambuki et al., 2020). Case studies have gained widespread acceptance in secondary and higher education and have even spawned sites specifically for sharing resources such as the National Science Teaching Association (NSTA, 2013).

An escape room can be adapted from a case study benefiting from active, collaborative, and experiential learning. Metacognitive learning may be observed but is not the focus of an escape room due to time constraints. Escape rooms have also gained acceptance with sites such as Breakout EDU focused on sharing content, but far fewer examples have been published than for case studies (Breakout EDU, 2018). This process takes more planning and thought than most other active-learning techniques but can be highly rewarding and exciting if implemented correctly (Veldkamp et al., 2021). A review correlating the design and implementation elements of escape rooms to course objectives and soft-skills application was recently published (Veldkamp et al., 2020). This article will attempt to provide a guide for extending a case study based on the PBS special "The Frozen Addict" into a more interactive escape room (The Case of the Frozen Addict, 1986).

2. Methodology: Escape Room Design

2.1. Why an Escape Room?

Escape rooms are a contemporary way for students to spend free time with friends that provide a challenging environment requiring teamwork and careful analysis of the data provided to escape. This is exactly what we would like for our students to do in class—use teamwork and careful data analysis to answer questions centered on course learning objectives. There are many aspects that may not be as useful or appropriate in the classroom—flashing lights, complete darkness, handcuffing or blindfolding participants, etc.—but others that we can easily utilize such as lock boxes, door codes, anagrams, picture puzzles, diagnostics, and many others. These smaller activities typically work in an additive nature with several smaller actions leading to a larger outcome—like opening a lockbox. When polling my classes, I found that most students had participated in at least one escape room with a core group in each class that had completed several. With an average cost of $30 - 40 per participant, an average time of 1-hour, and dedicated rooms being constructed for the activity, academic escape rooms may not be an exact replica, but many students would rather play an escape room game than listen to another lecture or fill in another short-answer worksheet on these same concepts.

2.2. How to Utilize

The first question to ask is how the escape room will be utilized—to introduce a new concept, to evaluate where students are at the beginning of the course, to be utilized as a graded assignment on material presented, or to use as a summary activity at the end of a section. This activity was to be used in an upper-level neurochemistry class taught in the chemistry department with a typical enrollment of 12 - 20 undergraduate students. The class begins with a quick overview of neuroanatomy—regions of the brain (cortex, hippocampus, dura mater), major signaling pathways (mesolimbic, nigrostriatal, etc.), and neuron function (cell structure, organelles, dynein/kinesin motors, action potentials)—then moves through disease states discussing symptoms, pathophysiology, biosynthetic pathways of neurotransmitters involved, and drug mechanisms and structures. Before the midterm, we typically finish Parkinson's disease, depression, and have started discussing physiological tolerance versus psychological addiction. This provided the perfect opportunity to design a midterm escape room that could incorporate many of the things already covered.

2.3. Individual or Teams

The second major part is deciding if this would be an individual, small group, or whole class activity. We do not have chemistry graduate students and our chemistry program averages ~ 50 chemistry major's total. Our enrollment minimum is 12 students per class so to make sure this elective would "fill", the only pre-requisite is organic chemistry 1 with a co-requisite of organic chemistry 2. This enables biology students interested in neuroscience to take the course as well, but significantly complicates the design. Some of our chemistry majors have never had a biology course while some of the biology majors have not had biochemistry, and many of them leave anatomy and physiology until later in their progression. Therefore, the class is taught from a review and collate information in the introductory portion with the knowledge that a significant portion of that material will be new for some students. The escape room was planned as a small group activity with the intention of splitting groups between biology and chemistry majors to maximize the familiarity of topics between the groups.

2.4. Timing

The third piece is deciding the timing. If no one finishes the escape room, then we have failed in our design, period. The timing is possibly the most difficult to gauge as some groups will be slow to decide each answer with much discussion while others make rash choices and need to repeat steps. Typically, the average group should finish, with top groups competing for times, and lower performing groups progressing towards the end. This can be accentuated by "tips" at predetermined time-points throughout the activity to ensure the groups perform as expected

(Section 3.7). If you desire to have a review of the activity or ask follow-up questions, that needs to be calculated into the timing as well. Immediate reinforcement strategies (probing questions, muddiest point, main concepts) are activities that require students to review and state their thought processes and enables them to extend and apply the concepts regardless of their performance in the escape room. Our classes run either 60 or 90 minutes and as always, we are limited on how much time to devote to an activity or assessment. For this class, a 40-minute escape room followed by a 5-minute discussion and review was decided upon. This would allow two groups per day in 90-minute classes (one week for 4 groups) or one group per day in 60-minute classes (one week for 3 groups).

2.5. Decide the Stages

The number of and depth of the stages are the next concept that needs to be decided. Stages are the large steps that make up the room, such as opening doors or lockboxes to move on to the next part. This is the section that takes the most thought and time to design. The content must be decided at this point in addition to where to end the activity; in other words, how much time will it take them to work through this activity on average.

There is a large Bloom's taxonomy difference between asking a student to identify a symptom of a disease state in a multiple-choice format and requiring that a disease state be recognized from a case of symptoms—especially if distracting symptoms are present as in this case.

2.6. Can I Grade the Outcome?

The fourth decision is how to grade the escape room. There are a lot of extenuating factors to consider here—individual versus groups, penalizing for tips/hints provided, objective versus competitive grading, etc.—but the key is to be generous the first time through. Stress does not correlate with peak performance so generously rewarding their progress helps with student engagement (and fun). For this escape room, a rubric was developed indicating a point value for making progress on and passing each stage. A small penalty for tips/hints was applied and a time for their dissemination predetermined to balance the playing field (Section 3.7). These tips were not direct answers but leading questions to advance the group to the next stage. By ensuring most groups neared the finish with these timed interventions, all groups could be graded on their progress in most of the stages with minimal point loss. Utilizing a specific rubric also allows for specific discussions later if students have questions about their grade.

2.7. Do I Tell the Students?

The fifth and final part was implementation and deciding whether to "warn" the students before they arrive. I typically provide study guides for exams and did not reveal the plan to utilize an escape room for their midterm, although they knew it would be a group exam as each group had a specific time to arrive. This allowed an excellent opportunity to provide some things they would absolutely need to know—such as symptoms, treatments, and neurotransmitters involved in Parkinson's disease, depression, and addiction. Being a class in the chemistry department, a focus on the structure and function of the neurotransmitters and treatments was also outlined in the study guide. These topics were most of our class time after the introductory material as would be expected for a midterm exam. The study guide allowed students to be prepared and tended to ease the anxiety once the activity began.

Showing up for the midterm at a closed door with their instructor in the hallway is a surprise. Students sign the attendance sheet, receive the rules, and enter the room as a team. As educators, our instinct is to help reason through the scenario and provide answers. To prevent this dynamic, an information sheet was placed prominently at the front and gestured to as they entered. This sheet introduced the case and their first task.

3. Results: Gameplay

3.1. The Room

For this escape room, sections were assembled to break up the parts with lock boxes being placed near the information needed to open them. The stages were two combination lock boxes, a keyed lock on a trunk, and a chemical question where the answer correlated to literature references.

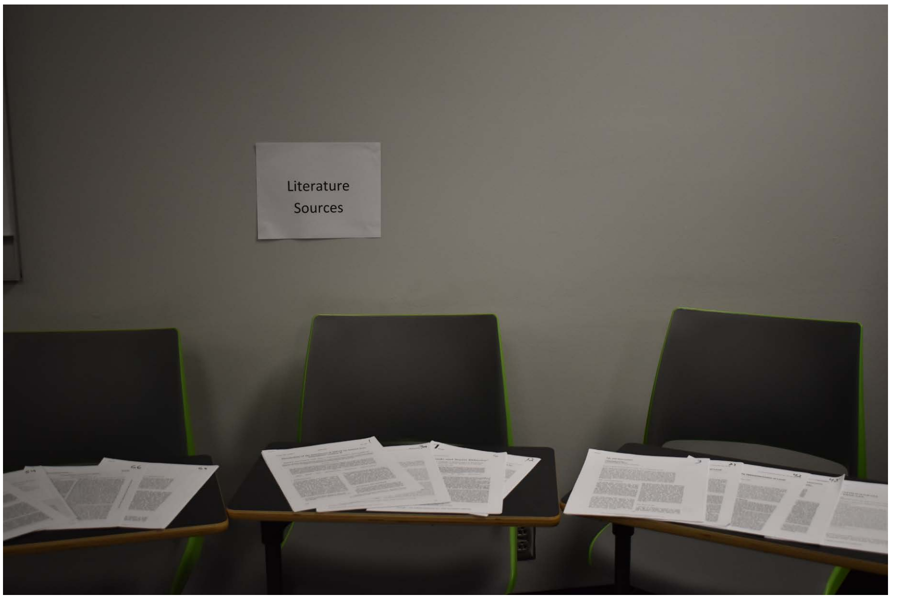

Figure 1. Literature sources section of the gameplay room.

The room set-up is basically divided into 5 sections and focused on three major disease states—depression, Parkinson's, and opioid addition—corresponding with our classroom content to this point in the semester. Each section is indicated by a sign hanging above simply stating the headings below:

1—Diagnostic criteria: This includes basic figures found online that describe criteria for the three disease states (depression, Parkinsons, and opioid addiction). These are simply taped or tacked onto the wall in the designated section.

2—Pharmacy holdings: These pages have the drug label, mechanism figure, the chemical structure, a footnote with the basic mechanism of action, and a header that includes a number (#30/100). The number of scripts ranking is mentioned during our classroom discussion of drugs to contrast those that are heavily utilized from historical or niche drugs; therefore, these numbers blend into the other information (**Figure 2**).

3—Literature: This section contains roughly 15 articles that are distributed between the three disease states (**Figure 1**). Some of these are general articles relating to the disease state, but three are specific in their analysis of MPTP.

4—Synthesis problem. This is a hand-written section on a white board or chalk board that outlines the reaction written in the original chemist's notebook with an additional arrow towards an unintended drug product. Students must utilize the literature articles to help fill in the missing structures and identify the type of reaction causing the unwanted intermediate (**Figure 3**).

5—Herbicides: These pages are identical to the drug section except they have instructions on the back. These are hung with a single piece of tape or single tack across the top so as not to obfuscate what is written on the back (**Figure 4**).

In addition, upon entering the room there are instructions on how to open the combination locks, a timer counting down, and an information sheet placed prominently that indicates the confines of the case.

3.2. Rules

Four simple rules are discussed prior to entering the room and written on the front board for reference:

1) You have 40 minutes to complete this midterm.
2) Keep it scientific.
3) No outside resources.
4) Think simply and communicate.

Knowing their time limit before entering prevents questions when the timer starts. In past renditions of this escape room, several individuals have immediately relied on their clinical shadowing knowledge. This is not a surprise as they are faced with a scenario that may be familiar in the clinical venue, but typically results in the group following the opioid addiction distractors (Alabama is in the top 10 for opioid addiction in the United States). Encouraging them to follow the scientific method keeps it narrowed to our class material as this is a science class. They are not allowed outside resources such as phones or laptops in accordance with typical exam procedures. Surprisingly, most of our students are not familiar with Occam's razor—the principle simply stated as "the simplest explanation is usually the best one". Therefore, when faced with a difficult clinical case with several distractors, some groups develop unnecessarily complex reasoning. This rule is a reminder that simple is better and communication with their team is key.

3.3. Stage 1

Stage one starts by reading the case and diagnosing the disease state responsible. This may seem to be an unfair clinical stage since diagnostics is a skill taught at the professional level; however, it is just a higher Bloom's taxonomy version of which disease state would involve inability to initiate movement (akinesia). It is also like the question typically asked in a case study based on this subject matter—what symptoms would be expected for a patient suffering from Parkinson's disease. In addition, there are multiple symptoms and diagnostic tables provided in the diagnostic criteria section for participants to utilize.

Figure 2. Pharmacy holdings section of gameplay room

Once the group has decided which disease state to treat, they must decide on three possible treatments that may help them to regain their muscle control. This step has a volume of clinically oriented issues—what is first-line therapy, which would have the quickest onset, etc.—that are completely ignored due to this being an undergraduate science course. The instructions are to find three possible drugs that could treat the disease state based on their mechanism—rules 2 and 4, keep it simple and scientific. Recall that the pharmacy holdings have the drug name (both trade and generic), the drug label, the chemical structure, the mechanism, and a number in the upper-left corner (**Figure 2**). The numbers for the Parkinson's disease treatments correspond to the combination lock on the nearby box. These locks were chosen specifically to have the largest number first and smallest number last in the sequence which is revealed in the combination lock instructions written on the board. This decreases the time and effort of attempting all possible combinations of numbers. Once opened, the lockbox has another instruction sheet for the next stage.

3.4. Stage 2

At the beginning of stage 2, the group successfully diagnosed the issue and chose three treatments that may help. Now they are faced with the question of how this happened to a seemingly random sampling of the population with no history of the disease and too young to be facing such advanced symptoms. Information is provided surrounding the lab notebook found in the illicit drug manufacturers lab. This is the synthesis problem already written on the board with notes and reference structures. The main issue is how this designer opioid would produce Parkinson's symptoms—a task that was not answered by the first team to come across this problem in the United Sates. Therefore, literature is provided for reference.

Three of these articles contain information on MPTP while others relate to Parkinson's disease, depression, and opioid addiction (Fritz et al., 1985; Singer & Ramsay 1990; Youngster et al., 1989). The synthesis problem shows the route to the meperidine (Demerol®) analog and a side sequence with an arrow indicating increased temperature and acid, an empty box, another arrow with monoamine oxidase B (MAO-B) above it, followed by another empty box, another arrow, and another empty box (**Figure 3**). An astute student can recognize the transition from MPTP to MPP+ indicated in the literature, but the jump to MPTP is difficult for many. The propionic acid induced elimination reaction of the benzylic alcohol would be easy to recognize in an organic chemistry class, but by this point most are watching the clock, and that organic chemistry knowledge becomes cloudy. After a few painful attempts (I also teach organic chemistry), the groups invariably connect the elimination to make MPTP and find the articles corresponding with its conversion to MPP+. The hand-written numbers at the top right of the literature articles are easily recognized by this point leading to the unlocking of the second box placed nearby. Keeping the boxes near their content has thus far decreased the attempt to open the second box with the first combination.

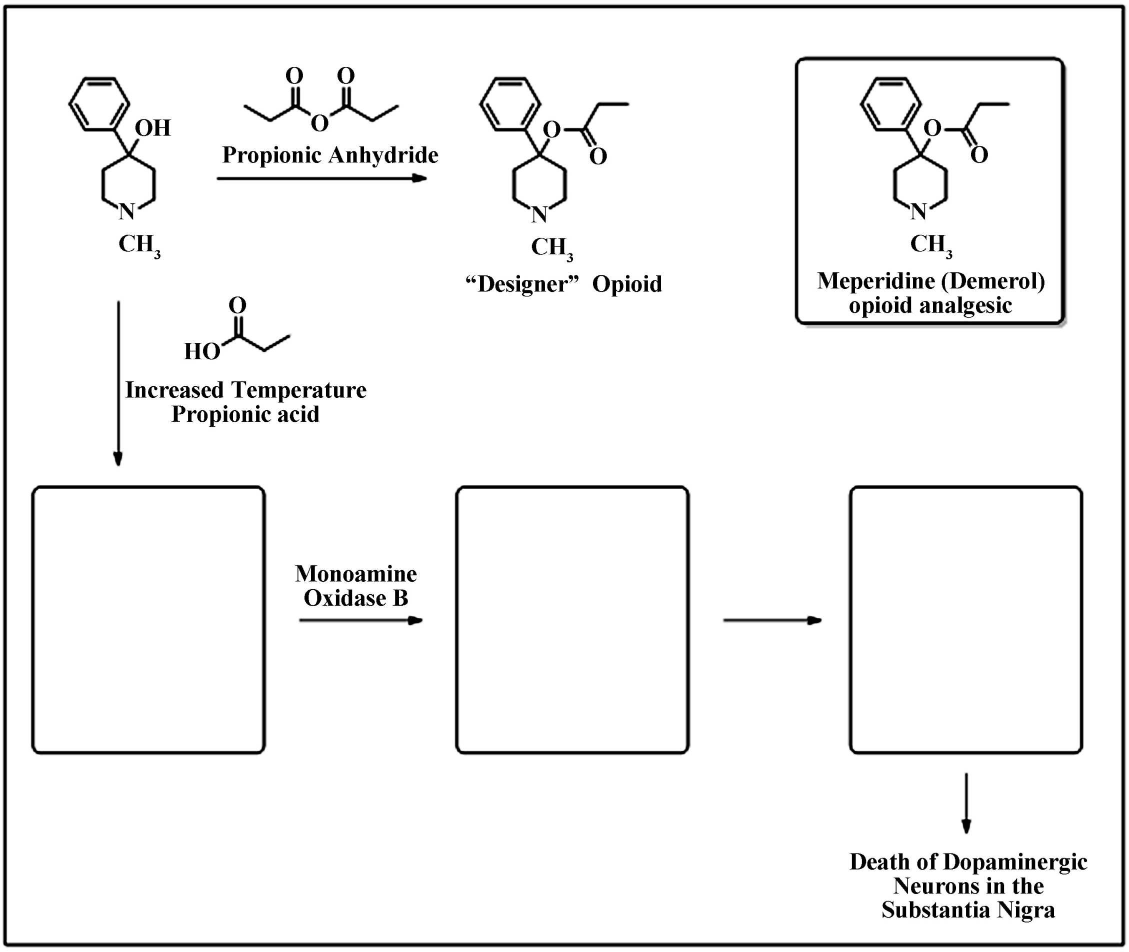

Figure 3. Synthesis problem as shown on a board in the gameplay room.

3.5. Stage 3

The second lockbox contains instructions on the reports of increased occurrence of Parkinson's disease in rural communities where certain herbicides are used (Figure 4). The group must then correlate why one herbicide would be more likely to cause Parkinson's disease than others based on its structure and mechanism. The strong chemistry student can quickly correlate the similarity of paraquat's structure to that of MPP+. Once that is made a frantic search typically ensues (time is running out and they are not aware this is the last stage) resulting in ripping the paper off the wall finding the note on the back directing to the key that will unlock the last trunk. This trunk contains a congratulatory message and boxes of candy. The incorrect herbicides have instructions that send participants to other places around the room only to find a message that indicates they chose the wrong herbicide.

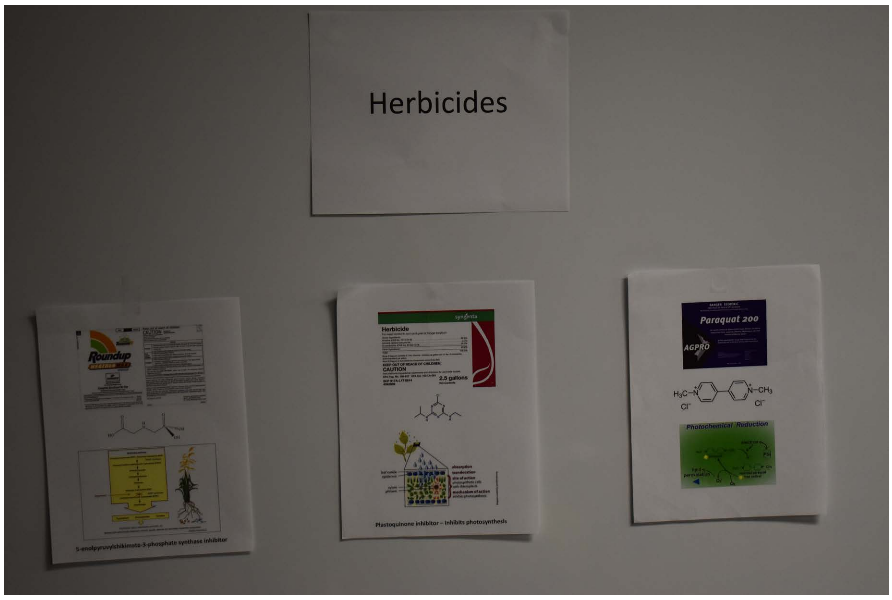

Figure 4. Herbicide section of gameplay room.

3.6. Immediate Reinforcement

The case is typically reviewed directly after finishing with some follow-up questions to evaluate comprehension of the case and extending their findings.

1) Why would the drug administered at the end of stage one (apomorphine) dissipate?

2) Which do you think would make it into the brain easier—MPTP or paraquat?

3) How would you make an animal model of Parkinson's disease?

3.7. Hints or Tips

Considering a 40-minute escape room:

12 minutes—Help direct diagnostics with group: what is the issue, what disease state does that correlate with, etc.

20 minutes—Narrow treatment options: what is the pathophysiology of Parkinson's, what treatments could increase this shortage of dopamine, etc.

30 minutes—Assist with chemical reaction: how does an alcohol behave (nucleophile or base), what will it do in the presence of an acid, what is a good leaving group (conjugate base of a strong acid), etc.

35 minutes—MPTP identification: do any of the papers have a structure like the one drawn here, what propels the change from MPTP to MPP+, which structure causes the toxicity, etc.

4. Conclusions and Implications

Hopefully, this quick discussion of converting a case study into an interactive and quantifiable escape room will enable others to utilize this exciting tool in their classrooms. This escape room was implemented with minimal physical resources including paper copies, three lockable boxes, and three locks. The major resource needed was time and effort on the part of the instructor to design, construct, and implement the activity. In the three iterations performed by this author there were no negative comments or responses to the exercise but many positive. Indeed, the biggest challenge encountered is students asking for a similar activity for their final exam or another escape room in other classes. The follow-up questions demonstrated excellent application and understanding of the concepts applied and reinforced the practicality of employing escape rooms as an assessment. This example was implemented in a limited enrollment upper-level elective course, but another is under development targeted for a larger general chemistry course.

Acknowledgements

The author thanks all the wonderful students at Jacksonville State University that have provided constructive feedback and encouragement to facilitate the design and implementation of activities such as escape rooms.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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