Using an Escape Room to Support the Learning of Science Content

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Abstract

Escape rooms are live action games where a group of players are locked in a room and must gather clues and solve puzzles to escape. The rising popularity of escape rooms as entertainment and the popularity of educational games led teachers to repurpose escape rooms for the classroom. Research into the impact of escape rooms as educational tools is still in its nascent stages, though studies have shown a positive impact on content knowledge and collaboration skills. This study explores a compost-themed escape room activity designed as part of a middle school science curriculum. The escape room was pilot tested with 22 pre-service teachers in an elementary science education course. Pre/Posttest with a mix of multiple choice and short answer questions was used to determine if the activity had an impact on learning. A post-activity survey was used to capture students' perceptions of the educational value of the escape room.

Introduction

Since their introduction in Japan, escape rooms have steadily grown in popularity. After making their way to the United States as a cultural phenomenon, escape rooms proliferated new markets and new audiences. The recent trend in incorporating games in education has further expanded the reach of escape rooms into the classroom. Studies have shown that escape rooms have been effective in increasing interest in learning (Borrego et al., 2017; Dietrich, 2018)), teaching domain-specific content knowledge (Eukel, Frenzel, & Cernusca, 2017; Voros & Sarozi, 2017) and increasing collaboration (Pan, Lo, & Nuestaedter, 2017; Zhang et al. 2018). The majority of these studies have been conducted at the college level (e.g., Eukel, Frenzel, & Cernusca, 2017; Hermanns et al., 2018; Voros & Sarozi, 2017); few have been conducted with middle school students (e.g., Bassford, Crisp, O'Sullivan, Bacon, & Fowler, 2016).

Our research group designed an escape room activity as part of a researcher-designed curriculum, called *Make Your Own Compost (MYOC)*, which is suitable for use in rural middle school science classrooms. This curriculum was developed as part of *Bio-Sphere*, a National Science Foundation (NSF) funded research project. The escape room activity we created was themed around the two major content focuses of the MYOC curriculum, creating ideal compost and the process of decomposition. In this study, we pilot tested the escape room with preservice teachers enrolled in a science education course. We were guided by the following research questions: *1) How do (or do not) escape rooms, designed with specific intentions, help students develop content domain knowledge?; and, 2) How do students perceive (or not perceive) the escape room as a valid pedagogical approach to learning?*

Literature Review

Given the popularity of escape rooms, it is no wonder they have been repurposed for the classroom to aid in student learning. A quick internet search will reveal a multitude of purchasable escape room kits designed to explore educational content in a variety of subject areas and grade levels (e.g., www.breakoutedu.com, www.theescapeclassroom.com). Other sites, such as https://lockpaperscissors.com, serve as resources for teachers who wish to design escape rooms for their own classrooms, offering advice in designing puzzles and storyboarding the individual challenges into a coherent experience.

While the idea of bringing escape rooms to the classroom has been a popular one, it does not come without its own challenges and compromises. Escape rooms challenges have the potential to provide hands-on, immersive

activities which require students to demonstrate their knowledge and skills in a 'real world' context (Clarke et al., 2016; Nicholson, 2018). However, it is not feasible, or legal with K-12 students, to lock a subset of a class in a room and wait until the puzzle their way out. As a compromise, many escape rooms designed for the classroom have been stripped back to a group tabletop activity involving a series of locked boxes (Schaffhauser, 2017). This revisioning of the escape rooms was first introduced by Breakout EDU, requiring players to break *into* boxes instead of *out of* rooms. While this type of activity loses the complete immersion of a true escape room, it can still provide a motivating and educationally beneficial experience for students when designed appropriately (Clarke et al., 2016). Escape activities are great platforms for developing teamwork and critical thinking skills while reinforcing classroom content (Schaffhauser, 2017).

Despite the eagerness with which teachers have adopted escape rooms into their classrooms, research into the educational benefits of escape rooms is still in its nascent stage. Most studies on the escape rooms have occurred in higher education programs, often in the medical field (e.g., Eukel et al, 2017; Hermans et al., 2018). Despite the limited amount of studies, escape rooms have consistently had positive results for education. For example, Eukel et al. (2017) conducted a diabetes-themed escape room with 83 pharmacy students and found significant knowledge growth from the pre- (m=56%) to the post-test (m=81%). A survey of the pharmacy student's perceptions of the escape activity revealed the students believed the escape room helped them understand the diabetes content and saw the benefit of using escape rooms as educational tools. Voros and Sarkozi (2017) found that after completing the physics escape room, even students with poor grades in physics received a good score on the post-quiz. Though research into the educational values of escape room game in classrooms is still in its early stages, the studies that have been conducted so far provide positive support of escape rooms on many fronts. Whether it's helping student learn new content, apply what they have learned, or build and support collaboration and communication skills escape rooms deserve their place in classrooms as an instructional tool.

Methods

Design-Based Research (DBR). This study is part of *Bio-Sphere*, a National Science Foundation (NSF) funded research project, which employs the flexible strategies inherent in DBR (Figure 1; Easterday, Rees Lewis, & Gerber, 2014). DBR studies are iterative and are designed to simultaneously inform the design of educational innovations and develop theory (Brown, 1992; McKenney & Reeves, 2013). The DBR phases (Figure 1.) are not conducted sequentially but rather, research moves purposefully between the stages based upon on-going analyses. This study focuses on the Build and Test phases as we pilot test the compost escape room and analyze the data for knowledge gains and students' perceptions.

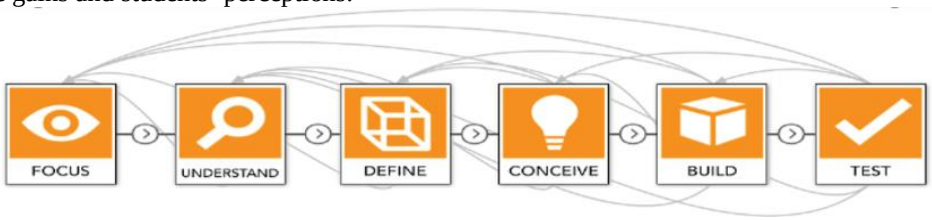

*Figure 1.*Design Based Research – Easterday, Lewis, & Gerber, 2014.

Context. This study was conducted at a large research university located in the southeast United States. Participants were 22 pre-service teachers recruited from an elementary science teaching methods course in a fifth year, Master of Arts in Teaching Program. The participants were reflective of the students enrolled within the program being predominately white, middle class women with two white men also enrolled in the course. The course was designed with a balance of lecture, in-class inquiry experiences, project-based learning, and discussions. The course also included a variety of additional activities from *Bio-Sphere's MYOC* unit for which the escape room was designed.

Escape room content. The escape room was designed to teach students about the process of creating quality compost and the process of decomposition. To address creating quality compost, puzzles were created which focused on understanding, identifying, and balancing browns and greens in compost piles. To address decomposers and decomposition, puzzles focused on identifying decomposers, understanding what physically happens during decomposition, and exploring how temperature in compost piles affects decomposers. The major puzzles from the compost escape room and the associated educational content they are expected to impart are detailed in Table 1.

Table 1. Compost Escape Room Puzzles.

	Educational Topic	Knowledge/skill gained	Gaming task
Puzzle 1 – Trash Sort	Sorting waste into landfill, compost, and recycling	Recognize properties of organic and non-organic waste; Identify recyclable material	*QR lock decoding*
Puzzle 2 – Compost Ingredients	List what should be included in compost piles Observe the results of a given pile of compost after 3 months	Understand what can be composted; Begin to recognize the effect on compost depending on the type of ingredients and the amount included	*Data hunt*
Puzzle 3 – Temperature Timeline	Sequence of decomposers that are present in a compost pile given common patterns in compost temperature	Understand that some decomposers (bacteria) will only be active during certain temperature ranges and the temperature in a compost pile fluctuates	*Data hunt* *Timeline puzzle*
Puzzle 4 – Decomp Mini-game	Concrete representation of decomposition (the way bacteria breaks down plant and animal material into its smaller building blocks)	Understand that bacteria secrete enzymes and those enzymes help the bacteria break down material; Understand that material breaks down into building blocks, (i.e., smaller molecules)	*Mini-game*
Puzzle 5 – C:N Calculator	Calculate the C:N ratio of compost based on ingredients	Understand that different material has different ratios of carbon and nitrogen; Understand that compost piles work best within a certain range of C:N ratios; Calculate the C:N ratio of 3 example piles of compost with 5 ingredients	*Data hunt* *Caesar cypher* *Use of Scratch program*
Puzzle 6 – Final Formula	Summarize learned facts on compost and decomposition	Understand how the different aspects of decomposition influence compost	*Fill-in-the-blank*

QR locks. When designing the compost escape room activities, we focused on creating an entirely print-and-play set of materials. To accomplish this, we designed paper locks using an image of a padlock and a password protected QR code created using http://www.quickmark.com. We generated QR codes with completely customizable alphanumeric passwords and messages which would display after the correct password was entered (see Figure 2).

Figure 2. QuickMark QR lock example

When students solved a puzzle, they used the free QuickMark app to scan the locks and enter the correct password given the clues on the box or lock.

Data sources. We collected data using a compost pre/post-test, and a compost perceptions survey. The compost test included ten multiple choice and four short answer questions. The perceptions survey was adapted from Eukel, Frenzel, and Cernusca's (2017) *Diabetes Escape Room Perception Scale*. It included 12 questions addressing the pre-service teacher's perceptions of the escape room and how it impacted their learning of the concept.

Procedure. Approximately halfway though the semester, students were provided with a link to the compost pretest through Qualtrics. The next week in class, the students participated in the escape room activity. The students were divided into groups of four or five and given a box containing the escape room activity. The groups were given an unlimited time to complete the escape room. Following the activity, the students were provided links through Qualtrics to the compost posttest and perceptions survey. Students were given a week to complete the survey and test.

Data Analysis

The compost test was split into the multiple-choice and short answer sections and analyzed separately. The ten multiple choice questions were analyzed with a repeated measures t-test to determine if there was knowledge growth. The four short answer questions were analyzed qualitatively for common themes that emerge in the answers between the pre-test and post-test. The compost perceptions survey was analyzed with a one-sample t-test to determine if the average of the pre-service teachers' scores on the scale were significantly different than the mean value of the perception scale (i.e., "3 - neither agree or disagree").

Results/Discussion

Pre/Posttest. The compost pre- and post-test were analyzed using R (mac version 3.5.1). All 22 students completed the pretest, but only 18 completed the posttest. Scores on the multiple-choice questions for both the pretest (m=9.55, sd=0.67) and posttest (m=9.33, sd=0.69) ranged from 80-100% correct. A repeated measure t-test revealed non-significant differences between the pre- and post-tests (t=-0.983, df=36.116, p=0.332). The lack of growth shown on this part of the assessment is most likely due to taking a designed for sixth graders which resulted in high pretest-scores and little room to show growth that may have occurred. The short answer questions, however were able to provide evidence of knowledge growth due to the activity. Growth was seen in questions 1, 2, and 4. Students were more likely to list bacteria as a decomposer, could better articulate how decomposers break down organic material, and could identify the ideal carbon to nitrogen ratio and explain why it was important to have this balance. Student answers of question 3 which asked them to define browns and greens did not appear to change. Students had a good understanding of greens and browns on the pre-test, listing correct examples of each, and their answers on the post-test were very similar. Despite these positive findings, misconceptions emerged on the post-assessment. For example, while students were more likely to list bacteria as a decomposer, some students also added enzymes to the decomposition list. While enzymes were featured as a part of the decomposition process within Puzzle 4 Mini-game, several students conflated the mechanism by which bacteria excreted enzymes to help with the decomposition process. This finding indicates that a design change to make the process more distinct needs to occur prior to the next iteration. An additional finding within the post-assessment was that the students' short answers included greater detail about the composting process that they had learned from participating in the experience.

Perception Scale. The compost perception scale was analyzed using R (mac version 3.5.1). The perception scale was completed by 19 of the 21 participants. Table 2, which follows, details the item, the item means, and the percent who chose each response option. Questions 9 and 10 were the only questions with a negative polarity, asking if the participants felt overwhelmed or distracted. After reverse coding questions 9 and 10, the overall mean was calculated. Individual participant mean scores ranged from 3.33 to 4.92. The overall pre-service teacher mean score for the perception scale was 4.11 with a standard deviation of 0.44. A one-sample *t*-test indicated that the students mean was statistically significantly higher than the mean value of the perception scale, "3 – Neither agree nor disagree," t = 10.92, df=18, p<.001. This significant result suggests a strong impact of the escape room game on pre-service teacher's perceptions of the educational and instructional potential of escape rooms as a learning tool beyond the mere novelty factor.

Table 2. Compost Escape Room Perception Scale (N=19).

Item	Mean (SD)	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
1. The escape room encouraged me to think about the material in a new way.	4.37* (0.6)	0	0	5.26	52.63	47.11
2. I would recommend this activity to other students.	4.58* (0.51)	0	0	0	47.11	57.89
3. I learned from my peers during the compost escape room.	4.37* (0.6)	0	0	5.26	52.63	47.11
4. The escape room was an effective way to review the topic of compost.	4.26* (0.65)	0	0	10.53	52.63	36.84
5. The escape room was an effective way to learn new information related to compost.	4.05* (0.91)	0	5.26	21.05	36.84	36.84
6. I learn better in a game format than in a didactic lecture.	4.42* (0.69)	0	0	10.53	36.84	52.63
7. The escape room was an effective way to assist my learning of the process of decomposition.	4.37* (0.6)	0	0	5.26	52.63	47.11
8. I feel I was able to engage with my teammates to learn new material.	4.42* (0.61)	0	0	5.26	47.37	47.37
9. It was difficult for me to focus on learning because I was feeling stressed or overwhelmed.	2.74 (0.93)	5.26	47.11	26.32	26.32	0
10. The non-educational portions (e.g., cyphers, puzzles, etc.) distracted me from learning about compost.	2.89 (1.29)	15.79	26.32	21.05	26.32	10.53
11. I prefer assembling information from a variety of sources when learning new material.	3.74* (0.81)	0	0	47.37	31.58	21.05
12. In general, I enjoy playing games (video games, board games, social media games, etc.).	4.42* (0.96)	0	10.53	0	26.32	63.16

Conclusion

Escape rooms present an exciting new way to engage students in domain content material. They have the potential to support the development of content knowledge (e.g., Eukel et al., 2017) and collaboration skills (e.g., Zhang et al, 2018). Escape rooms also provide a platform for bringing technology to the classroom, as websites, videos, or other interactive digital material can easily be incorporated into the various puzzles of the escape activity. The results of this study support the findings of other studies which show escape rooms contribute to both knowledge growth (Eukel et al., 2017, Voros & Sarkozi, 2017) and positive perceptions of escape rooms as educational activities (Eukel et al., 2017, Hermanns et al, 2018). However, this escape room is still only in the pilot and development phase. Preliminary analysis of the pre-post assessment suggests that this assessment needs to be revised and additional questions added in future iterations in order to determine what students know and what they may have learned from the escape room. Short answer responses within the assessment demonstrated some growth by the students from pre- to post-assessment; however, they also revealed new misconceptions that appeared only in the post-assessment. These are issues that will need to be addressed in future design iterations. The preliminary findings that the perceptions scale, which demonstrated that the pre-service teachers could see the benefit of using escape rooms as an educational tool to help their students learn science content, provides a basis for the promising exploration of the use of escape rooms in the science classroom.

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