# Creating Engaging Escape Rooms in First Year Engineering Courses: A Pilot Study

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# Full Paper: Creating Engaging Escape Rooms in First Year Engineering Courses: A Pilot Study

## Introduction

The use of game-based learning in classrooms as a means to foster motivation, communication skills, promote problem solving, and to encourage student interaction is well established [1],[2]. In game-based learning environments, rules structure the learning, rewards are given when goals are achieved, and trial and error is promoted [3]. Game-based learning can be particularly beneficial to those students who are already intrinsically motivated [3]. Games have been used in engineering classrooms to teach a variety of concepts ranging from programming skills and logistics engineering to engineering ethics [4]. One type of game that has not been implemented and thus understudied in engineering education is "live-action games" such as escape rooms. These types of games can be ideal for in-person classrooms as they require little technology and can take advantage of the shared environment of the classroom [5]. Nicholson defines escape rooms as "live-action team-based games where players discover clues, solve puzzles, and accomplish tasks in one or more rooms in order to accomplish a specific goal (usually escaping from the room) in a limited time"[5]. Escape rooms allow students to cooperate under a time limit, which creates an urgency that drives student teams to engage with content in a way that traditional learning activities may not.

This full paper presents the development and implementation of two escape room design projects in first-year engineering at two universities in the northeastern U.S - Rowan University and Northeastern University. In these pilot projects, first-year engineering students worked together to design, build, and fabricate their own class-wide escape rooms. Students explored the non-linear, iterative, and creative characteristics of design thinking while collaboratively designing an educational escape room. This paper will describe the structure and timeline of the projects, the required tasks from the student teams, and initial feedback from students in terms of project execution and student learning.

## Project Overview

The escape room projects at both universities were conducted in teams (typically three to five students) and included the following graded deliverables:

- A narrative-based cooperative challenge in the form of an escape room
- Documentation on the escape room details, including a written narrative, flow chart solutions for the escape room (and the puzzles therein), and marketing materials to recruit participants

The project was implemented across 4 sections from Rowan University and 3 sections at Northeastern University. Both universities had roughly 80 students enrolled. Each participating class was split into teams of three to five to design a particular aspect of the escape room. Each team was responsible for making:

- **A fabricated object** – a themed object from scratch, which could include puzzle boxes, chests/drawers, or theme appropriate furniture. The objects were limited to 2' x 1' in size.
- **Puzzles** – each team had to contribute an easy and a hard puzzle, of which only one was selected to be used in the escape room. One of the committees (explained below) decided on which puzzles from each group would be used for the escape room
- **3D printed object** – each team had to 3D print a small piece(s) that could be used in their puzzle or fabricated object

A jigsaw method was utilized to further split the class into escape room committees. Each team contributed one student to each committee. The purpose of the committees was to help connect the escape room pieces together and included the following:

- **Narrative** –responsible for writing the story behind the escape room and decided where to put the various pieces. Their job was to guide the creation of the escape room so that it aligned with the story and felt immersive.
- **Flow** – threaded the puzzles together to make a cohesive escape room. They decided which puzzle the teams would make (the easy or hard puzzles). They were also responsible for creating the final flow chart (solution) of the escape room.
- **Infrastructure** – made the extra things the escape room like timers, pathways to a secondary room, and any additional structures not covered by one of the teams. They also designed the layout of the room.
- **Marketing** – made marketing materials, a schedule to take reservations, a strategy to attract customers, and documented the process of creating the escape rooms (pictures, compiling narrative).

Each committee had to nominate one person to be the "liaison" who was responsible for communicating with the other committees. There were several differences in the project structure across the two universities, namely the required content of the escape rooms, the project timelines, and how the documentation of the escape room was formalized. Regardless of these differences, the learning and feedback was threaded through the two universities in similar ways. This study highlights how using different models appropriate to each individual university can yield similar results in creating engagement with course content, helping students learn about the importance of teamwork, communication, prototyping, design, project management, and creating accountability between the groups to deliver a high quality product.

The sections below detail the project implementation at both universities (including some examples), as well as discuss the initial feedback from the students, addressing learning outcomes around motivation, student accountability, teamwork, and project management. Finally, this paper concludes with lessons learned and next steps for project implementation, including more formalized assessment strategies.

**Escape Room Design Project – Rowan University**

The 5-week project had students from four first-year engineering classes in the Fall 2018 semester design and build full escape rooms using their shared learning environment with the constraint that each puzzle included had to incorporate content from class. The topics included unit conversions, uncertainty, statistics, significant figures, and MS Excel skills. The project was

conducted in milestones and students submitted several check-in deliverables to ensure they were staying on schedule. Each milestone had both team and committee deliverables. The milestones covered throughout the project were as follows:

- Milestone 0 – Introduction to Escape Rooms and Puzzles
- Milestone 1 – Project Management; Design Heuristics and Ideation
- Milestone 2 – Makerspace Orientation; Puzzle Prototyping
- Milestone 3 – Alignment of Puzzles and Fabricated Objects
- Milestone 4 – Playtest Escape Room
- Milestone 5 – Run Escape Rooms with Outside Participants

The details and overall schedule (including milestone deliverables) can be seen in Appendix A.

The final deliverable for the project at Rowan University was to create an Escape Room Google (web) site. This Google site was created collaboratively by all of the teams and committees, with each being responsible for a particular aspect of the site. For example, each team was responsible for providing the content related to their puzzle (including the solution flow diagram) and the committees were responsible for various pages on the site including the landing page, the overall solution flow chart, and the look/feel. Below is a short description of the four student-developed escape rooms, with links to their developed Google sites.

- OPERATION: Rescue Rowan's Riches!
  *https://sites.google.com/students.rowan.edu/escape/home*
- Krampus Escape Room
  *https://sites.google.com/students.rowan.edu/escape-room/home*
- Escape Rowan Finals
  *https://sites.google.com/students.rowan.edu/fec-escape-room/home*
- Nightmare on Everest Street
  *https://sites.google.com/rowan.edu/mallouks-fec-class/home*

**Escape Room Design Project – Northeastern University**

The 12-week project had students from three first-year engineering classes in the Spring 2019 semester design and build full escape rooms guided by learning objectives. This included topics such as C++ programming, Matlab, AutoCAD, Solidworks, Engineering Design, Engineering Ethics, and Arduino hardware. Students used 3D printing, CNC milling, and laser cutting to give their projects a professional aesthetic and used tools at the First Year Learning and Innovation Center to perfect their use of power tools and hand tools under the supervision of TAs. The project was conducted in milestones and students submitted several check-in deliverables to ensure they were staying on schedule. The milestones covered throughout the project were as follows:

- Milestone 0 – Introduction to Escape Rooms and Puzzles
- Milestone 1 – Ideation and Presenting your Plans (both objects and puzzles)
- Milestone 2 – Puzzle and Object Prototyping

- Milestone 3 – Finalizing One Puzzle and Both Objects
- Milestone 4 – Playtesting Escape Room and Finalizing Other Puzzle
- Milestone 5 – Final Dry Run and Having Outside Participants Play the Escape Rooms

The project schedule and milestones can be seen in the Appendix B.

**Survey Administration, Feedback and Next Steps**

Students from Rowan University and Northeastern University provided feedback on the Escape Room Design Project through an online Qualtrics and Google survey respectively. Out of the 160 students total, 134 provided feedback resulting in a response rate of 83.8%. The students were prompted to identify the aspects they liked most (and least) about the project, as well as what they learned. As the questions were all open-ended, the authors read through each response to the prompts above and identified common themes by looking for particular keywords and patterns in the data. From this survey data, the major themes were:

Enjoyed by students:
- Using outside resources
- Creating and building different parts using 3D printers and laser cutters
- Working together with the entire class to design one big project
- Freedom and creativity/create something fun to do and play
- Incorporation of engineering principles into a non-engineering product

Needs Improvement:
- Confusion of the end goal/unclear expectations
- Committees had trouble communicated and workload was not balanced
- Organization/collaborating with 20-30 people towards an end goal/difficult to communicate with 20 people
- The final escape room looked kind of empty

Emergent Learning Outcomes
- Teamwork, Leadership, and Communication
- Fabrication Techniques and Prototyping
- Ideation and Design Heuristics
- Project Management (at larger scales)

A complete set of themes, as well as the exact questions asked across the above areas, can be seen in Appendix C.

Northeastern ran the escape rooms for 9 consecutive hours and had 109 participants played through the escape rooms during spring 2019 with 45% providing feedback. The participants rated the escape rooms on the following metrics: difficulty 6.7/10, enjoyment 9.0/10, and aesthetics 7.8/10. Participants also left comments such as:
- "Great integration of puzzles, theme, and fun!"
- "The puzzles were very innovative and well-constructed. Having 4 people was the right number of participants in the room."
- "I can't believe Freshman designed it!"

In general, the students liked the project and highlighted many aspects that increased their enjoyment. Students remarked on using 3D printers and other fabrication techniques (such as laser cutters) to create and build different parts of the escape room. They also stated they liked working with others to design the puzzles and it allowed them enough freedom and creativity to create something fun to play. Finally, the students enjoyed how the project mimicked real-world teamwork in a job setting where individual work was brought together to create something "bigger than themselves". This made the project more fun and engaging while also authentically incorporating lessons on individual accountable.

As this was the first time at least at Rowan and the second time at Northeastern of running the project, there were many aspects of the project that can and should be changed going forward. Students identified many aspects that they found not enjoyable. The slightly open-ended nature of the project led to confusion of the project goals and unclear expectations. The students also remarked on the difficulty of working and communicating with multiple teams at the same time. This also made the project more difficult. The distribution of work between the committees was not even, which bothered some students. Some committees were busy throughout the entirety of the project while others had to wait on others to get work done. Finally, the required connection of the escape room puzzles to class content made the process less fun and feels less like an authentic escape room.

Even though there were areas of the project that did not work out as planned, the students did learn quite a bit through the process of building an escape room collaboratively with their entire class (although no formal assessment of these learning outcomes have been carried out). The two areas where students felt they learned the most was communication and teamwork skills. The fact that students had to coordinate their efforts throughout the project (i.e., working on two teams with different tasks) forced the students to practice communication skills and work with different kinds of people. According to the students, they also learned how to take individual ideas and incorporate them into one design. This required students to learn how to make a step-by-step plan for larger scale projects, keeping the big picture in mind at all stages of the design process.

Student-designed escape rooms create memorable learning experiences that cannot be replicated by standard classroom activities [5]. The authors believe that having first-year engineering students design and play through escape rooms provides a holistic, student-centered approach for teaching design thinking with an emphasis on art and creativity. The authors plan to adjust the project to address the concerns students had in terms of timing, workload, and content, as well as include more formal assessments for both the first-year engineering students who create the escape rooms (i.e., communication, teamwork, project management, and creativity) as well as the external participants who play the escape room.

# References

[1] C. A. Bodnar, D. Anastasio, J. A. Enszer, and D. Burkey, "Engineers at Play: Games as Teaching Tools for Undergraduate Engineering Students," *Journal of Engineering Education*, vol. 105, no. 1, pp. 147-200, 2016.

[2] C.A. Bodnar and R.M. Clark, "Can Game-Based Learning Enhance Engineering Communication Skills?" *IEEE Transactions on Professional Communication*, vol. 60, no. 1, pp. 24-41, 2017.

[3] P. Buckley and E. Doyle, "Gamification and student motivation," *Interactive Learning Environments*, vol. 24, no. 6, pp. 1162-1175, 2016.

[4] D. Burkey and M. Young, "Work-in-Progress: A 'Cards Against Humanity' – style Card Game for Increasing Engineering Students' Awareness of Ethical Issues in the Profession," *Proceedings of the ASEE Annual Conference and Exposition*, June 2017.

[5] S. Nicholson, "Creating engaging escape rooms for the classroom," *Childhood Education*, vol. 94, no. 1, pp. 44-49, 2018. Available online at
http://scottnicholson.com/pubs/escapegamesclassroom.pdf

# Appendix A: Rowan University's Escape Room Project Schedule and Deliverables

| Week | Description | Team Deliverable | Committee Deliverable |
|---|---|---|---|
| 0 | 1. Introduction to escape rooms and puzzles<br>2. Establish engineering teams and committees<br>3. Play through different kinds of puzzles (i.e., maze, sudoku, logic, dexterity, escape room in a box)<br>4. Create individual puzzles | Individual puzzle (1 per person) | |
| 1 | **Team**<br>1. Project Management (Gantt Chart)<br>2. Play, analyze, and review individual puzzles<br>3. Design Heuristics and Ideation<br><br>**Committee (30 minutes)**<br>1. Initial meeting<br>2. Brainstorm sub-milestones for achieving the main milestones | Memo of summary of puzzle ideas (at least 2 – easy and hard).<br><br>Include description of the fabricated object and how it interfaces with the puzzles<br><br>Gantt Chart | Memo including notes from brainstorming meeting and sub-milestones |
| 2 | Makerspace Orientation<br><br>**Team**<br>1. Prototype two puzzles (easy and hard)<br>2. Work on 3D modeling of fabricated object AND printed part<br><br>**Committee**<br>1. Work on narrative/construct storyline<br>2. Brainstorm infrastructure and layout of google site<br>3. Work on marketing flyers<br>4. Flow diagram | Precision drawing of the fabricated object (Onshape) and the 3D printed part (Cura) | Memos on storyline/narrative, infrastructure, marketing, and flow |
| 3 | **Team**<br>1. Presentation (~5 min) on work so far – include how each puzzle works with fabricated object AND two other groups fabricated objects<br>2. Work on final version of puzzle (chosen by flow committee), 3D printed object, and fabricated object<br><br>**Committee**<br>1. Continue work towards sub-milestones and milestones | Final version of puzzle<br><br>3D printed object<br><br>Rough construction of fabricated object | Reflection of your committee's progress and how your committees work fits into the escape room (1 per person) |
| 4 | 1. Finishing touches on escape room<br>2. Break into two teams and play through half of the escape room, each.<br>3. Team – start creating content for the google site | | |
| 5 | 1. Play escape rooms (~8-10 at one time)<br>2. Run escape rooms with other classes | | Escape Room Google Site |

**Appendix B: Northeastern's Escape Room Project Milestones**

**Milestones:**
o    MS1) In class you will present to the class about your planned project for up to 5 minutes. Must include:
- Summary of your puzzle ideas (at least 2 completely different puzzles).
- A description of both your 3D printed and fabricated object.
- Bullet points of your plan to make both objects and both puzzles. Include an estimate of how long each step will take.
- Submit the presentation on Blackboard on the date listed.

o    MS2) In class you will play your classmates puzzles and critique their objects. You must bring:
- Precision drawings of both the fabricated object (any program) and the 3D printed part (Solidworks). Please include dimensions for both. I recommend using orthographic projection to describe your fabricated object fully. Please keep the theme in mind: A teleportation pad does not belong in a Gothic Castle library.
- A playable paper prototype of both the hard and easy puzzles.
- **Due date on Blackboard** – Post on the class Slack channel and submit on Blackboard a 1 page write up of how your puzzles (each one separately) could **work with your fabricated object and 2 other groups' fabricated objects.** (1 per group). In addition, you must comment on 2 other people's posts on slack before Milestone 3.

o    MS3) In class you will present your creations and then play/provide feedback on your classmate's projects. Bring the following to class:
- Final versions of the puzzle chosen for the escape room (based on Flow committee decision) and the 3D printed object. **The puzzle used in the waiting room does not need to be brought on this day. It needs to be finished by Milestone 4.**
- Rough construction of fabricated object. It needs to be functional but does not need to be perfect.
- Group led presentation of your work so far (~2 min/group). Please include a status update and a future plan for each object and puzzle. This do not need to be a power point, but you could present slides if you would like.
- **Due date on Blackboard** - Reflection on your committee's progress and how your small group's project (puzzles and objects) fits into your committee. If there is not a lot of overlap between your group and your committee, talk how your small group's project fits into the escape room instead (2 pages max, 1 per individual).

o    MS4) In class, half of the class will play through the escape room (in groups of 6-8 people at a time). Everyone else will playtest the waiting room puzzles.
- Your group's contribution to the escape room should be done other than minor tweaking (1 puzzle, 3D printed object, and fabricated object). You will get a chance to modify your waiting room puzzle.
- We will setup the entire escape room and have small teams of 6-8 people play through it while everyone else tests the waiting room games. Once a group finishes, we will reset the room and send another group through.

- **Due date on Blackboard** - Reflection on waiting room puzzles you played. What were you favorites? Are there any last minute changes that would improve one of these puzzles? Be positive and constructive (2 pages max, 1 per group)

o      MS5) In class, we will setup the escape room. Anyone who did not play through the escape room will get a chance to try it. Everyone else will play the final versions of the waiting room puzzles. Everything should be done by this point.

- All groups and committees are finished
- **Due date on Blackboard** - Full report about the escape room, your critique of it, your contributions to your group and to your committee (1 per individual).

**Appendix C: Escape Room Project Feedback for Universities A and B**

Q1: What did you like most about the Escape Room Design project?

- Use of outside resources
- **Creating and building different parts using 3D printers and laser cutters**
- **Working together with the entire class to design one big project**
- **Freedom and creativity/create something fun to do and play**
- The final product and how the different puzzles flowed together
- **Individual work being brought together/required the entire class/made the project more fun and engaging/mimicked real-life teamwork in a job setting**
- Teams based on major (Rowan) Teams based on schedule (Northeastern)
- Incorporation of engineering principles into a non-engineering product

- "I loved pretty much everything save for the write ups."

- I liked the freedom we had in designing puzzles and the pacing of the milestones

- "What I liked the most about the Escape Room Design Project is how the individual puzzles made by small groups came together to form a final product. I really enjoyed working together as an entire class, and I especially enjoyed getting to see my friends play through the escape room. My least favorite part of the project was actually making my small group project; compared to last semester, my group members were not as willing to put in time and effort, and it was difficult and tiring trying to coordinate with my group members. "

Q2: What did you like least about the Escape Room Design project?

- **Working with multiple teams/committees/communication between teams/confusion working with multiple teams/lack of communication between committees (Northeastern used Slack to help with communication but still received some of these comments)**
- Initial personal puzzles
- **Confusion of the end goal/unclear expectations**
- Testing the escape room
- Personal groups
- **Committees had trouble communicated and workload was not balanced**
- Connecting the puzzles together
- **Creating puzzles and not using them**
- **Organization/collaborating with 20 people towards an end goal/difficult to communicate with 20 people**
- **The connections to PF (made it less fun and less like an escape room)/catering the puzzles to PF**
- Gannt chart not effective
- Website

- Lack of individual responsibility
- The final escape room looked kind of empty

Q3: What did you learn during the course of the Escape Room Design Project?

- **Communication skills**
- **Teamwork**
- Time Management
- The design process
- **Laser cutting and prototyping/fabrication techniques/utilizing outside resources and Makerspace**
- **How to take individual ideas and incorporate them into one design/experience**
- **How to work with different kinds of people**
- **Problem solving**
- Puzzle making
- **How to work towards a common goal/ How to make a step by step plan for a large scale project/how to look at the big picture**