# Design of a Virtual Escape Room for K-12 Supplemental Coursework and Problem Solving Skill Development

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## Abstract

This paper describes the process of creating an educational and entertaining game for K-12 students based on the "escape room" concept. Escape room games require players to find objects and use them in specific locations; the challenge is to vary the virtual problem solving system to allow the game to be replayed and new material to be incorporated into the game. This instructional escape room will require students to use skills and concepts learned from their coursework to solve puzzles to advance within the game and provide a supplemental method for reviewing material as well as improve their problem solving and logic skills. The authors are working with senior computer science majors to design a modular and flexible game play system and a separate development interface that allows teachers to add content specific to their class.

**Keywords:** K-12 Education, Educational Games, Problem Solving, Escape Room

## The Game

The majority of K-12 students play video games daily[1] and using video games has been shown to increase student motivation toward learning[2]. Games often encourage students to work for longer durations than traditional homework[3]. Because video games are so familiar to this generation of students, we feel this is an opportunity to incorporate educational material into a video game structure. We have chosen to use a new and popular type of game known as an escape room. Escape Rooms generally come in two varieties: (1) virtual and (2) real-life. In a real-life escape room, a group of players is "locked" into a room and required to solve puzzles/find hidden objects in order to "escape" the room. These real-life experiences are popping up all over the world and becoming a new activity for team building experiences[4]. In a virtual escape room, a player attempts to solve a mystery or escape the virtual environment to win the game. Virtual escape rooms generally require locating hidden objects and using those objects to solve puzzles. Both varieties are generally themed (e.g., Haunted House, Police Detective, Prison Break, Lab Accident, etc.) and are one-time play (i.e., the game is "spoiled" after you know the answer).

The purpose of this project is to develop a virtual escape room game that is not only flexible and customizable in content but is somewhat re-playable. The flexible and customizable content will allow the game to be played by the large range of ages (i.e., K-12) with questions relating specifically to their coursework. Teachers will be able to select from a range of subject areas such as history, English, general science, biology, chemistry, and mathematics. Additionally, the game allows for a wide variety of question types ranging from traditional select the answer or fill in the blank, mathematics or calculation based, algorithm based, visually based (recognizing information from a picture), logic based, or pattern recognition based. Teachers will have

flexibility with not only choosing questions from a database but also easily adding specific material and questions to suit their own classroom environment needs. Questions will be categorized by subject, difficulty, and problem type to allow teachers control over content to include in the experience. The authors envision that this software will be used by many teachers as a review exercise incorporating material from the entire academic year. The ability to customize content and problem solving activities should lead to re-playability by the students and allow the same program to be used by a teacher multiple years without students finding out the "solution" from others.

Many virtual escape rooms have very limited puzzles, with little logic required to solve them. One goal of this game design is to allow teachers to incorporate a significant amount of problem solving into a course review. This will offer students the opportunity to develop and practice independent problem solving and critical thinking skills. Many college students struggle with critical thinking skills in a variety of STEM courses, and the authors anticipate that practicing these skills from an earlier age in this type of experience will increase student confidence in their ability to think through problems.

The theme of the escape room for this project will require students to find their way out of a medieval-like Tower Building. The height of the tower and number of rooms per floor will increase as difficulty and grade level increases. Furthermore, as the difficulty increases, the total number of questions and puzzles per floor will also increase in conjunction with the difficulty and complexity of the game. The game begins with the students in a particular locked room(s), and as they answer questions to solve puzzles, they gain information and items that will help them escape to the next level—once they have completed the puzzles on the current level. As students work through the various levels, both the questions and puzzles become more challenging. Although there is an overall theme, each level will be different from previous levels to avoid repetition and avoid student boredom.

**The Game Development**

The Department of Computer Science and Information Systems requires all students to complete a two-semester senior project experience that takes them through the entire software development process. During the first semester, students find a project, meet with their customer, write specification documents, and provide proof of concept for various components of their project. During the second semester, students create the full project using the specifications and customer feedback. The authors are acting as the customer for a two-student senior design team. The team was tasked with creating two interacting pieces of software: (1) the game that is accessible to anyone and (2) a development interface accessible only to teachers.
The students are developing the game portion of the project using the Unity Game Engine and the C# programming language for development. The Unity Game Engine will provide an easy platform for the students to create a 3D-like gaming environment with "realistic" lighting. With solid graphics and gameplay that looks closer to "real" video games on the market, the hope is players (students) will be intrigued and engaged in completing the game while also being interested in replaying the game.

The moderator interface will be designed using a database and a webserver. This will allow teachers to remotely connect to the game from any computer (or tablet that has a web browser).

From this web-based form, teachers have the ability to customize portions of the game with specific topic questions, change the difficultly, or do other administrative tasks – like track student progress. The ability to alter the questions and "update" the game will increase the ability for the game to be "re-playable". This is not a feature available for most escape rooms on the market as most current escape room games are designed to be "one-play". The authors are currently reaching out to teachers at several schools to gather possible question types from a range of grade levels to provide the senior design students working on the development of the software with ideas/customer requirements. By "pre-loading" these questions into the database, other teachers will be able to see example questions and test the playability of the software.

**Challenges in Game Development**

There are several challenges that need to be overcome during development. The first challenge is making the questions flow within the game to avoid having only straightforward multiple-choice questions. The current method under consideration is to use a combination of answers and information found within the game to act as passwords or combinations to unlock new rooms and puzzles. The second challenge is "swapping out" the original questions with the custom questions loaded by a teacher without adversely affecting the game play and storyline. Additionally, placement of the puzzles and questions within the rooms and towers should change to make the games re-playable. The third challenge is designing a game that appeals and is playable to the large age range of children (i.e., K-12). The fourth challenge will be designing an easy to use development interface that allows teachers to easily incorporate new material and choose how that material fits into the storyline.

**Assessment Strategy**

As this project is in the early stages, the authors seek to evaluate multiple aspects of the instrument. First, in the development stage, we need to assess the user interface and player interaction with the game as well as the ability of the instructors to modify and change the scenarios to evaluate student performance on different content and at different levels. To facilitate this evaluation, we will employ targeted surveys and open-forum focus groups. Continuing to the ability of a student to increase learning through playing the game, we will administer pre-and post-content evaluation to identify any change in learned content. Additionally, focus groups with students playing the game will be used to identify student enjoyment in playing the game as well as their willingness to dedicate more time to this type of learning when compared to traditional content review. Once the instrument is fully developed and we have established baseline usability, we will develop assessments to evaluate the ability of the instrument to improve critical thinking of players, to determine if any improved critical thinking skills translates to content outside the game, and the timeline for developing any improved critical thinking skills.

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**Kimberlyn Gray**

Kimberlyn Gray is an assistant professor of chemical engineering at West Virginia University Institute of Technology and received her BS and PhD in biomedical engineering from Louisiana Tech University. She is working to improve first-year engineering courses by incorporating more critical thinking and problem solving activities and has begun a project with the capstone design course to incorporate first-year students into senior design teams. She is involved in outreach such as summer camps and k-12 classroom and on campus visits.

**Marcia A. Pool**

Marcia Pool is a Lecturer and Director of Undergraduate Programs in the department of Bioengineering at the University of Illinois at Urbana-Champaign; she received her BS and PhD in biomedical engineering from Louisiana Tech University. Marcia has been active in improving undergraduate education through developing laboratories to enhance experimental design skills, developing a preliminary design course focused on problem identification, mentoring student teams through capstone courses and a translational course, and developing a writing in the disciplines course. She is actively involved in outreach and educational programs, such as summer camps, researcHStart, and the Cancer Scholars Program.