A Gamified Educational Escape Rooms' Framework for Computer Programming Classes

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Abstract

This paper presents a study on the use of gamified educational escape rooms to foster the teaching-learning process of computer programming, based on an user type taxonomy. The ultimate goal of this work is to identify and validate the most suitable gamification elements and mechanics for each user profile, providing case studies that illustrate their implementation. The main contribution of this work is to guide the design process of educational escape rooms in any domain, by considering the needs, preferences, and motivations of different user types.

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1 Introduction

Teaching computer programming is a complex task that requires a deep understanding of programming concepts, problem-solving skills, and, as in any other domain, a lot of practice. However, traditional approaches to teaching programming often fail to engage learners, leading to high dropout rates and low learning outcomes [15, 2].

In order to address this issue, new approaches have emerged, such as gamification and educational escape rooms, with the aims to make learning programming more engaging, effective and fun. Gamification involves using game design elements and mechanics in non-game contexts, such as education, to enhance motivation, engagement, and learning outcomes. On the other hand, educational escape rooms are immersive learning environments that simulate real-world scenarios, requiring learners to solve puzzles, complete tasks, and collaborate with others to achieve a common goal [7].

By combining gamification and educational escape rooms, educators can create an interactive and dynamic learning experience that caters to the diverse needs of learners. By using gamification elements and mechanics (e.g. points, badges, leaderboards), educators build a sense of achievement and recognition for learners, while also fostering healthy competition and collaboration. Additionally, educational escape rooms provide an engaging way for learners to apply their programming knowledge in a practical setting, enhancing their problem-solving skills and critical thinking skills.

In this paper, we present a study on the use of gamified educational escape rooms (GEER) to foster the teaching-learning process of computer programming based on the User Type Hexad Taxonomy of Andrzej Marczewski [10]. For each user type profile, a set of gamification elements and mechanics are provided and applied in case studies related with the computer programming domain. The contribution of this work is to guide the design process of educational escape rooms in any domain by considering the needs, expectations, and motivations of different user types.

The rest of the article is structured in three sections: the second section presents related work on educational escape rooms, user type taxonomies and gamification frameworks. The following section present a GEER framework based on the User Type Hexad Taxonomy. Hence, for each user type profile a set of gamification components are assigned and deployed in a specific case study within the realm of the computer programming domain. Finally, the contributions of this article to the scientific community are presented as well as the future work.

2 Related work

This paper aims to present a study on the use of GEER to promote computer programming learning, based on Andrzej Marczewski's Hexad taxonomy of user types [10]. The work seeks to identify the most suitable gamification components for each user profile. With these ideas in mind, this section explores the concepts of educational escape rooms, gamification and user type taxonomies in order to give a richer context to the selected educational approaches, in order to overcome students' difficulties in the computer programming learning.

2.1 Gamification

With the growing demand for computer programming professionals, teaching programming has become increasingly important at different educational levels. Gamification has proven to be a promising approach to make learning programming more attractive for students. Gamification is defined as the use of game elements and mechanics in non-game contexts in order to increase user motivation in several activities [6].

By applying gamification to teaching programming, educators can create a more engaging and challenging environment, making the learning process more interesting. Gamification frameworks, such as Octalysis [4] and Hexad [10], can be used to guide the gamification design process and ensure that the chosen game components are aligned with educational goals and, most important, with the student preferences [13].

In fact, some research stated the effectiveness of gamification in teaching programming. A recent study by Cai et al. [3] presented a systematic review of the literature on gamification in education, showing that gamification can lead to significant improvements in student performance and engagement with content. Furthermore, the use of games and gamification elements in programming education can contribute to the development of cognitive skills, such as critical thinking and problem solving [12].

2.2 Educational Escape Rooms

Educational escape rooms are immersive learning environments that simulate real-world situations in which students work in teams to solve problems and complete tasks in a limited amount of time. These escape rooms, typically used for entertainment games, have been adapted for educational purposes as a way to engage students in learning in an interactive and playful way. This approach has received attention from educational researchers, who have investigated how educational escape rooms can be used to promote learning of specific content and develop skills such as teamwork, problem-solving, decision-making, and critical thinking [7].

Some studies have shown that educational escape rooms can be effective in engaging students and enhancing their cognitive and social skills [12]. Moreover, the use of gamification elements in educational escape rooms can further increase student engagement [3].

However, the design and implementation of educational escape rooms can be challenging for educators. Not only for the lack of knowledge on this domain as well the selection of the best tools to do it. Regardless of the tooling set, the most important is that the experience provides students with an interesting and meaningful challenge, which in turn promote the acquisition of specific knowledge and skills in students [9]. It is also necessary that educational escape rooms are carefully planned, so that the proposed tasks and challenges are aligned with the desired learning objectives [14].

2.3 User types taxonomies

User types taxonomies are frameworks that classify users based on their psychological profiles and behavioral tendencies. These frameworks have been widely used in various fields, including human-computer interaction and marketing, to help designers understand their target audience and create more engaging and effective products [11]. One of the most well-known user type taxonomy is the Hexad framework [10] developed by Andrzej Marczewski, which categorizes users into six types based on their motivations and preferences in software applications:

- **Achievers**: users who seek mastery, completion, and recognition of their accomplishments;
- **Socializers**: users who seek social interaction, collaboration, and feedback from others;
- **Philanthropists**: users who seek to help others, contribute to a cause, and make a positive impact;
- **Free Spirits**: users who seek novelty, freedom, and self-expression;
- **Players**: users who seek competition, challenge, and rewards;
- **Disruptors**: users who seek to break the rules, challenge authority, and explore alternative solutions.

Other popular user type taxonomies include the Bartle Taxonomy of Player Types [1], the Self-Determination Theory of Motivation [5], and the Big Five Personality Traits [8]. These frameworks provide valuable insights into how users interact with software applications and can enrich the design process to create more personalized experiences.

3 GEER framework

This section presents a framework for GEER based on the user type Hexad taxonomy (Figure 1). For each identified user profile, we present the most suitable gamification components and apply them in a specific computer programming case study comprising a storyline and a gameplay.

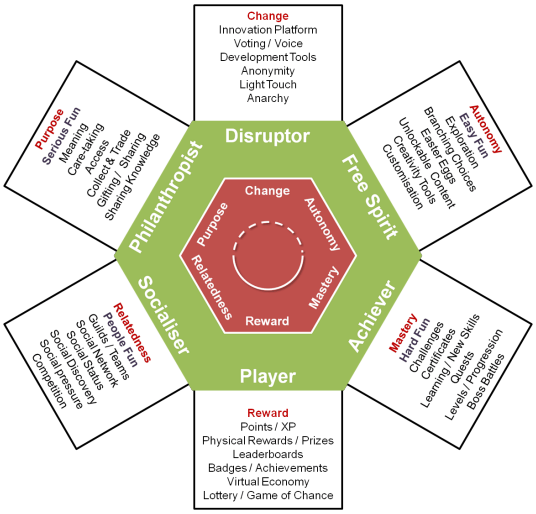

Figure 1 User type HEXAD.

3.1 Achiever – Cybercrime Investigation

The Achiever is motivated by competition and achievement. They are likely to enjoy an escape room scenario that involves a race against the clock, where they can compete against other teams to see who can escape the room fastest. The room could have multiple paths to escape, allowing the Achiever to choose the most challenging path to prove their skills.

For the achiever user type the most important gamification elements are:

- Challenges and quests to encourage mastery and accomplishment;
- Progress bars and badges to track accomplishments;
- Leaderboards to foster competition and drive motivation.

The case study chosen for this user type is a **Cybercrime Investigation**. In this story, the user is a detective investigating a cybercrime. The suspect has locked the detective in their own office, and the user should escape the room to continue their investigation and catch the suspect.

In terms of gameplay, the room is designed to look like a typical detective's office, with clues and puzzles hidden throughout the room related to the cybercrime investigation. The puzzles are designed to test the player's knowledge of computer programming concepts, such as coding languages, data structures, and algorithms. For example, one puzzle could involve decoding a message written in a programming language, while another could require the player to debug a code snippet.

In order to add a competitive element to the achiever profile, the room could have multiple paths to escape, each with increasing levels of difficulty. The user can choose the most challenging path to prove their skills and compete against other users who have completed the room. The room could have a leaderboard displaying the fastest escape times and highest scores, encouraging users to come back and beat their previous records.

3.2 Socializer – Hackathon

The socializer is motivated by social interaction and collaboration. They would enjoy an escape room scenario that requires teamwork and communication, with puzzles that can only be solved through cooperation. The room could have a theme that encourages socializing, such as a murder mystery or a haunted house, to make the experience more immersive.

For the socializer user type the most important gamification elements are:

- Collaborative and social challenges that promote teamwork;
- Interactive leaderboards that allow for social comparison and recognition;
- Community features such as forums, chats, and social media integration (likes, following friends and sharing resources).

In order to apply some of these elements the case study will be a **Hackathon**. In this story, the user is a member of a team participating in a hackathon, a collaborative programming competition. The team has been locked in a room and must escape before the time runs out in order to submit their project and win the competition.

The room is designed to look like a typical hackathon workspace, with computer workstations and programming equipment scattered throughout the room. The puzzles are designed to test the player's knowledge of computer programming concepts, such as coding languages, data structures, and algorithms, but also require teamwork and communication to solve. For example, one puzzle could require the player to share their screen with a team member and work together to debug a code snippet, while another could involve coordinating multiple players to input different pieces of code into a shared program. To encourage socializing, the room could also have elements such as a shared whiteboard or a chat system, where players can collaborate and communicate with each other.

Overall, the hackathon theme would make the experience more immersive and exciting, while the collaborative puzzles would promote socializing and teamwork.

3.3 Philanthropist – Humanitarian Aid

The philanthropist is motivated by helping others and making a positive impact. They would enjoy an escape room scenario that involves solving puzzles for a good cause, such as finding a cure for a disease or stopping a disaster from occurring. The room could be designed to look like a laboratory or research facility to reinforce the sense of purpose.

For the philanthropist user type the most important gamification elements are:

- Charitable donation or volunteerism opportunities as rewards for achievement;
- Sharing or promoting positive social impact on social media;
- Offering virtual gifts.

In order to apply some of these elements the case study will be a **Humanitarian Aid**. In this story, the user is a member of a team tasked with providing humanitarian aid in a crisis-stricken region. However, the aid shipment has been blocked and the player must escape the room to find a way to get the aid through and help those in need.

In this case study, the room is designed to look like a logistics office, with maps, shipping records, and other aid-related documents scattered throughout the room. The puzzles are designed to test the player's knowledge of computer programming concepts, such as coding languages, data structures, and algorithms, but also require problem-solving and critical thinking skills.

For example, one puzzle could require the player to analyze shipping records and optimize delivery routes using algorithms, while another could involve debugging a program used to track the shipment.

To promote philanthropy, the room could also have elements such as a live feed showing images and videos of the crisis-stricken region, and information about the impact that the aid will have on the local population.

Overall, the humanitarian aid theme would make the experience more emotionally engaging, while the programming puzzles would promote critical thinking and problem-solving skills.

3.4 Free Spirit – Virtual Reality Adventure

The Free Spirit is motivated by creativity and self-expression. They would enjoy an escape room scenario that allows them to use their imagination to solve puzzles, with a variety of open-ended challenges that can be tackled in different ways. The room could have a theme that allows for self-expression, such as an art gallery or a music studio.

For the free spirit user type the most important gamification elements are:

- Creative challenges that allow for self-expression and experimentation;
- Non-linear or open-ended gameplay that encourages exploration and discovery;
- Self-guided quests that allow players to set their own goals and direction.

For this type of user the case study selected is related with a **Virtual Reality Adventure**. Here, the user is a virtual reality game developer who has been transported into their own game world by a glitch. The user must escape the game world by solving programming puzzles and fixing the code in order to return to the real world.

The room is designed to look like a virtual reality environment, with futuristic technology and gaming equipment. The puzzles are designed to test the player's knowledge of computer programming concepts, but also require creativity and imagination. For example, one puzzle could involve programming a character to navigate through a maze-like environment, while another could require the player to design and code a new game feature on the spot. To promote free-spiritedness, the room could have elements such as open-ended puzzles that can be solved in multiple ways, or a "sandbox" programming environment where the player can experiment and create without limitations.

Overall, the virtual reality theme would make the experience more exciting, while the programming puzzles would promote problem-solving and critical thinking skills in a fun and imaginative way.

3.5 Player – Hacking Adventure

The player user type is motivated by the thrill of the game and the experience of playing. They would enjoy an escape room scenario that is designed like a video game, with a clear objective and challenges that gradually increase in difficulty. The room could have a futuristic or sci-fi theme, with high-tech gadgets and special effects to enhance the gaming experience.

The Player type feels comfortable with the following gamification elements:

- Point systems and rewards for achievements;
- Unlockable content and in-game purchases for added benefits;
- Competitive gameplay with leaderboards and multiplayer options.

In this realm, a **hacking adventure** was the case study selected. The user is a hacker who has been recruited by a secret organization to complete a series of hacking challenges. The user must escape the room by solving programming puzzles and completing hacking tasks in order to prove their skills and earn the organization's trust.

The room is designed to look like a hacker's lair, with computer workstations and hacking tools. The puzzles are designed to test the player's knowledge of computer programming concepts, but also require quick thinking and problem-solving skills. For example, one puzzle could require the player to hack into a computer system using a specific programming

language, while another could involve decoding a complex encryption algorithm. To promote the player's motivation for competition and rewards, the room could have elements such as a leaderboard showing the player's progress and a reward for completing all the challenges.

3.6 Disruptor – Cybersecurity Breach

The disruptor user type is motivated by the desire to challenge the status quo and push boundaries. This user type seeks to break down existing barriers and explore new possibilities, often by challenging conventional wisdom and advocating for change.

In this profile, users will be satisfied with the following gamification elements:

- Challenging gameplay that requires strategic thinking and creativity;
- Unique and unconventional gameplay elements that break from traditional game design;
- Risk-taking opportunities, such as high-stakes challenges or timed events.

In this storyline, the user is a cybersecurity expert who has been called in to investigate a major **security breach** at a government agency. The user must escape the room by solving programming puzzles and detecting vulnerabilities in the agency's computer systems in order to prevent further damage and restore security.

The room is designed to look like a government agency's computer center, with advanced technology and equipment related to cybersecurity investigations. The puzzles are designed to test the player's knowledge of computer programming concepts, but also require strategic thinking and creativity. For example, one puzzle could require the user to analyze a system's code and detect any vulnerabilities, while another could involve creating a program to block a hacker's access. To promote disruptive thinking, the room could have elements such as fake news articles or social media posts related to the security breach displayed on the walls. The puzzles could be designed to encourage users to think creatively and outside the box, challenging them to find innovative solutions to the problems they encounter.

4 Conclusion

This study has demonstrated the potential of gamified educational escape rooms as a valuable tool for enhancing the teaching-learning process of computer programming. By using a user type taxonomy, the study has identified the motivations, preferences, and needs of different user profiles and provided case studies that illustrate the successful implementation of gamification elements and mechanics for each profile.

The results of this study have practical implications for the design and implementation of educational escape rooms in any domain. By considering the unique characteristics of each user type, designers and educators can create tailored gamification experiences that are engaging, effective, and inclusive. Overall, this paper contributes to the growing body of research on gamification in education and highlights the importance of user-centered design in the development of educational technologies.

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