An Innovated Design of Escape Room Game Box Through Integrating STEAM Education and PBL Principle

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Abstract. The aim of this study is to explore a design project of "escape room game box" through integrating STEAM education and PBL principles in a series activities within a creative course. To analyze, the STEAM education and PBL principles are applied to inspire the problem-solving potential of students. The findings show: (1) that there is no direct correlation between time and space factors with regard to the subjects' access to the Citizen Cloud service; (2) that because of its convenience, subjects consider contacting others and sharing should be a standard feature in the Citizen Cloud; (3) that while comparing subjects' use of Citizen Cloud, "command" is more popular than other online features; (4) In their overall experience subjects prefer higher interaction with cloud computing service.

Keywords: STEAM education · PBL · Makerspace · Escape room game

1 Introduction

To face the complex problems of the world, the current trend and challenges are towards to train learners owning multiple abilities constructed by interdisciplinary experience. Since 2000, in the US, the importance of STEM-related teaching has been proved by some educational organizations through teaching and studies. Some attaching organizations of the US government, for instance, the NASA, or NSF aimed at STEM innovation and assisted to fund the development of STEM education in succession through some community projects [18]. For the past several years, the STEM teaching not only has been taking root but also is surging forward as the active style of movement. However, in order to match the demand of the economy in the 21st century, the original STEM movement is integrated with "art" to evolve into STEAM education [2]. While [12] proposes that educators should have a duty to inspire students

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to spread better talents in courses of STEM or STEAM and in their later career, it will be "part of the solution to a major national problem".

Obviously, today's learners need an innovated vision and skill to overcome any difficulty in their life. Until now, there are some researchers find that children those who perform well on academic tests for creativity may correlate positively with playing video games [14, 21]. While a new style game named "escape rooms" may create a Connection between individual and problem-solving. The "escape rooms" is a live-action team-based game 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 amount of time [24]. This study is shaped from a series of "escape rooms" table game design with PBL principle in a creative design class.

2 Literature Review

This section firstly reviews related literatures of STEM and STEAM education, principle of maker and makerspace; then, introduces the features of the problem-based learning (PBL) that will be exploded on game design of "escape room" to arrange for later experiment design.

2.1 STEM/STEAM Education

The term "STEM" was married from science, technology, engineering, and math by the National Science Foundation (NSF), the US in 1996. It's an assembled educational tactic, which is guided students to learn science, technology, engineering, and mathematics, obtaining the ability of inquiry, dialogue, and critical thinking. While, the STEM is gradually transformed to STEAM, according to Julian and Parrott [22] states that to inject art into STEAM is for resulting from some art projects based on science and mathematics.

Also, STEAM is an interdisciplinary approach as students apply science, technology, engineering, arts, and mathematics to coupled with real-world issues and learn to make connections between rigorous academic concepts of school, community, work and the global enterprise in context [32]. The concept of STEM/STEAM is to encourage student attempting to hands-on do something with plural knowledge, skills, as well as to encourage higher-order reasoning and problem-solving skills. The final target is to offer students thinking risks, engage in experiential learning, persist in problem-solving, embrace collaboration, and work through the creative process (educationcloset.com), then, to be the whole new innovators, leaders, and learners of the 21st century. Due to the society that is in transition can enable the development of STEM/STEAM connotation. More and more styles of STEM/STEAM courses are popular, especially, Julian and Parrott argue that one current successful direction to develop STEM/STEAM education is to establish some makerspaces.

2.2 Maker and Makerspace

The "maker" means some people who like to do something by himself, especially concrete objects; while the maker movement, promoted by maker groups with an artisan spirit will form a social, cultural movement. The maker culture is a contemporary subculture representing a technology-based extension of trendsetting DIY that intersects with hacker culture [35]. According to Dougherty [6] proposed, some features of maker are - 1. The general engineer focuses on a single technical field, and the maker is interested in the technology in each field; 2. They would like to know the operation principle of things and make some devices to verify it; 3. They have a "play" quality; 4. Be willing to share with the open source community; 5. They can think the world can be improved, problems can be solved, things can be changed.

The "Make magazine" is the initial publication of maker by Dale Dougherty, as well as the one who gave the maker movement its name in 2005 [20]. Through "Make magazine", Dougherty wants to help people starting a hobby, learning new skills, and help the new hobbyist find a community of like-minded tinkerers to talk with about it [6]. In 2006, a year after the Make magazine, Dale Dougherty held her first makerspace in San Mateo, California, the Bay Area named "Maker Faire". The Makerspace is a place can let makers expand their idea of learning and continue the conversation with members of the community. Although the first Makerspace first appeared around 2005 as part of the popular DIY (Do it Yourself) movement [13], however, the purpose of a new pattern of makerspace is to create a comfortable environment for users to experiment, create and learn within a controlled setting. These places enable makers (educators and students included) to apply scientific principles and meet curricular science through the design, creation, and building of products [22], as Rivas [27] is an electrical engineer and educator, she created a makerspace for young women being able to create real products, like toys, video games, and electronic garments in the community.

2.3 Problem-Based Learning (PBL)

PBL means problem-based learning, began in the 1960s at McMaster Medical School in Canada [31] has been applied in health professions education for a long time. Nowadays, PBL methods have been adopted across several institutions, medical curricular and also been introduced in many different disciplines such as social work, science, engineering, business, management etc. [1], and especially, is extensively promoted in science education [8, 25].

In PBL situation, the learning task is addressed by the students in a real naturalistic context [32]. On one hand, PBL has been located as a transformative instructional strategy in existing literature, and one of the vital key component of PBL for its success is the provision of feedback to learners [19]; on another hand, PBL is a learning strategy that students in a small social group adopt it to solve problems and reflect upon to regard their group activity as learning processes collaboratively [17].

During a learning task, students co-work in small groups (called tutorial groups) brainstorm the problem and identify what they need to learn [9] trying to solve the problem, guided by facilitators. However, the facilitators won't teach them, but just guide the students on the way to discovering new knowledge on their own [28]. Therefore, the feedback of course shaped from the facilitator will be a very influential strategy for elevating learning, PBL facilitators also need to emphasize it [10]. Hence, the main characteristic of PBL is contextualized learning through a problem solved by students within a tutorial group without formal lectures or prior preparatory study [33]. In general, there are some important reasons for the implementation of PBL: training professionals with competencies such as critical thinking, problem solving, reflection, collaborative, self-directed as well as life-long learning [29, 34].

3 Methods

This pilot study was one arm of a major creative design course study. In this study, a qualitative method was applied to consist of an analysis of the contents of both creative concept maps in the design procedure and interviews with students. The objective was to present an all-inclusive of the contextual process of learning in a PBL class [5, 15]. Due to the process of drawing the creative concept maps let the participants express their perspectives in a more innovative, active, and autonomous manner than usual, the study will survey the creative concept maps produced by the students [3, 4, 11].

3.1 Phase and Flowchart of Executing

The study is separated into four steps to explore the design procedure of "escape room game box" design and evaluation of players' experience. The flowchart of executing refers to the 4D method developed by the UK design council. This study modifies the 4D method as well as integrate PBL principles and a part of knowledge from STEAM courses into the design procedure, a whole research flowchart through PBL model is shown in Fig. 1.

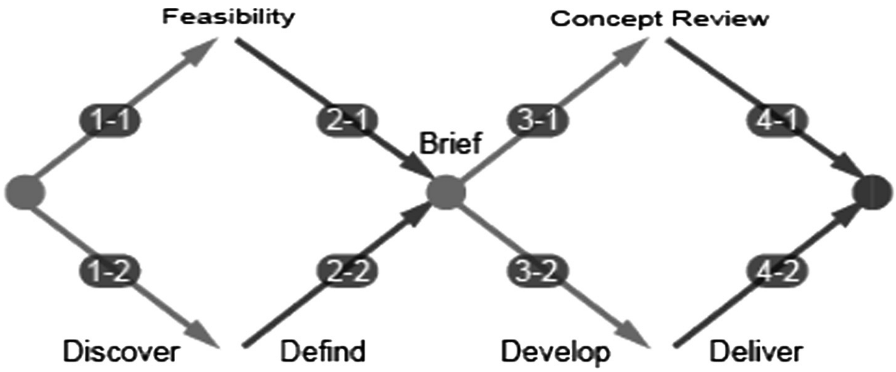

Fig. 1. Research flowchart

The phases of the study are shown as followed:

Phase 1. To conduct a literature review on PBL, maker, game design of escape room etc. In this step, the work of “1-1 Read and analyze the scenario of situation in every gate” and “1-2 List your personal understanding, ideas, or hunches” are included.

Phase 2. The data from a series of creative maker courses are recorded through participant observation. In this step, the work of “2-1 List what is known” and “2-2 List what is unknown” are included.

Phase 3. To conduct content analysis to classify the recording data. In this step, the work of “3-1 List what needs to be done” and “3-2 Develop a problem statement” are included.

Phase 4. To integrate different kind data. Write a research full paper that combines the relevant theory and data analysis results. In this step, the work of “4-1 Gather information” and “4-2 Present findings” are included.

3.2 Participants

The participants were twenty-four undergraduate students from various departments of a medical university were recruited by selecting randomly out of volunteer on a social media website in Taiwan. They consisted of ten males and fourteen females ranging from 19 to 22 years old (*M* = 20.17, *SD* = 1.31). In terms of experience with creative thinking and design, eleven of the participants were realizable with something else. Eight of them had ever planned one table game at least, seven stated to be experts of table games, and the rest of them had interested in the table game but were not well-versed in design the game. Only one of them had never played any table games, near half played some table games less than one hour a week, and others spent more than one hour every day on table game. They were randomly distributed into four groups in a classroom, each containing six students, to participate in cooperated one concept maps during the creative design class, as shown in Fig. 2. When the study The ethical of body approval was obtained prior to collect the data with the consent forms were collected from the participants.

Fig. 2. The design procedure of “escape rooms” games

3.3 Estimative Material – Escape Room Game

The estimative material of this study is a table game named “escape room”. This table game is modified from real-life escape rooms, represented a new type of game. In real-life escape room game, people to be players are locked in a room or series of inclosed spaces, so they must deal with some tasks for solving puzzles or riddles in order to escape these airtight spaces. Therefore, through considering the holistic, essential, and functional constraining of escape room rules, the students learn to find answer of problem-based by some creative thinking skills can lead them to finish the tasks. Moreover, the real-life escape room games not only are represented to train a collaborative experience where players work on team building, communication, and coordination, but also based on live-action role playing games, treasure hunts. Most of such a game often ask players try to escape within a set time limit, typically 45–60 min [16].

3.4 Design Contents and Standard

To consider the integrity of escape room game, the researcher and teacher formulate standard contents of this game in the design and plan procedure are - A. story/role cards (human or non-human) as shown in Fig. 3; B. boxes (scenes of game) as shown in Fig. 4; C. game accessories (break the cue card, password card for each gate are included) as shown in Fig. 5.

The play rules of the escape room game are - (1) three scenes with individual riddle or puzzle; (2) coded lock on the door of the scene. The players must unlock the coded locks step by step with a right password through the story, roles, game accessories, and break the cue card.

Fig. 3. The design of multiple story card in “escape rooms” games

Set1 game box: unlock the coded locks by systematic thinking, math and logic.	Set2 game box: unlock the coded locks by math, knowledge and logic.	Set3 game box: unlock the coded locks by math, pattern, shape and colors.	unlock the coded locks by colors, numbers

Fig. 4. All of 4 sets “escape rooms” game boxes

Fig. 5. The design of Game accessories in “escape rooms” games

3.5 Data Collection

In the creative design class, students are asked to collaboratively do an escape room box with multi-materials. They tended to start discussing the concept and mode of escape room game by analyzing the key points of the story-telling and logical context of the patient’s situation. Then, they share and present their own experience and make some sketches. Finally, they build the concept model and write down the key point of it. After they are satisfied with the final set of the game they developed, they take photographs of the concept model and other accessories of game. Ultimately, a total of 4 sets of a concept model of the game box were collected.

4 Result and Discussion

4.1 Escape Room Game Box

The groups of students in the creative design class design the concept models of escape room game box with PBL principle shown in Fig. 3. There are 4 sets of escape room game boxes developed by students. All design of game box is used by students to combine the systematic thinking, math, logic, color, numbers, pattern, shape, and knowledge etc.

5 Conclusion

Although in this pilot study we adopt simple samples from a creative course, the findings are usefully shown as follows:

(1) Most of the concept model of escape room game boxes had a balance of informative and artistic elements. The students demonstrated creative skills by concreting the design processes of PBL application using simple shapes.
(2) However, since the composition of these game boxes is restricted by the PBL procedure, storytelling, etc. the theoretical connection among the concepts was not fully spread out.
(3) The students can show more of their artistic ability by building a game box on the faces of the STEAM positions.
(4) Even if students' not enough experience in PBL content, they can share or contact others through cooperation to apply STEAM knowledge, moreover, the students can have employed more critical thinking on the contents of escape room game.

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