The Rooms of Newton: Can You Escape?

Low Jie Ying

***Abstract* – Newton's laws are one of the most important concepts in classical mechanics. However, many students from different countries found the learning area of forces and motion challenging as they faced difficulties understanding the concepts and solving the related problems. Similarly, students from a school in Perak face the same situation. They have issues relating the forces and motion concepts to solve real-life situations given in the essay questions that require them to make evaluations, decisions and modifications. Since game-based learning (GBL) has been proven to enhance students' learning and problem-solving skills, an educational digital game named "The Rooms of Newton: Can You Escape?" was created. This game was developed based on the Integrated Design Framework of Playful Learning to provide students with a playful and engaging environment while solving real-life situations that test their higher-order thinking skills. This study aimed to examine how this digital game could facilitate students in solving real-life problems given in the essay questions format. A total of 18 secondary school students took part in the game. Quantitative data was collected via a pre-test, post-test and surveys. The results indicate that the game significantly enhances students' problem-solving skills in answering essay questions, and they showed positive attitudes towards the game. This game can be used when online learning occurs or compliments face-to-face learning in schools when COVID-19 becomes endemic. The findings of this study can be a cornerstone for educators to decide whether to integrate GBL in teaching Physics or not.**

***Keywords* – Newton's laws, digital game, game-based learning, educational game**

I. INTRODUCTION

According to Guido (2013), Physics is the most complicated subject in the realm of science; hence students are not having positive attitudes towards Physics compared to Biology and Chemistry. Numerous past studies pointed out that both teachers and students face different challenges in teaching and learning Physics (Nkurikiyimana, Uwamahoro & Ndihokubwayo, 2022). One of the challenges is understanding and mastering the abstract concepts of Newton's laws and solving the related problems (Mansyur, Kaharu & Holdsworth, 2020; Handhika et al., 2018; Fratiwi et al., 2017). Additionally, Aykutlu, Bezen and Bayrak (2015) claimed that teachers marked "Forces and Motions" as the most challenging learning area in classical mechanics.

Subsequently, Astutik et al. (2019) found that students face difficulties in solving Physics questions that require higher-order thinking skills (HOTS). In fact, students in a school in Perak faced a similar situation where they could not solve questions related to Newton's laws that required HOTS. The current Physics curriculum in Malaysia is based on *Kurikulum Standard Sekolah Menenga*h (KSSM), which emphasises HOTS. Usually, HOTS related questions appear in the essay questions of Paper 2 in Section B and Section C.

Concurrently, the worldwide education system has been affected by the COVID-19 pandemic, where face-to-face learning was forced to shift to online learning (Dennon, 2021). According to Klein et al. (2021), the sudden shift leaves educators limited time to adjust their teaching approaches and materials as well as consider the efficiency of the online teaching and learning process. Furthermore, it is challenging for educators to keep their students motivated and engaged during online lessons (Nair, 2021; Zainuddin et al., 2021).

On the other hand, Raitskaya and Tikhonova (2019) asserted that game-based learning (GBL) is gaining more and more attention in educational research as GBL embraces the learning process with different game mechanics (Gros, 2007). Besides, GBL could foster students' learning through a fun and engaging environment (Akademi Sains Malaysia, 2015) and increase students' motivation and learning outcomes (Shemran et al., 2017). Since learning cannot be separated from playing, gamification and GBL is the current trend for STEM education, especially educational escape room games (Lathwesen and Belova, 2021).

Escape room games have been commonly used in academic training for nurses and STEM education such as chemistry, mathematics, physics and biology (Lathwesen and Belova, 2021). According to Tulha, Carvalho and Coluci (2019), digital escape room games improved students' motivation. Moreover, after playing the escape room game about the physics of fluids that was created by Vörös and Sárközi (2017), students' grades and retention improved. In addition, Monnot et al. (2020) tested both digital and physical escape room games with chemical engineering students, and both games showed promising outcomes.

Hence, the researcher created a digital escape room game named "The Rooms of Newton: Can You Escape?" based on the Integrated Design Framework of Playful Learning to provide students with a fun and engaging environment while solving real-life situations that test their higher-order thinking skills.

II. PROBLEM STATEMENT

Due to the COVID-19 pandemic, lessons were conducted online. The researcher found it difficult to keep the Form 5 students engaged with the online classes without face-to-face interactions. At the same time, students showed a low response rate in their homework completion, especially dealing with HOTS essay questions related to Newton's laws that require students to make evaluations, decisions and modifications. The total marks for these types of essay questions are 10 marks. However, based on

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observations and students' homework, students could hardly score full marks when dealing with these HOTS essay questions.

Hence, the researcher took the initiative to integrate GBL into lessons since GBL has been proven to enhance learning and motivation. The researcher decided to use a self-designed digital escape room game, "The Rooms of Newton: Can You Escape?" to facilitate students' ability to answer HOTS essay questions related to Newton's laws.

Research Objectives

This study evaluates the effectiveness of the self-designed educational escape room game- "The Rooms of Newton: Can You Escape?" in improving students' ability to answer HOTS essay questions on Newtonian concepts through the GBL approach.

III. LITERATURE REVIEW

According to Anderson et al. (2001), higher-order thinking skills (HOTS) is a metacognitive dimension that involves the abilities to make connections, interpretations, decisions, discovery, reasoning and problem-solving. Furthermore, Astutik et al. (2019) elaborated that HOTS is the capability to think more than just remembering, restating or reciting. It includes transferring, processing, analysing information, and critical thinking. Thus, Scott, Barbarin and Brown (2013) claimed that in solving problems, HOTS is required as it involves the thinking and reasoning process.

The current educational trend is focusing on HOTS as HOTS prepares students to face the challenges in the modern world (Yee et al., 2015). With HOTS, students would be able to analyse complicated situations and suggest possible solutions to solve the problems (Kuhn, 2005). Besides, students would be able to think critically, ask complex questions, and present solid arguments and opinions when equipped with HOTS (Miri & Dori, 2009). Hence, the development of HOTS among students is essential for their growth and future.

The essay questions in Physics Paper 2 come in two different formats. The essay questions in Section B are real-life situations which require students to select the best choice based on the listed characteristic for each aspect. Students need to give justifications for each element of the chosen model. Meanwhile, students are required to make modifications or suggestions for the real-life problems in Section C by providing appropriate reasons. Therefore, students' HOTS is harnessed throughout the process of answering the essay questions.

On the other hand, according to Nicholson (2015), the concept of escape room games has flourished since 2012. Initially, escape room games are physical adventure games where players work together in a group or team to solve various puzzles or tasks in a limited time, and the final goal is to get out of the locked room. Usually, escape room games come with stories, such as solving a criminal case or finding hidden treasures and a set of rules and safety instructions (Nicholson, 2016). Due to modernisation, there is an increase in digitalised escape room games (Nicholson, 2016).

In recent years, the escape rooms game concept has been getting more popular in schools and STEM education (Lathwesen & Belova, 2021). It has been integrated into teaching Chemistry, Mathematics, Biology, Science and Medicine. Concurrently, educational escape rooms have been integrated successfully into teaching Physics. For example, Monnot et al. (2020) used physical escape rooms and labs to conduct general physics and chemistry activities as well as lab-based activities. Besides, Hou and Chou (2012) used digital escape room games to foster learning in the electromagnet, and the findings showed positive learning outcomes. In addition, Vörös and Sárközi (2017) and Vörös (2019) used escape rooms to address the concepts of physics fluids and Pascal's laws. Both studies showed positive impacts on students' performance and motivation.

The Integrated Design Framework of Playful Learning as shown in Figure 1 was proposed by Plass, Homer and Kinzer (2014). In order to create an educational game that is playful and engaging, one must take the three major perspectives, namely cognitive, affective, and socio-cultural, into account. Then, one needs to embed the learning game design elements into the game by ensuring the four types of engagement: affective engagement, physical engagement, cognitive engagement, and social engagement. The educational escape room game used in this study was created based on this framework.

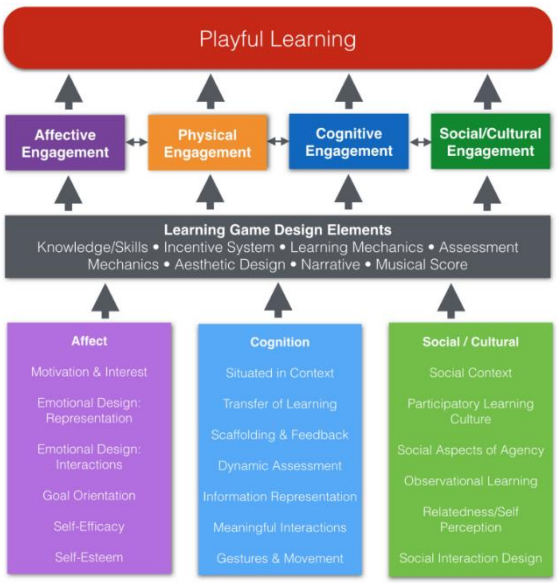

Figure 1. The Integrated Design Framework of Playful Learning

IV. METHOD

Research Design

This study was conducted based on Kurt Lewin's model (1946). It employed a quantitative approach by using pre-test, post-test and survey to determine the effectiveness of implementing "The Rooms of Newton: Can You Escape?" in improving students' ability to answer HOTS essay questions related to Newtonian concepts. The data collected was analysed and interpreted after the intervention in the last phase of Kurt Lewin's model.

Sampling

This study involved 18 Form 5 students aged 17 years old from a school in Perak. There were eight male students and ten female students. The purposive sampling method was used as out of 29 students in the class, 18 were identified as having difficulties solving HOTS questions in the essay format.

Research Instruments

A pre-test and post-test were used to measure students' ability to answer HOTS essay questions. Both tests consisted of one essay question (10 marks) adapted from the past year's SPM Paper 2 questions.

Meanwhile, an online survey that consisted of seven questions with a 5-point Likert scale ranging from "strongly disagree" to "strongly agree" was used to collect students' feedback regarding the escape room game. All the items in the survey were adapted from past studies.

Data Collection Procedure and Analysis

The problems that students faced were determined through class observations and their homework. Since all the lessons were conducted online, the pre-test and post-test were administered online. Before the intervention, a pre-test was issued to the students to assess their ability to answer HOTS essay questions related to Newtonian concepts. After the intervention, a similar post-test was administered to the students. The pre-test and post-test results were compared using a one-sample t-test. Additionally, students' feedback was collected via an online survey. Descriptive data analysis was used by using SPSS software 17.0.

The Rooms of Newton Escape Room Game

The escape room game in this study is a digital escape room game created via Microsoft PowerPoint software. Students need to download the game to their computers or laptops and play it at home. It can be played individually or in pairs where students gather at a particular location and play it together. The game consists of two rooms, Escape the Basement and Escape the Crocodiles Lake as shown in Figure 2 and Figure 3. The playing time for each room is within 10 to 15 minutes.

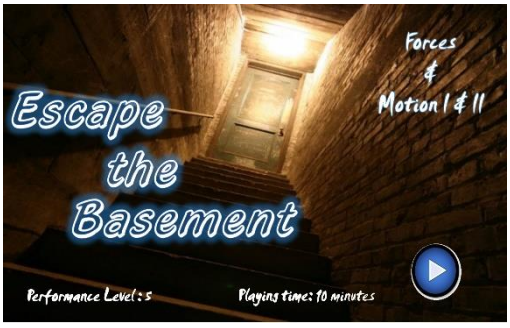

Figure 2. The First Scene of the Escape the Basement

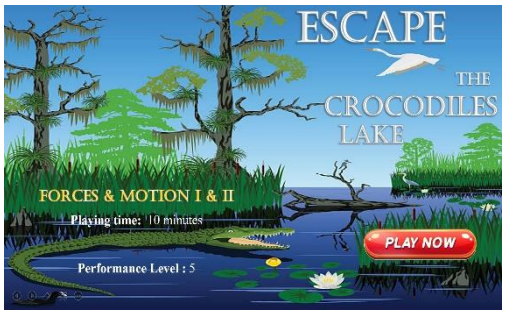

Figure 3. The First Scene of the Escape the Crocodiles Lake

Each room consists of a different game story and tasks. Figure 4 shows the game rules. Students are required to crack the clues and puzzles given within the limited time frame to obtain an eight-digit passcode to escape the rooms successfully. When COVID-19 becomes endemic, lessons are no longer conducted online; teachers can print out the materials and let the students play the game in a group of four to five players in school.

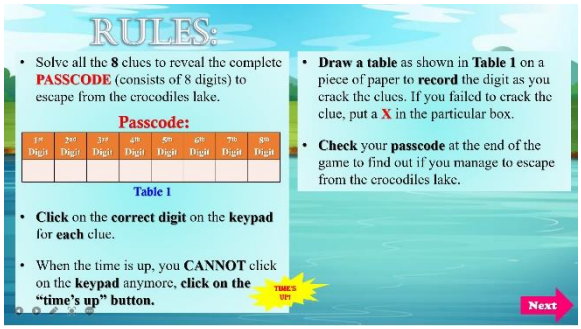

Figure 4. The Game Rules

V. FINDINGS

Based on the classroom observations via students' work and verbal responses during lessons, it was found that 18 of the students were having difficulties in answering essay questions. They did not perform well in the essay questions given.

Apart from that, Table 1 shows the pre-test and post-test results of the 18 students. Initially, students performed poorly in the pre-test as none of them scored more than 7 marks. There were only three students who scored 6/10 marks. Majority of them scored 5 marks and below. There was a significant improvement in the post-test results after the intervention. 7 out of 18 students scored full marks in the post-test and the others scored 8 marks and above.

TABLE I: COMPARISON OF THE RESULTS OF PRE-TEST AND POST-TEST

No.	Student	Pre-Test Marks (10%)	Post-Test Marks (10%)
1.	A	5	9
2.	B	6	10
3.	C	4	9
4.	D	6	10
5.	E	5	10
6.	F	5	9
7.	G	4	9
8.	H	3	8
9.	I	4	9
10.	J	5	8
11.	K	6	10
12.	L	5	10
13.	M	5	10
14.	N	4	8
15.	O	5	9
16.	P	5	10
17.	Q	5	9
18.	R	4	9

Table II shows the analysis of marks for pre-test and post-test by using the SPSS software.

TABLE II: PAIRED SAMPLE MEAN FOR PRE-TEST AND POST-TEST (ONE SAMPLE)

	Mean	N	Std. Deviation	Std. Error Mean
Pre-test scores (100%)	4.7778	18	.80845	.19055
Post-test scores (100%)	9.2222	18	.73208	.17255

PAIRED SAMPLE T-TEST

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre-test – Post-test	-4.44444	.61570	.14512	-4.75062	-4.13826	-30.626	17	.000

Table II shows the mean scores for pre-test and post-test which is 4.78 and 9.22 respectively with standard deviation (SD = 0.81) and (SD = 0.73) respectively, with the sample of 18 students. The standard deviation (SD) shows that the post-test scores deviate less than the pre-test scores, with a difference of 0.076. In the paired samples test, as shown in Table II, the "Sig. (2-tailed)" value is 0.000 ($p < 0.05$), this indicates that there is a significant difference in the pre-test scores and post-test scores.

The results showed that students performed significantly better in the post-test after implementing the escape room game compared to the pre-test.

Subsequently, based on the survey conducted, students showed positive feedback regarding the escape room game. The results are as shown in Table III below.

TABLE III: SURVEY RESULTS

No.	Item/ Statements	SD Frequency (%)	D Frequency (%)	N Frequency (%)	A Frequency (%)	SA Frequency (%)	Mean (SD)
1.	The activities in the game capture my attention.	0 (0.0)	1 (5.6)	3 (16.7)	8 (44.4)	6 (33.3)	4.06 (0.873)
2.	The amount of work in the game is suitable.	0 (0.0)	0 (0.0)	3 (16.7)	8 (44.4)	7 (38.9)	4.22 (0.732)
3.	I think the given tasks are not too difficult.	0 (0.0)	1 (5.6)	8 (44.4)	6 (33.3)	3 (16.7)	3.61 (0.850)
4.	The content of this game is useful to me.	0 (0.0)	0 (0.0)	5 (27.8)	6 (33.3)	7 (38.9)	4.11 (0.832)
5.	This game helps me in answering essay questions.	0 (0.0)	0 (0.0)	3 (16.7)	7 (38.9)	8 (44.4)	4.28 (0.752)
6.	This game enabled me to learn better.	0 (0.0)	0 (0.0)	2 (11.1)	9 (50.0)	7 (38.9)	4.28 (0.669)
7.	This game can foster my higher-order thinking skills.	0 (0.0)	0 (0.0)	3 (16.7)	8 (44.4)	7 (38.9)	4.22 (0.732)

Table III shows that the majority of the students agreed and strongly agreed that the game helped them in answering the essay questions (83.8%), enabled them to learn better (88.9%), and fostered their HOTS (83.8%). However, 50% of the respondents claimed that the given task in the game was difficult.

VI. DISCUSSION

Statistical results showed that the implementation of escape room games has positively affected students' performance. Students scored significantly better in the post-test after the intervention. This finding is in line with the outcomes in the studies conducted by Vörös and Sárközi (2017) and Vörös (2019). Even though some of the students found that the tasks or puzzles given in the game were complex, those tasks enhanced students' HOTS skills and abilities to answer HOTS essay questions. Students claimed that the tasks assigned in the game were complex as they were required to think out of the box in solving the situations given since the game challenges offered involved lateral thinking. At the same time, students enjoyed playing the game, and the game captured their attention.

VII. CONCLUSION (OR LIMITATION OR SUGGESTION FOR FURTHER STUDIES)

Based on the findings, it can be concluded that the usage of escape room games facilitated students learning and enhanced students' problem-solving ability in answering HOTS essay questions. Students performed significantly better after the intervention. This study could be a reference for other educators to decide on their adoption of GBL in teaching Physics. For further investigations, scholars might include virtual reality or augmented reality technologies in creating escape room games that could lead to new research interests and investigate how educational escape room

games affect students' motivation, collaboration and creativity.

Limitation

This current study is a small-scale study that used pre-test, post-test and feedback surveys to investigate the effectiveness of the escape room games towards students' performance. Besides, the digital escape room game created can be considered relatively low-tech since it only involved the usage of Microsoft PowerPoint software due to limited funding.

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