Faculty of Cognitive Sciences and Human Development

GAME-BASED LEARNING SYSTEM FOR SECONDARY SCHOOL STUDENTS IN PHYSICS LEARNING

Low Han Cheng

Bachelor of Science with Honours
(Cognitive Science)
2020

UNIVERSITI MALAYSIA SARAWAK

Grade: A

Please tick one

Final Year Project Report ☒

Masters ☐

PhD ☐

DECLARATION OF ORIGINAL WORK

This declaration is made on the 7 day of AUGUST year 2020.

Student's Declaration:

I, LOW HAN CHENG, 61332, FACULTY OF COGNITIVE SCIENCES AND HUMAN DEVELOPMENT, hereby declare that the work entitled, GAME-BASED LEARNING SYSTEM FOR SECONDARY SCHOOL STUDENTS IN PHYSICS LEARNING is my original work. I have not copied from any other students' work or from any other sources with the exception where due reference or acknowledgement is made explicitly in the text, nor has any part of the work been written for me by another person.

7 AUGUST 2020

LOW HAN CHENG (61332)

Supervisor's Declaration:

I, DR. JULIA LEE AI CHENG , hereby certify that the work entitled, GAME-BASED LEARNING SYSTEM FOR SECONDARY SCHOOL STUDENTS IN PHYSICS LEARNING was prepared by the aforementioned or above mentioned student, and was submitted to the "FACULTY" as a *partial/full fulfillment for the conferment of BACHELOR OF SCIENCE WITH HONOURS (COGNITIVE SCIENCE), and the aforementioned work, to the best of my knowledge, is the said student's work

Received for examination by: Julia Lee

(DR. JULIA LEE AI CHENG)

Date: 10 September, 2020

I declare this Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*****

☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*****

☒ **OPEN ACCESS**

I declare this Project/Thesis is to be submitted to the Centre for Academic Information Services (CAIS) and uploaded into UNIMAS Institutional Repository (UNIMAS IR) (Please tick (√)):

☒ **YES**

☐ **NO**

Validation of Project/Thesis

I hereby duly affirmed with free consent and willingness declared that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abide interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic and research purposes only and not for other purposes.
- The Centre for Academic Information Services has the lawful right to digitize the content to be uploaded into Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis if required for use by other parties for academic purposes or by other Higher Learning Institutes.
- No dispute or any claim shall arise from the student himself / herself neither a third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student himself/herself without first obtaining approval from UNIMAS.

Student's signature: _____ Supervisor's signature: Julia Lee

Date: 07 AUGUST 2020 Date: 31 August, 2020

Current Address:

178, Lawan Kuda,
31600, Gopeng,
Perak

Notes: ***** If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the date of restriction indicated, and the reasons for the confidentiality and restriction.

GAME-BASED LEARNING SYSTEM FOR SECONDARY SCHOOL STUDENTS IN PHYSICS LEARNING

LOW HAN CHENG

This project is submitted
in partial fulfilment of the requirements for a
Bachelor of Science with Honours
(Cognitive Science)

Faculty of Cognitive Sciences and Human Development
UNIVERSITI MALAYSIA SARAWAK
(2020)

The project entitled ‘Game-based learning system for secondary school students in physics learning’was prepared by Low Han Cheng and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours (Cognitive Science)

Received for examination by:

JuliaLee

(JULIA LEE AI CHENG)

Date:
31 August, 2020

Grade
A

ACKNOWLEDGEMENTS

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully.

Next, I would like to express my deep and sincere gratitude to my supervisor, Dr. Julia Lee Ai Cheng for providing invaluable guidance throughout this research. Her dynamism, sincerity and motivation have deeply inspired me. It was a great privilege and honor to do this research under her guidance. I am extremely grateful for what she has taught me, especially in report writing.

Furthermore, I express my special thanks to the Form 4 Physics teacher of SMK Seri Teja, Encik Abdul Aziz Khahar bin Sainudin, who allowed me to do data collection of this research in his class. I also like to extend my appreciation to all students who participated in my research. Without their cooperation, this research would not have been possible.

Finally, I would like to say thank you to my friends and family who have supported me all the time. Without their support and advice, the project would never be completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

In Malaysia, most of the teachers are still using traditional teaching approach to teach physics in school despite the rapid growth of educational technology. There are some issues related to physics learning in the current education system, such as the difficulty in learning physics, lack of students' motivations to learn physics, poor academic performance of students in physics, and the weakness in traditional physics teaching approach. Game-Based Learning is a learning approach which aims to achieve specific learning outcome of learners through gaming. Game-based learning is better than traditional learning method because of its vitality and attraction to the students. Therefore, this study aims to develop a game-based learning system based on ARCS model for Form 4 students to learn physics, and the motivation level and learning achievement of the students after using the game-based learning system were examined. This study also compared the learning achievement between traditional teaching approach and game-based learning approach. The findings from this study showed that the motivation level and learning achievement of students were significantly higher after using the game-based learning system. However, there was no significant difference when comparing the learning achievement between students who used game-based learning approach and students who used traditional learning approach, due to the limitations of this study. In overall, the game-based learning system showed positive effects to the students. Last, it was hoped that the game-based learning approach should be popularized in Malaysia's education.

Keywords: game-based learning system, game-based learning approach, ARCS model, physics learning, learning achievement, motivation level

ABSTRAK

Di Malaysia, kebanyakan guru masih menggunakan pendekatan pengajaran tradisional untuk mengajar fizik di sekolah. Masalah seperti kesukaran dalam pembelajaran fizik, kurang motivasi pelajar untuk belajar fizik, prestasi akademik yang buruk pelajar dalam bidang fizik dan kelemahan pengajaran fizik tradisional masih berlaku dalam pendidikan semasa. Pembelajaran berasaskan permainan adalah arah yang popular dan mempunyai tujuan pendidikan untuk meningkatkan keupayaan pemain yang boleh digunakan dalam kehidupan sebenar. Kajian ini juga dibandingkan dengan pencapaian pembelajaran antara pendekatan pengajaran tradisional dan pendekatan pembelajaran berasaskan permainan. Penemuan kajian ini menunjukkan bahawa motivasi pembelajaran dan pencapaian pembelajaran pelajar adalah jauh lebih tinggi selepas menggunakan sistem pembelajaran berasaskan permainan. Walau bagaimanapun, tidak ada perbezaan yang ketara apabila membandingkan pembelajaran berasaskan permainan dan pengajaran tradisional, kerana batasan kajian ini. Secara keseluruhannya, sistem pembelajaran berasaskan permainan menunjukkan kesan positif kepada pelajar. Akhir sekali, adalah diharapkan bahawa pendekatan pembelajaran berasaskan permainan hendaklah dipopularkan dalam pendidikan Malaysia.

Kata kunci: sistem pembelajaran berasaskan permainan, pendekatan pembelajaran berasaskan permainan, model ARCS, pembelajaran fizik, pencapaian pembelajaran, tahap motivasi

CHAPTER ONE

INTRODUCTION

STEM education system contributes in the advancement of technology because scientific knowledge can improve the quality of life by innovation. According to The National Council for Scientific Research and Development, Malaysia requires a workforce of 493,830 people in STEM related industries by 2020 (MOE, 2013). So, the Malaysian Ministry of Education (MOE) set a target to allocate the ratio of students in Malaysia to be 60:40, where 60% of science stream and 40% of art stream students in upper secondary school (Saleh, 2014). The aim of this policy is to accomplish vision 2020 and the National Science and Technology Policy by encouraging more science students to be involve in science related work in the future, such as engineering, chemical industry and ICT.

However, the number of students enrolled themselves in science stream does not reach the target because the percentage of the science stream students is still less than 40% in the majority of schools in Malaysia (Utusan Malaysia, 2009). There are approximately 15% qualified secondary students rejected to enrol in science stream in upper secondary school (MOE, 2013) with the reason that science subjects are difficult, especially physics subject (Utusan Malaysia, 2009).

Physics

Physics is a science discipline that studies anything that related with energy and force. According to Young and Freedman (2014), physics is the most fundamental discipline to understand how the universe behaves. The area of physics is very wide as it can intersect with the other fields of sciences like biophysics and quantum chemistry. According to O'Keefe (1997), physics is the knowledge about physical world and how it affects people's life. Most

of the times, advancement in physics knowledge leads to advanced technologies, such as the understanding of Newtonian physics has led to the projection of rocket to the space.

Physics Learning in Worldwide Context

In worldwide context of physics learning, it was found that the number of students who take physics at the higher level of education is far fewer than the other science subjects (Owen et al., 2008). Furthermore, physics is the subject with the least choice in school (Alexander et al., 2010). Therefore, a lot of research has been carried out to investigate this phenomenon by finding out the factors that caused difficulties in physics learning and the reasons that made students lack interest in learning physics (Ekici, 2016).

The Difficulties in Learning Physics

Physics is generally recognised as a difficult subject, either to learn it or even to teach it (Mulhall & Gunstone, 2008). Based on Owen and other researchers (2008), the changing nature of physics over secondary school period, such as becomes less descriptive and more mathematical is one of the factors that lead to increase the difficulties faced by students when learning physics. It was supported by Karakuyu (2008), where his study showed that the difficulty of using mathematical formulae of students is the obstacle faced by physics teacher when teaching the subject. Besides that, factors such as 'lack of background about physics subject', 'unfamiliar with physics subject from daily life' and 'abstract concept of physics subject' were identified from his study. According to the findings of Ekici (2016), students still think physics is difficult even though they get excellent scores in the subject. In a nutshell, the difficulty of physics learning by students mainly due to the learning processes that require the logical thinking such as calculation and the comprehension of abstract physics concept (Saleh, 2014).

Lack Motivation of Students to Learn Physics

Most of the students have negative view toward physics subject where they consider it is dull and pointless (Lavonen et al., 2007). According to Murphy and Whitelegg (2006), there is a decline of students' interest associated with increasing negative feeling towards physics subject in school, especially the female students. If this kind of situation is not taken seriously, the motivation of students to learn physics will be jeopardised and lead to negative attitude and perception towards physics (Business Coalition for Education Reform, 2002). Furthermore, the decline of academic performance in physics is also an alarming issue in nowadays (Guzel, 2004).

Physics Learning in Malaysia

In Malaysia, the academic achievement of students in physics subject was less than satisfactory. Based on the analysis data of Malaysian Certificate of Education (MCE) examination of 2018, the overall achievement of students in physics was not satisfied, even though there was an increase of 1% for the students who passed the physics paper. There were only 22.5% of students obtained A in physics paper in the year of 2018, and these phenomena has been quite consistent for a few years (MOE, 2019).

There are also some local studies conducted in Malaysia to investigate the motivation and academic performance of students in physics subject. Based on Saleh (2014), majority students lack interest in studying physics, not only in school level, but in higher learning institutions also. High number of students that avoid from taking physics related courses at universities was found, and this situation is alarming. Furthermore, the findings of Ibrahim, Zakiang, and Damio (2019) showed that poor academic performance of students in physics was detected even students showed positive attitude to learn physics. Next, students failed to comprehend the Newtonian force concept in physics because they faced difficulties in solving

problems about force and motion (Tomara et al., 2017). The phenomena of less motivation and poor academic performance of students in physics learning is a serious issue today as physics plays a very important role in science and technology. Therefore, efforts must be made to overcome this problem.

Weakness of Traditional Physics Teaching

According to Sidin (2003), the teacher-centred approach makes students hate to learn physics and affects their understanding of physics indirectly. So, other better teaching approach to teach physics should be implement instead of using traditional way to make physics more attractive and more motivating to study.

There are a lot of teaching methods that can be applied in classroom, such as cooperative learning, inquiry-based learning and the others. From that, game-based learning is one of the methods studied by many researchers and educators in the world today.

Game-Based Learning

In this modern education era, the importance of e-learning is gaining traction. However, the current teaching materials in e-learning such as text, pictures and video are lacking interaction (Ying & Yang, 2013). Computer games, especially serious and educational games, have provided significant success for learning complex topics. The advantages of games as valuable education tool are that they are attractive, novel and provide a better atmosphere that allow leaners to focus on the task (Heinich, Molenda, Russell, & Smaldino, 2002). According to Gee (2003), a good computer game allows people to recreate themselves in a new world and carry out deep learning simultaneously. Therefore, the game approach should be applied in education.

Game-Based Learning (GBL) is a learning approach aims to achieve specific learning outcome of learners through gaming. In other words, GBL uses game as the main instrument

in learning or teaching process. GBL aims to improve learner's self-confidence and problem-solving skills (Liang, et al. 2010). Prensky and Prensky (2007) claimed that GBL is "about the combination of learning and entertainment together in an interactive environment.". Chang et al. (2009) also mentioned that GBL is a popular direction in education to improve the skills of player that can be used in real life. Educational games make learning process easier, more interesting and more effective.

GBL in Education

From the educational perspective, GBL may be an effective teaching method (Von Wangenheim & Shull, 2009). Based on Prensky (2001), GBL has the characteristics that can increase motivation of students, such as fun, play, goals, challenge, problem solving, story and the others. The game elements make learning a hard curriculum become interesting, where the game levels present the content of curriculum, and the knowledge of the curriculum can be obtained from GBL. GBL combines fun, entertainment and interactive into education, which allows students achieve personalized learning by "learning through play".

For research purpose, most of the GBL researchers focus on the learning effectiveness such as the learning motivation and learning achievements (Hamari et al., 2016). There are various studies that investigate GBL, such as Papastergious (2009) who studied the learning effectiveness and motivation of GBL for Computer Science. Next, a GBL system, which provide learning scenarios by mapping the course content in game was developed to enhance self-confidence for student's learning (Su & Cheng, 2013). Moreover, Lester and other researchers (2014) developed a GBL system called "Crystal Island: Uncharted Discovery" for upper elementary science students. Furthermore, a gesture interactive GBL approach was developed for preschool children (Hsiao & Chen, 2016). Additionally, there are some studies that implement Input-Process-Outcome model into GBL, for example, Garris and his

colleagues (2002) that used IPO model to improve children's learning performance. Then, there is also an educational game that designed by Ghergulescu and Muntean (2014) by using Motivation Assessment oriented Input-Process-Outcome (MotIPO).

From the evidences above, it can be concluded that GBL is better than traditional learning method because of its vitality and attraction to the students (Ying & Yang, 2013). In sum, GBL improves the student's learning by increases their motivation and decreases the stress in learning at the same time (Su & Cheng, 2013).

Research Objectives

In this study, there are four research objectives:

1. To develop a game-based learning system with high usability for secondary school students to learn physics.
2. To examine the motivation level of students in physics learning before and after used the game-based learning system.
3. To examine the learning achievement of students in physics before and after used the game-based learning approach.
4. To compare the learning achievement between students who used game-based learning approach and students who used traditional learning approach.

Research Questions

There are four research questions correspond with the research objectives:

1. Does the game-based learning system exceed the average benchmark of usability?
2. Is there any difference on motivation level of students to learn physics before and after used the game-based learning approach?
3. Is there any difference on learning achievement of students in physics before and after used the game-based learning approach?
4. Is there any difference on learning achievement between students who used game-based learning approach and students who used traditional learning approach?

Hypotheses

From the research objectives, the following hypotheses are made:

1. There is significant difference on motivation level of students to learn physics before and after used game-based learning approach.
2. There is significant difference on learning achievement of students in physics before and after used the game-based learning approach.
3. There is significant difference on learning achievement between students who used game-based learning approach and students who used traditional learning approach.

CHAPTER TWO

METHOD

Research framework

This study analyses the motivation level and learning achievement of students that used different teaching strategies in learning physics. The independent variables are teaching methods, where the experimental group uses the game-based learning while the control group uses the traditional learning. The dependent variables are the motivation level and learning achievement of students. For control variables, teaching content is the Hooke's law, which is a subtopic of Chapter 2 in Form 4 physics textbook, and the test hour is 30 minutes respectively for the students to do the tests in both pre-test and post-test. The research framework is as shown in Figure 1.

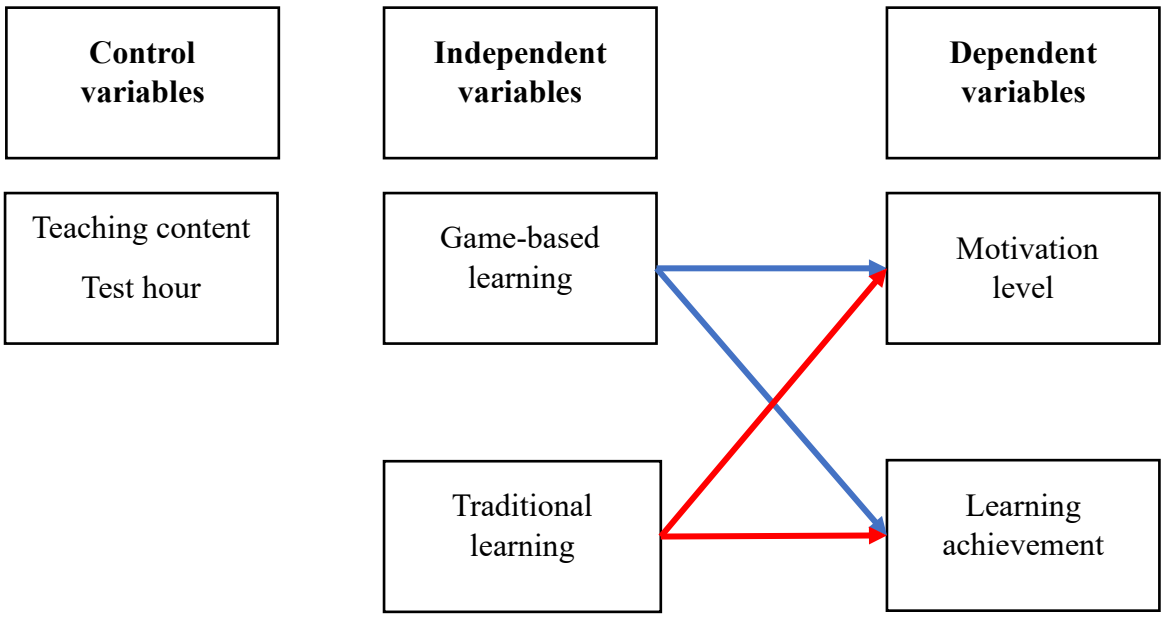

Figure 1. Research framework

Research concept

This study not only aims to develop a game-based learning system for secondary school to learn physics, but it also used to analyse the motivation level and learning achievement of the students. In the study, students were required to play the game to obtain specific physics teaching content. After that, students were given with a questionnaire and a physics test paper to test the students' motivation level and learning achievement. Then, the proposed hypotheses were analysed by statistical test in a quasi-experimental design. The research process was separated into system development phase and evaluation phase.

System Development Phase

The Waterfall Model System Development Life Cycle (SDLC) was employed for the development of the game-based learning system. Waterfall model is the oldest and most famous system development life cycle model (Balaji & Sundararajan Murugaiyan, 2012). I chose this system development model because of its advantages, which are simple to use and works well for quality control (Alshamrani & Bahattab, 2015). There are six stages in the Waterfall Model SDLC, which are requirement, design, development, testing, deployment and maintenance. The workflow of the Waterfall Model SDLC is as shown in Figure 2.

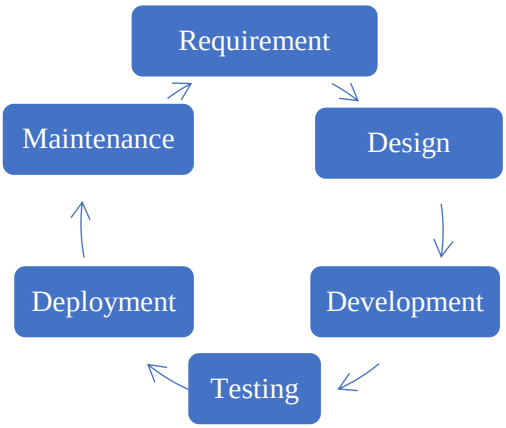

Figure 2. Waterfall Model SDLC

Requirement. The requirement for the system development in this research is to develop a game-based learning system with high usability.

Design. As the participants of the study were Form 4 physics students, the game-based learning system was designed based on Form 4 physics teaching content. The game-based learning system focused on Hooke's Law, a subtopic of Chapter 2: Force and Motion in Form 4 Physics Textbook (Badariah, Chang, Koay & Yew, 2006).

Furthermore, the game design of the game-based learning system was based on the ARCS model. The ARCS model is a design model to increase student's learning motivation level when studying (Keller, 1983). ARCS model emphasizes motivation, where encourage students to accomplish a specific goal by getting involved in an activity. The ARCS model focuses mainly on strengthening systematic instructional design and designing materials that encourage student participation.

Karoulis and Demetriadis (2005) claimed that the change of learning motivation of learners by the game can be measure by ARCS model. The ARCS model has four dimensions, which are attention relevance, confidence and satisfaction, as shown in Table 1.

Table 1

The dimensions of ARCS model

Factor	Definition
Attention	A student's attention has to be aroused and sustained.
Relevance	After the student's attention gained, a student may wonder how the given material relates to their interests and goals. If the content is perceived to be helpful in accomplishing one's goals, then they are more likely to be motivated.
Confidence	Students have to know that they will probably be successful before completing a given task. They have to feel somewhat confident. Success is not guaranteed and enjoy a challenge. However, the challenge cannot be too difficult.
Satisfaction	If the outcomes of a learner's effort are consistent with their expectations and they feel relatively good about those outcomes, they will remain motivated

Development. The game-based learning system was built by Unity3D. Unity 3D is a game engine developed by Unity Technologies that is multi-platform and user friendly. It is widely used by industries nowadays to create three-dimensional, two-dimensional, virtual reality, and augmented reality games, simulations as well (Axon, 2016). The game-based learning system was built in WebGL format, so that it can be uploaded to a website.

Testing. To make sure the game-based learning system developed is usable by the users, a usability testing was carried out to the experimental group. The usability of the game-based learning system was evaluated by System Usability Scale (SUS) questionnaire. SUS is a reliable tool created by Brooke (1986) to measure usability of products and services, such as software, mobile devices, websites and applications.

Based on Thomas (2015), the average SUS score is 68 and the system with SUS score that lower than 68 will have a serious usability problem. So, the SUS score of 68 been chosen as the benchmark for the usability of the game-based learning system developed.

Deployment. After the game-based learning system developed successfully, the game-based learning system was uploaded to a website called itch.io. Itch.io is a free platform for developers to publish their games online.

Maintenance. Maintenance is the final process. If found any problems from the game-based learning system, modification will be made.

Evaluation Phase

After the intervention, the students were asked to complete Instructional Materials Motivation Survey (IMMS), a questionnaire to test the students' motivation level. IMMS is an instrument designed by Keller (2010) to measure learner's motivation level by applying ARCS theory. The instrument consists with 36 items to measure the participant's score based on 4 dimensions of ARCS model, which are attention, relevance, confidence and satisfaction.

Furthermore, the students were required to complete a physics test paper prepared by the domain expert, which is the school physic teacher. The purpose of this physics test is to measure the learning achievement of the students after playing the game. Non parametric tests were done by SPSS, where Wilcoxon signed-rank test used to evaluate the motivation level and learning achievement of students after used the game-based learning system and Mann-Whitney U test used to evaluate the learning achievement between students who used game-based learning approach and students who used traditional learning approach.

Quasi-experimental design

The study used quasi-experimental design, which included with pre-test and post-test, as shown in Figure 3. First, the students were divided into experimental group and control group, and all students studied about the Hooke's law. Then, they did pre-test which consists of a physics test paper and questionnaire. Next, the experimental group used game-based learning while the control group used traditional face-to-face learning to learn physics. After that, all students must complete the physics test paper and questionnaire again in post-test. The data collected analysed by examining the difference of motivation level and learning achievement between pre-test and post-test in the experimental group. Furthermore, the study also examined whether there is any significant difference of the learning achievement between experimental group and control group.

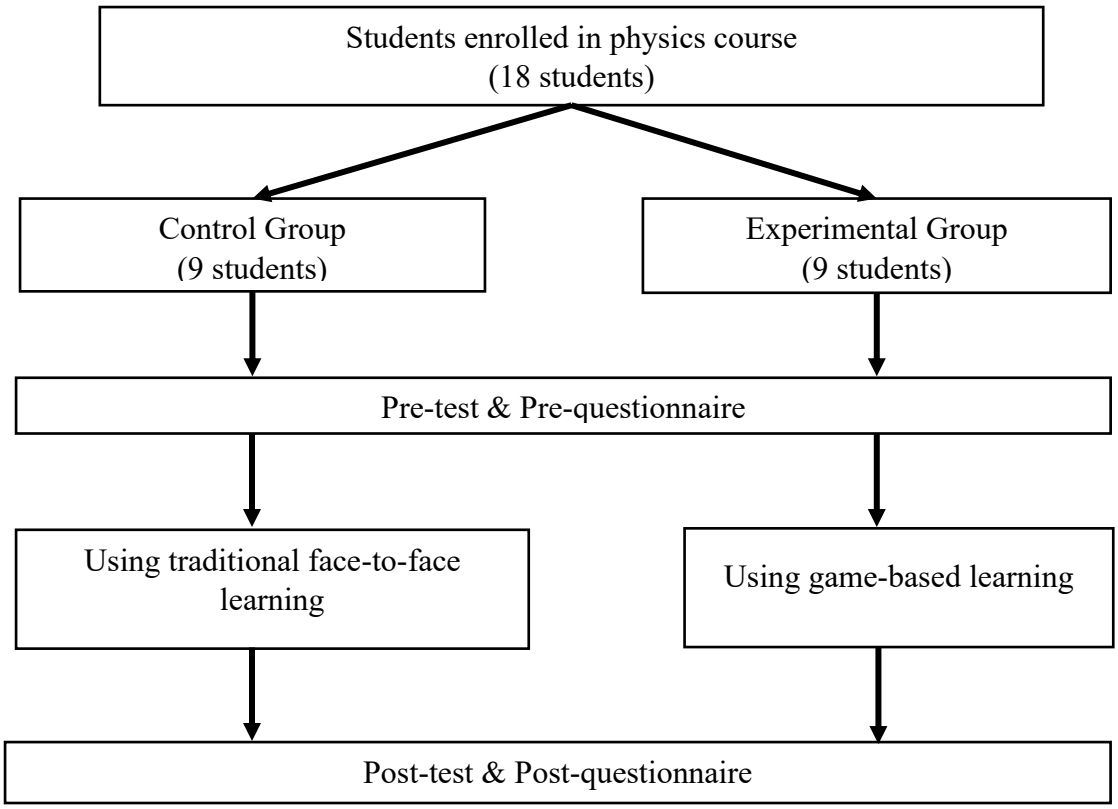

Figure 3. Quasi-experimental design

Participants

The participants in this study were 18 students of SMK Seri Teja that enrolled in Form 4 physics course, where they scored the lowest result among peers in previous examination result, which is the science subject in the Form Three Assessment (PT3) paper. The reason in this participants selection is to ensure the equal ability in academic among the participants.

Ethics

Permission to conduct this study was obtained through informed consent form. The informed consent form explained the purpose of the study to the participants. The participants' identity and information collected were kept confidential and for research purpose use only.