

# DIGITAL GAME DESIGN USING NON-PROGRAMMING SOFTWARE FOR PHYSICS EDUCATION

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## ABSTRACT

*The Malaysia's Ministry of Education confirmed that the number of students who enrolled in school's science stream option declined in the year 2018 than years before that. Physics is listed as one of the must enroll subject under STEM education. There are some research done previously stating that students had some kind of negative perception towards Physics. Therefore, teachers or educator have to come out with some strategies to trigger the interest and motivation of their students toward this subject. Among the strategy is the game-based learning approach. However, there are some challenges that the teachers have to encounter even though they had some interest in the approaches, mainly due to the lack of basic programming skills. This research was initiated in order to assists teachers to explore the concept of game development without any programming background. This research is also aimed to highlight some free and open sources game engine available in the market. Using the Game Development Life Cycle approaches, this research explored and experiment three easy and free software to develop games for Physics education. With that, the research aims to help teachers to utilize the free and easy software and build their own game without any basic programming skills.*

**Keyword:** Game-based learning, GBL, digital game, teaching and learning, TnL, STEM, Physics education, GDLC, non-programming game development

## I. INTRODUCTION

Physics is one of the subjects listed under the STEM education. Based on a research conducted by the Faculty of Science, Universiti Putra Malaysia, students that enrolled in the science stream had some kind of negative impression on Physics. Ministry of Education (MOE) also confirmed that the number of students enrolled in STEM stream has been inclining by years, based on facts, 49 percent student enrolled in 2012 but the number reduced to 44 percent in 2018. Therefore, various programs and events has been initiated in order to spark students' interest in understanding the subjects of STEM.

Mazlin and Iksan (2018); Salleh and Halim (2016) based on the research on student's motivation against Physics subject, stated that students encountered problems to understand the concept and elements because they assumed it to be too abstract and concrete. There are students that who consider Physics as a tedious, uninteresting and irrelevant to be learnt (Saleh 2014). This kind of perceptions gave impacts on the student's achievements, which leads to the situation where they did

not understand what has been taught as well continuously depending on teachers without any effort to master the knowledge by themselves (Jufrida et al. 2019).

We have seen teachers had to venture into technology for TnL due to the closure of schools nowadays. Lay and Osman (2018) brought a new approach in the TnL of Chemistry by introducing a digital game, KimDG, to assist students in understanding the topic of salt. In the same study, the researchers found that the game allows students to work together in searching to understand and creating more effective, understandable ideas and concept. Anderson and Barnett (2013) study on America's high school students, showed a positive result on the approach of Physics digital game, Supercharged! rather than conventional TnL.

The game-based learning approach is more likely give the positive impacts on students' understanding and mastery of a subject. The game-based learning approach is seen to be more relevant either digitally or not compared to conventional learning (Hafis & Supianto 2018). However, the digital game-based learning approach could be challenging especially when the teachers in Malaysia mostly came from a non-technical background (Mat Diah & Yahya 2009).

Teachers have to double their efforts to increase their own ICT literacy and explore multimedia tools as their alternative TnL tools (Ahmed Qasem & Viswanathappa 2016). However, the level of technology literacy differs by teachers. There are teachers that able to innovate further with available technology, but some are not as their literacy are low. Lack of training could be one of the reason why the teachers resisted the usage of technology (Singh & Chan 2014).

In order to develop a digital game, the developers usually came from technical background with at least some basic knowledge in coding and programing. There are multiple game engines available in the market for people to utilize, however with some requirement of programming language mastery (Chamillard 2007) such as C++, C# or Java programming. This kind of requirement however makes the development of digital game much harder for some people especially, teachers. This is due to their non-technical background and making it more complex for teachers to try developing their own games for the subjects.

According to Mohd Hashim and Mat Diah (2016), lots of people have interest and wanted to try and develop their own game, however it seems impossible for them due to no skills in programming. Even for someone with programming experience also find it hard to understand and master the skills (Mohd Hashim & Mat Diah 2016). Therefore, any game engines that available without any programming skill requirement are most likely have the potential to be utilize by people with no programming background. This study has been done in order to highlight the concept of non-

programming game development for teachers to develop their own game. Within the study, we have determined multiple free and non-programming software or game engines that can be explored by teachers. The study also did develop some simple games prototype using the selected game engines and tested the prototype to some secondary school students that enrolled in Physics subject around Malaysia.

This paper consists of five (6) sections. Section I discuss the background of this study including the issues and problems of Physics education from teachers' and students' side, game-based learning approach challenges by teachers as well as the overall study introduction. Section II discuss the STEM approaches in Malaysia, students' attitude and acceptance on Physics education, game-based learning in Physics education and its elements as well as the concept of non-programming game development. Section III elucidates the methodology used in the study. Section IV highlight the design and the development of game prototypes. Section V presents the findings of the work and discussion. Lastly, section VI concludes the paper with a summary of the findings and recommended future work.

## **II. LITERATURE REVIEW**

### *A. STEM Education Approach in Malaysia*

STEM in Malaysia has been highlighted as an important agenda in the Malaysia's Education Blueprints where educational transformation has been conducted in order to prepare the young generations for the 21<sup>st</sup> century's challenges. MOE in the blueprints stated that STEM Education will be implemented in three waves. The waves are:

- Wave 1 (2013 – 2015)

Wave 1 includes the strengthen of curriculum, study and practicality of teachers as well as the usage of multi-mode learning to strengthen the STEM Education quality.

- Wave 2 (2016 – 2020)

Wave 2 is done in order to increase the community awareness and interest regarding STEM. Various kind of campaign and collaboration between MOE and schools as well as related NGOs has been done.

- Wave 3 (2021 – 2025)

Last wave of the blueprints, where STEM will be enhanced further towards excellence through operational flexibility advancement. In this last and final wave, the schools and

their teachers' performances should already be over than standard. This should be done so that the STEM's performance will be better.

Aside from the PPPM 2013 -2025, the government also instituted the 60:40 Science/Technical: Arts, as an effort towards becoming a developed country. According to Abu Bakar (2019), the result from 60:40 observation is getting further from it target when the number of student enrollment for STEM decreases by year. In order to realize the STEM Education, MOE actively to run the agenda to integrate STEM in TnL with collaboration of local universities as well as non-government organization (Mohammad Ayub 2018).

### *B. Students Attitude and Acceptance Towards Physics Education*

Physics in general is a subject that require students to search for answer for the issue of "why" and "how" certain phenomena happens around people (Saleh 2014). However, according to Saleh (2014), there are some students characterized Physics as a hard subject due to the complexity of learning which require students to understand various formula, calculations and concepts. Meanwhile, Abdul Kadir et al. (2016) in their study stated that some students had a perception, Physics is only for smart student which make Physics labelled as an "elite" subject in school. The negative perception indirectly affects students' motivation and disrupt their performances. Another study by Meng et al. (2014), mentioned that Physics is considered as irrelevant by some students. As a summary, attitude and acceptance of students towards certain subject sometimes depending on their own thought which leads to some early perception without experiencing it first.

### *C. Game-based Learning Approach in Physics Education*

Siong and Osman (2018) mentioned in their study, the application of serious game in TnL could increase the students' collaboration and problem solving skills (Antunes et al. 2012) while interacting with the game. Game-based learning is increasingly giving good impact when being used in TnL. Some of the example of digital game that seen to be successfully implemented in classroom TnL are Sim City and Civilization III. According to Squire and Jenkins (2003), students are able to learn the knowledge of economy, social hierarchy as well as politics in population played within the game. Whereas Civilization III gives students the opportunity to explore things that can help in the civilization played such as searching for life supplies, generating economy and the civilization's growth within the game play (Brom et al. 2010; Squire & Jenkins 2003).

In another study by Cardinot and Fairfield (2019) which implemented a non-digital game using a board game for Physics education in Ireland, the game was used to generate student's

understanding in the topics of Physics and Astronomy while having fun in classroom. The game according to Cardinot and Fairfield (2019) manage to attract the students' interest and attention while exploring the topic and enhancing their understanding. Applying the concept of board game, but in digital way, Souza et al. (2018) introduced another approach in Physics education which is by using a game named Spies. The game requires students to play in teams and the game play was also for the purpose to evaluate students' understanding through pictures. With the adoption of digital game, teachers not only can attract the students' interest but also their understanding of Physics concept not only in school but wherever they are. Therefore, it can assist teachers to create variation of TnL in while motivating the students.(Rodrigues & Simeão Carvalho 2013).

#### *D. Elements of Game-based Learning in Education*

In order to produce an interesting game which can potentially be integrated in TnL, the design and development should be given more attention. This is for the game developed not only can generate interest but also be a tool to deliver knowledge effectively and innovatively. There are several elements that can potentially be a guide to build a digital game for education. According to Novak (2011) the first element is genre. The genre chosen by developers should be according to their targeted market and it should be determined so that the next process of development shall be continued.

The second element to be considered is the visual and audio design (Plass et al. 2015). Without interesting visual and pleasant audio background, it could be hard to maintain player's interest in the game. Visual design according Plass et al.(2015) includes the characters, information, animations etc. which can portray the game play itself. While the third element is the game play and motivational value (Buckley & Doyle 2016; Plass et al. 2015). Motivational elements are important in order to guide player to find the purpose of the game itself. Motivational element includes the rewards received by player upon completion of mission for example, (Plass et al. 2015).

Lastly, the most important element is the element of targeted learning to be translated into digital game for education (Plass et al. 2015). This element has to be the foundation for every educational game development so that it won't be diverted from its original goal, which is to educate. Liu and Chen (2013) in their study mentioned that game make the learning session be more active and positively impact the students by not only targeting the fun side but also the value behind it.

#### *E. No Programming Game Development*

Nowadays, with the advancement of technology, no programming game development is no longer impossible. Rémi (2015); Revell (2019) defined visual programming as a language that allows user to explain processes using easier illustration or graphical element. The interesting feature of visual programming is that it offers any development of system or even games be done without any programming code. The visual programming is easy to be used, simple with the concept of “drag and drop” (Chamillard 2007)

Mohd Hashim and Mat Diah (2016) in their study highlighted a model of a no programming game engine’s characteristics. The characteristics are emphasizing the development without programming code for people with no basic skills in programming, the game engine’s ease of use which includes the concept of “drag and drop”, guidelines, tools available as well as the editor space for user to develop their game without any limitation. The last characteristic is the ease of game export which should allows the developer to publish and distribute their final products. In short, the concept of visual programming is seen to be potentially introduced to teachers so that they can explore and create their own game.

### III. RESEARCH METHODOLOGY

This study adapted qualitative research while using the Iteration Game Development Life Cycle approach in game development. There are four phases altogether. This approach is chosen as it is suitable with the development cycle of educational game. It is because the cycle could be revisited anytime according to the syllabus. The details on the research development model are as per Figure 1.

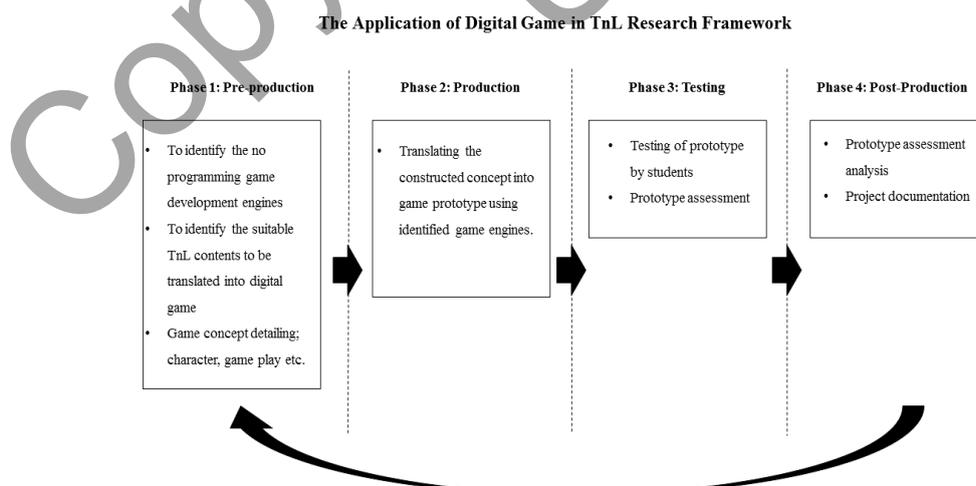


Figure 1 Research Framework

### A. Pre-Production (Phase 1)

In this phase, every basic elements of a research such as problem statements, objectives as well as scope determination process take place. Following that, the data collection techniques for the study were document analysis, observation and open as well as closed interview format. Document analysis approach were adapted in order to find some information regarding strategies of TnL from home as well as for conventional TnL. Interviews with teachers in order to collect some information regarding of the execution of TnL, conventional and online. Open ended survey of a few teachers around Malaysia also has been conducted to generate some idea of digital game in development.

### B. Production (Phase 2)

In this phase, the early concept of digital games was constructed based on the early research findings. The concept suggested was the role-playing with the additional quiz concept to make the game much more interesting. Storyboard and the game interface design also included in this phase 2. Figure below shows the digital game for Physics education concept.

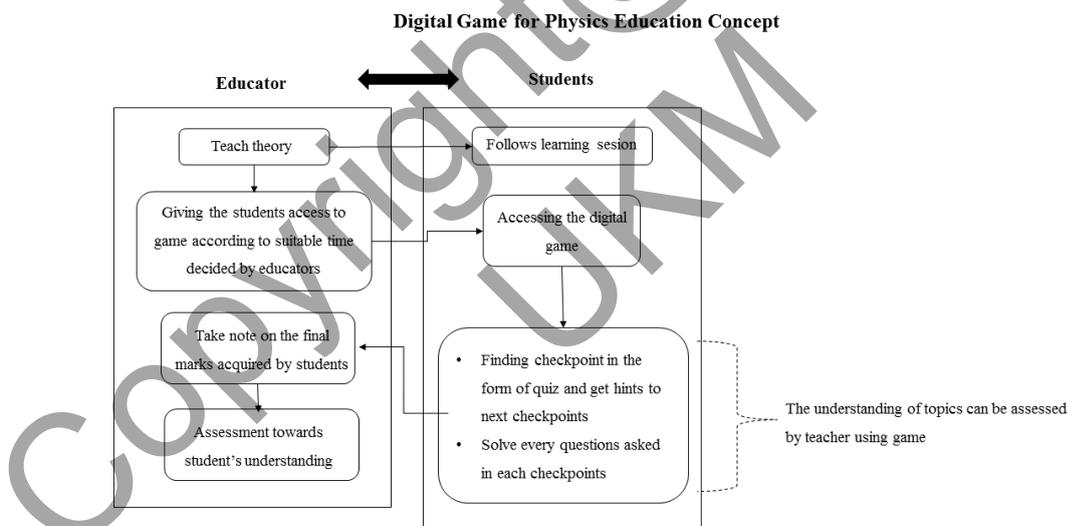


Figure 2 Digital Game for Physics Education Concept

### C. Testing and Prototype Evaluation (Phase 3)

Prototype testing and evaluation has been done. A digital game developed in this project were send to secondary school students from different states around Malaysia through Physics teachers across Malaysia. Survey conducted in this phase were based on the Game User Experience Satisfaction Scale (GUESS) introduced by Phan et al. (2016). GUESS in this study highlights six from nine factors to be considered in the study. The six highlights are usability/playability of the game, enjoyment, fun, audio aesthetics, self-satisfaction and the visual esthetic scale/

#### D. Post-Production (Phase 3)

Post-production phase in this study refers to the project documentation done in this study. Which this study could become a guideline for teachers to explore the easy game technology and develop one by themselves.

### IV. DESIGN AND DEVELOPMENT

#### A. Storyboard Design

The storyboard designed in this study were based on the results acquired earlier. Storyboard acts as a guideline in the game development phase. The storyboard in this study, explained every function, feature and game play for each and every element to be unloaded into the discussed games. Every characters and roles are as followed in Figure 3 while the example of character and roles as well as the encounter of characters.

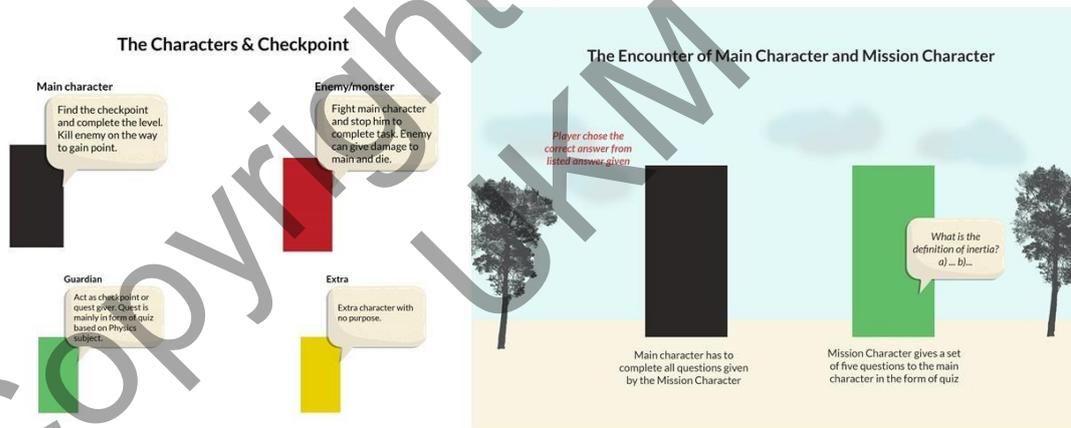


Figure 3 Character and roles

#### B. Interface Design of Team Games, Microsoft Powerpoint

The study considered easy but powerful software to be used in order to develop a digital game. The software is Microsoft Powerpoint. This desktop built-in software is actually had the ability to create game, in this study a game with the concept of quiz. The game uses advanced function available in Microsoft Powerpoint which enable player to navigate through each interface easily. The development of the game backgrounds was designed using Adobe Photoshop CS6. Example of process and game interface can be seen in Figure 4 below.

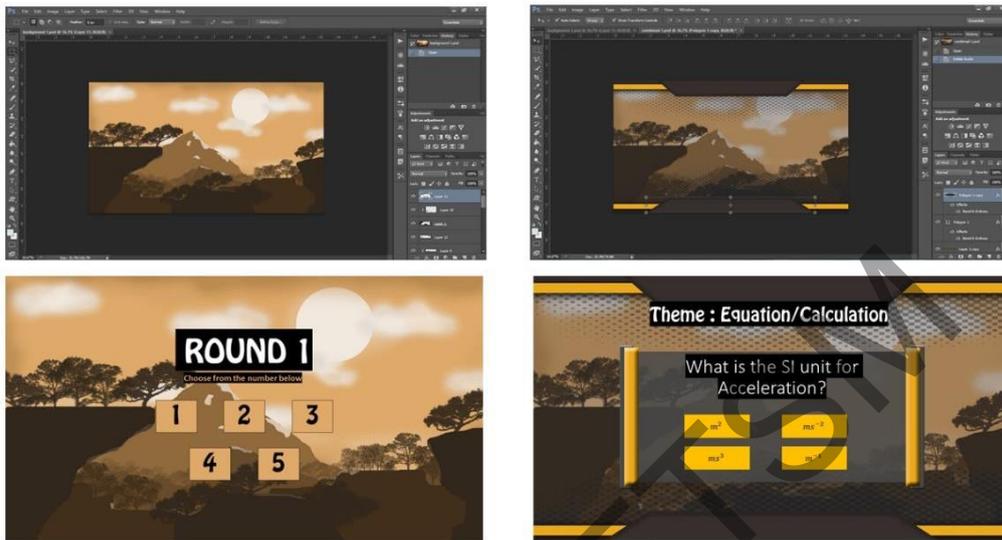


Figure 4 Background design and game interface example

### C. Interface Design Using Construct 2

Construct 2 has been used to develop a puzzle platformer 2D game. The game is named as Physics Ninja!. Physics Ninja was built based on the concept of visual programming, which is the “drag and drop” concept. The game focuses one character which is ninja who had a mission to find the mission character, collect keys, gems and most importantly answer all quiz given by the mission character. Gems and keys will be the determining marks for each student upon completion. Encounter of main character and enemy will deduct the count of gems while two gems acquired for each enemy destroyed. The process of visual programming and example of game play interface can be seen as Figure 5 below.



Figure 5 Process and game interface example

#### D. Interface Design Using RPGPlayground.com

The development of game prototype using the RPGPlayground is considered easy. This is because all graphical need such as characters, background, animation, sound and even the command for every character are ready to be used. The developer only needs to prepare their scenario and arrange it according to preference. RPGPlayground.com can be access easily through web browser and it provide unlimited free game development for individual without programming background.

In this study, the game developed was given a name of Journey to A+ with the genre of puzzle role-playing. The aim of the game is for the main character to complete every mission which requires him to solve multiple questions given by mission character at different places. The concept is similar to Construct 2 game but, there is an extra mission for the main character in this game, which is to save the mission characters from various enemy. The process of the game development using visual programming and interface design can be seen as in Figure 6 below.

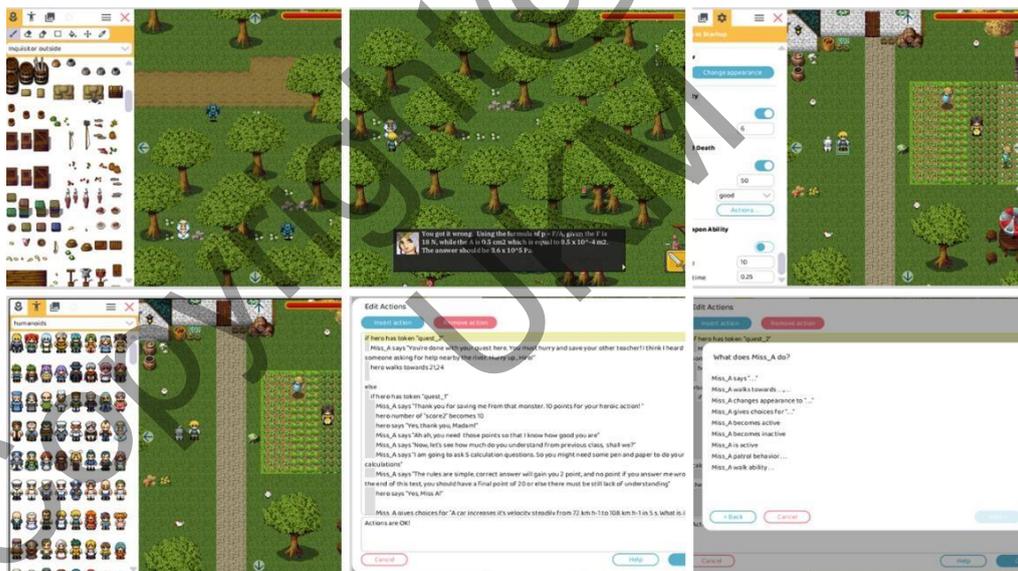


Figure 6 Development process and interface design example

## V. RESULT AND DISCUSSION

### A. Interview and random survey on teachers

The question developed by was used for early interview to gather the required data from the teachers. The table below listed the item and summary of responses by interviewed teachers as well as the random survey towards few other teachers in this study. The interview session was done with two

teachers from different school in two states, Negeri Sembilan and Selangor. While the respondents for random survey consists of six teachers from different school and states.

Table 1 The summary of interview findings

Item	Conventional Teaching	Online Teaching
Technique used	Two ways TnL involving students in class activity, class start with teacher delivering theory and ends with problem solving activity.	Using technology such as virtual conferencing and Whatsapp to communicate when the time comes
Student assessment towards understanding	Calling students to answer question on the spot, student solve written quiz and test as part of assessment	Same approach except for the usage of technology, Google Form to give out quiz and test for assessment
Technique used to make student stay focus and give attention	Two ways communication, calling student names, asking question, having group activities etc.	Calling names and asking questions.
Challenges in the TnL	Students get bored easily if the session only consist of explanation. Group activity always being conducted to maintain students' interest.	The limitation of technology, internet coverage as well as devices. There some students lose their interest to join the online classes conducted.

After the interview was conducted, finding shows the TnL techniques approach by the teachers are similar either conventional or online. Things that differentiate between the two was the difference in the medium itself. The usage of technology itself gave some side effects, not only to students but to teachers as well. Apart from the finding above, there are few other findings acquired from the teachers. Among identified is that student had problems to determine the usage of correct formula for calculations problem given. As an addition, student also seems hard to relate the theory learnt with its application from the learning session which leads them to have a thought that Physics is a very hard subject.

Apart from the interview session conducted, a random survey conducted as an additional data gathering managed to get six respondents from different area across Malaysia. The purpose of the survey was to gather information on teacher's readiness and initiatives taken by teachers along the closure of schools. The findings from random survey conducted were summarized as follows.

Table 2 Random survey findings

Item	Findings
Respondent background	Varies from Bahasa Melayu, Science, Geography, Account and Physical education
Techniques used in TnL	Similar to conventional classes, theory delivery then continues with quiz, question and answer session
Student assessment towards understanding	Giving out test or quiz by google form or student submit the answer through Whatsapp application
Technique used to make student stay focus	Use interesting item such as videos, graphic and communicating in two ways
Challenges in the TnL	Students' involvements, no responses from students as well as limitation on internet coverage.

From the findings above, the study found an area or opportunity where the implementation of digital game could be done in class activity. It can be implemented in the assessment session as well as the group problem solving. That is where the digital game could penetrate and be implemented in classroom activity, does not matter conventionally or through online.

#### *B. Findings from Interface Design Testing and Assessment Survey*

Prototype that has been developed using the RPGPlayground.com game engine managed to be send for testing by secondary school students across Malaysia who enrolled in STEM stream. 18 (16 female and 2 male) respondents or students participated in the testing and evaluation conducted. The students came from different schools in six states in Malaysia, Negeri Sembilan, Sabah, Selangor, Kuala Lumpur, Johor and Melaka. The survey form included in the testing consists of three part. The three part is A – Demographic, B – Assessment towards the digital game prototype and C – Game- based learning acceptance survey. The questionnaire question in part B and C uses the 1 – 5 likert scale which represented by 1 – Strongly Disagree to 5 – Strongly Agree based on the GUESS scale. Based on the scale, if the mean score acquired is greater than 3.00 score, the study determine that respondent agree with the digital game suggested and the usage in TnL.

Table 3 Finding for part B, prototype game assessment

Question	Mean Score	Standard Deviation
The game is interesting	4.17	1.20
The instruction is clear and understandable	4.06	1.06
The navigation in the game is easy	3.67	1.14
Easy to be use interface design	4.00	0.97
Audio content is suitable	4.39	0.85
I'm excited to play the game	4.33	0.77
The example given help me understand the topic better	4.28	0.89

Based on Table 3, for question one the mean score is 4.17. This shows that the respondents agree with the statement that the game tested was an interesting game. While for question 2, the mean score is 4.06 which means the respondent agree the with the statement that the istructions within the game play is easy and understandable. No doubt that a clear and easy instructions make games easy to be used.

Next is for question 3, the mean score is 3.67. Based on this score, it shows that the respondent agree that the navigation within the game is easy without any limitations. Whereas for question 4, the mean score acquired is 4.00. The score shows that respondent agreed that the interface design of the game is easy to be used. For question 5, the mean score aquired is 4.39. The score shows that the respondent agreed with the audio content used is suitable with the game. While for question 6, the mean score is 4.33 shows that the respondents agree with the statement where they feels excited while playing the game. Lastly, for score 7, the mean score acquired is 4.28. The score represents respondents' agreement on the game helps them to understand the topic better.

### *C. Findings from Students Opinion on Game-Based Learning Approach Survey*

There are five questions or statement available in part C or the test. The findings from the game-based learning approach acceptance survey are as follow.

Table 4 Finding for part C, game-based learning approach acceptance survey

Question	Mean Score	Standard Deviation
Game-based learning approach can be implemented as TnL tools for Physics	4.56	0.62
Game-based learning progress further well with technology advancement	4.61	0.61
Game-based learning able to attract student attention in subject	3.61	0.70
Game-based learning helps to enhance the understanding of subject	4.39	0.78
Game-based learning has potential to be fully developed	4.72	0.67

Based on Table 4, for question one the mean score is 4.56. This shows that the respondents agree with the statement that the game-based learning approach can be implemented as TnL tools for Physics. While for question 2, the mean score is 4.61 which means the respondent agree with the statement that the game-based learning progress further well with technology advancement. Next is for question 3, the mean score is 3.61. Based on this score, it shows that the respondent agree that game-based learning able to attract student attention in subject. Whereas for question 4, the mean score acquired is 4.39. The score shows that respondent agreed that the game-based learning helps to enhance the understanding of subject. Lastly for question 5, the mean score acquired is 4.72. The score shows that the respondent agreed with the statement where game-based learning has potential to be fully developed.

#### *D. Comparison on Game Engine Suggested and Tested*

There are three no programming game engine that have been explored and experimented in this study. These three game engines can be easily access, either need to be downloaded or access it through online. The game engines chosen each has its own advantages and disadvantages. Therefore, listed below in Table 5 is the summary of comparison for each game engine.

Table 5 Game engine comparison

Game engine/ Comparison	Microsoft Powerpoint	Construct 2	RPGPlayground
Cost and installation	Free and built-in the computer	Free with limited feature, can be downloaded through internet	Free, register to use and online
Basic feature	<ul style="list-style-type: none"> <li>- Access in computer</li> <li>- Distributed in .pptx</li> <li>- Support audio and simple animation</li> </ul>	<ul style="list-style-type: none"> <li>- Access in computer</li> <li>- Game can be uploaded in .html5</li> <li>- 2D game dev, multi-genre</li> </ul>	<ul style="list-style-type: none"> <li>- Access online</li> <li>- Distributed through online link</li> <li>- Role-playing genre</li> </ul>
Development	Use the linking function and can be added with VBA	Visual programming, actions can be chosen from list given	Visual programming, actions can be chosen from list given
Game assets	Need to be designed/created or use built-in shapes or function	Need to be designed, has template and asset available but limited	Free assets in game editor
Help and Guidance	Can be search in internet	Guidebook available and forum also available online	Guidebook, video guide and forum available online
Limitation	Suitable for basic games without advanced graphic	Free feature limited	Focus solely on the role-playing concept

## VI. CONCLUSION

This study was designed to identify either game-based learning can potentially be implemented in Physics education with the development that requires no programming. As this study focuses on to assist and guide teachers to explore variety of technology tools especially using the game-based learning approach. In this study, we have identified in which area that digital game can be implemented, which is as an alternative tool for student assessment. Next in this study also we have identified multiple no programming game engine available, free for teachers to utilize and build their own game using the concept of visual programming. Lastly in this study, through the development of prototype we managed to identify students' assessment on the game and their acceptance to game-based learning approach in Physics education. As a conclusion, the study hope to be able to bring new opportunity for teachers to provide variety of teaching tools for Physics education and increases students' interest on the subject.

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