

Learning Application Based on Games for Electrical Installation Course (E-Game Wiring)

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The mastery of the practical work is very important among students in the technical field as the lack of mastery can lead to the lack of skilled manpower in Malaysia and teaching materials to provide an impact on learning and facilitating to enable each learning to be clearly received. Therefore, the study is intended to design and develop a simulation of the specific circuit connection game for assembly and electrical wiring courses as one of the learning materials that assists in the learning process. The learning simulation game developed is a concept of constructivism theory that can help individuals to learn independently and to provide new experiences along with the rapid development of this technology. A preliminary survey study was conducted among students who took assembly and electrical wiring courses to identify problems faced during the teaching and learning and type of practical sessions. As a result of the initial review, finding positive feedback was received regarding the application of simulation of the game in learning. Further, the results of alpha testing from the development of this app, developers found close to all elements are working as expected. However, this E-game application wiring still needs to be improved and improvements and suggestions for the future to improve the difficulty and content in the game.

Key words: *E-games, Game simulation, Game-based learning, ABBM, Electrical installation and wiring courses.*

1.0 Background of Study

Teaching in engineering fields should involve more than just the physical needs of the student to give a realistic picture of the subject matter that has been discussed. This is because today's society is less aware of the complexity of the language processes in each person's brain, which makes learning approaches to each person different (Abidin, Noor, & Ashaari, 2018). Furthermore, learning through mobile will enhance the level of understanding of the students and also provides students with fun learning (Shah, Suhailiezana, Kob, & Khairudin, 2019). Besides, the use of the game as an ABBM can also gain a positive impact on students as students can practice concentration while learning and teaching and socializing with peers to motivate students to learned (Marta, Supriadie, & Susilana, 2017) .Among the factors leading to a shortage of skilled labor is students' mastery of hands-on or hands-on skills in the field of electrical engineering especially for women (Esa, Sapon, & Ibrahim, 2014). He added that the reason for students' poor mastery of the practice was due to the lack of involvement in the practice. This is because learning alone cannot make a student competent (Hanif, Azman, Pratama, & Ma'arof, 2017). Therefore, to produce quality and skilled people for students in technical and vocational education mastery of theory and practical learning is important (Kiong, Florentius, Abu, Rubi, & Mohamed, 2017).

Problem Statement

Practical skills in electrical installation and wiring are essential to meet the needs of the course for electrical and electronics students. However, based on the background of the study, the developer found that the importance of physical use needs to provide a real picture for students is still lacking. Some of the students taking electrical installation and wiring courses where they are not exposed to game based-learning usage. Besides, students are often involved in an accident due to a lack of sensitivity to safety during wiring. Furthermore, student mastery is poor in practical skills because they often take a long time to practice. Therefore, the development of this game application is to help students to solve the problem based on the conducive teaching and learning system.

Objectives

This study has several objectives to achieve the aim of the study. These include:

- (i) Designing game-based learning applications for electrical installation and wiring courses.
- (ii) Develop a game-based learning application for electrical wiring and installation courses.
- (iii) Test the functionality of game-based learning applications for electrical installation and wiring courses.



2.0 Literature Review

This section explains the literature reviews of previous studies that are associated with product development. A few important points will be emphasized in order to give an overview of the product that will be developed in this study.

TVET Development

Technical and Vocational Education and Training (TVET) is an educational and training process introduced by the ministry of education that brings students to a career path with a strong emphasis on industry practice (Lah, 2019). On the other hand, TVET is a field focused on psychomotor domains that equip students with the hands-on skills required by the industry (Saari & Rashid, 2013). In addition, a TVET transformation has been undertaken to enhance the quality of education and skills-based training and to strengthen cooperation with the industry for better recognition (Rasul et al., 2015). The author also added that, the focus of TVET transformation is towards graduate employability which aims to contribute to the revenue of the country. Therefore, the high-skills of TVET graduates can be produced through the teacher's involvement which needs these teachers to be more sensitive to the changes in industrial fields (Ahmad, Jalani, Hasmori, & Vokasional, 2015).

Technical University is one of the educational institutions that aware of the importance of TVET transformation to produce high-skills TVET graduates. FPTV is one of the faculties in UTHM that offers various TVET program that focuses to enhance skills and knowledge of the students where they can meet the industrial needs. Electrical Installation and Wiring are one of the TVET courses that compulsory for electrical and electronic students in FPTV, UTHM. This course introduces to the students the basic concept of a one-phase system. Additionally, electrical installation and wiring are also an electrical conductor network system that aims to conduct electrical current for electrical equipment and it is subject to the rules set by the Energy Commission of Malaysia (Rashid, Salleh, & Halim, 2012). In this course there are several types of practical wiring namely One-way switch controls one light, One-way switch controls two lights, Two-way switch controls one lamp, Two-way switch controls two lights, Two-way switch and the intermediate switch control one lamp, Outlet socket: Radial circuit and Outlet socket: Ring circuit. Therefore, in order to deliver as much knowledge to students, lecturers always used different kinds of teaching aids to ensure that the students will be able to catch up with the lessons.

Constructivism Theory

Constructivism theory is a theory that refers to one's responsibility for learning that is often used as a guide for teachers in education (Amat, 2016). This theory emphasizes the discoveries made by the students so that the students are able to replicate the knowledge learned (Lokita &

Utami, 2016). In addition, Amat (2016) further explained the general concept of constructive approach such as:

- (i) Students become active in developing knowledge from existing experiences.
- (ii) The relationship between previous learning and recent learning is mutually influential which can actively help students in developing knowledge.
- (iii) The main factor of learning motivation is due to imbalance. This situation occurs when a student realizes that his ideas are not in line with scientific explanations
- (iv) The provided teaching materials should be relevant to the student's experience in order to attract their interest.

Furthermore, constructivism is a knowledge that results from the activity of an individual rather than information or teaching that is passively received from the outside and is a knowledge that cannot be transferred from one person's mind to another's mind (Zakaria, 2015). Therefore, this situation or theory is applied when the user of the E-game wiring application is forced to solve a given problem based on his experience in the theory class.

Game-Based Learning (GBL)

In this sophisticated era of game-based learning (GBL) is no longer something inconvenient to implement in education. According to with the widespread use of the internet and an increase in more attractive educational strategies has led to the emergence of serious games as a new form of education and training (De Freitas & Liarokapis, 2011). Where serious games are, they are not designed solely for entertainment purposes.

On the other hand, the serious game is also known as GBL or Edutainment games or Learning Games which is always used in various industries and agencies. Serious games are usually adopted in the conducive teaching and learning system (PdPc) which aim to provide training as well as to improve the quality of education and student's transformation (Jasni, Zailani, & Zainal, 2018). Additionally, the serious game also gives impact to their users that makes them tend to try and improve their comprehension and not affected their attention if making any mistakes (Lee, Heeter, Magerko, & Medler, 2012). Therefore, serious games can be explained from the combination of several elements that include content in education, game technics, storyline and fun. This combination is illustrated in Figure 1.



Figure 1: Serious Games (Authors)

Based on Figure 1, four elements are involved in the development of serious games in which one element are connected with another element. The element of educational content is connected with serious purpose elements by e-learning. Then, the serious purpose is also connected to the game technique by gamification. At the same time, the game technique is connected to fun and storytelling by video games. Therefore, the combination of four elements (educational content, serious purpose, game techniques, fun and storytelling) will produce a serious game that contains three features such as e-learning, gamification and video games.

In the context of mobile games, gamification development is generally giving lessons and experiences as well as motivates their users (Deterding, 2012). There are various genres of games that suit the player's interest. Grace (2005) found six genres of games that usually applied and played in mobile games. The genres are presented in Table 1.

Table 1: The types/ genres of the games (Grace, 2005)

Types of games	Description
Action	The game emphasizes the physical movement of the main character as a center of attraction. Players have to control the character of the game to collect and dodge objects and obstacles. This type of game often allows players to change the character throughout the game.
Adventures	This type of game offers player to explore and solve problems as the main attraction. The wide and attractive background is specially designed to allow the character to move freely in the game but is still limited by the map.
Puzzle	A game that does not have an age limit. This type of gameplays with the player's IQ to solve problems. Example: Tetris, minesweeper and so on.
Roleplaying	The player acts as a character in the game and controls the character who performs quests in the imaginary world.
Simulation	This type of game has the ability to match real-world situations. This

	simulation game is divided into combat simulation and social situation simulation. Example: Sims and Tycoon games
Strategy	This is a game that the outcome is determined by the choices made by the player. The game requires players to use tactics such as Chess and Checkers.

As explained in Table 1, there are six types/genres in the mobile games that are usually used by the game's developer namely action, adventures, puzzle, role-playing, simulation and strategy. Every type/genre have their own features and strength that suit the player's interest.

Model of Game Development

It is important for a game developer to identify an appropriate model that can be adopted in order to develop games. The process of selecting an appropriate model for game development is important to ensure that each final product will be able to solve existing problems. There are various models of game development that are usually used by a game developer in order to produce a perfect game. For this study, three models will be explained and compared. The models are Waterfall, GDLC (Game Development Life Cycle) and Prototype. For this study, the GDLC model was chosen as the model of game development for the E-game wiring application.

Waterfall Model

The waterfall model is one of the existing models in the System Development Life Cycle (SDLC) methodology. This model consisting of five phases where each phase must perform in sequence until completed and not allowed to overlap, which means that the researcher cannot repeat the previous phase (Susanto & Andriana, 2016). The waterfall model is illustrated in Figure 2.

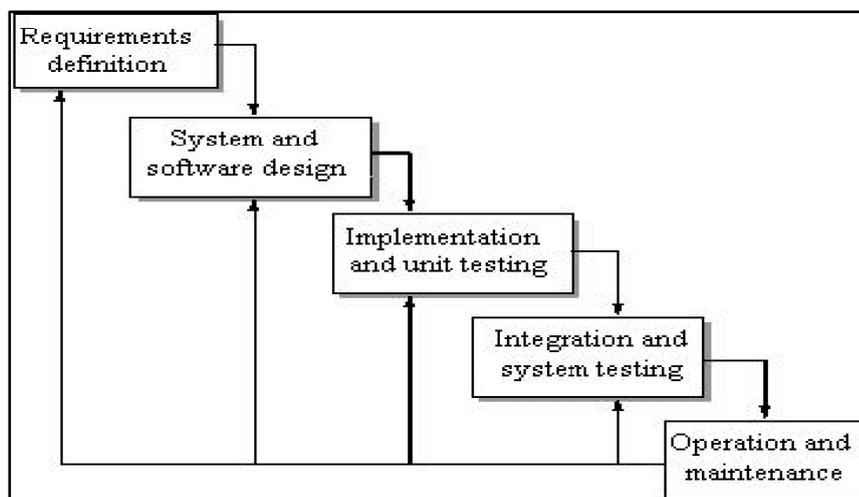


Figure 2: Phases in the waterfall model (Susanto & Andriana, 2016).

There are five phases contain in this model which are analysis, design, implementation, testing and maintenance (Bassil, 2012).

Prototype Model

The prototype model is a software development life cycle model used by the software industry to design, develop and to test high-quality software. The author also added that prototype software is application prototype construction software that shows the functionality of the product being developed but may not hold the actual logic of the original software. The phases in the prototype model are illustrated in Figure 3.

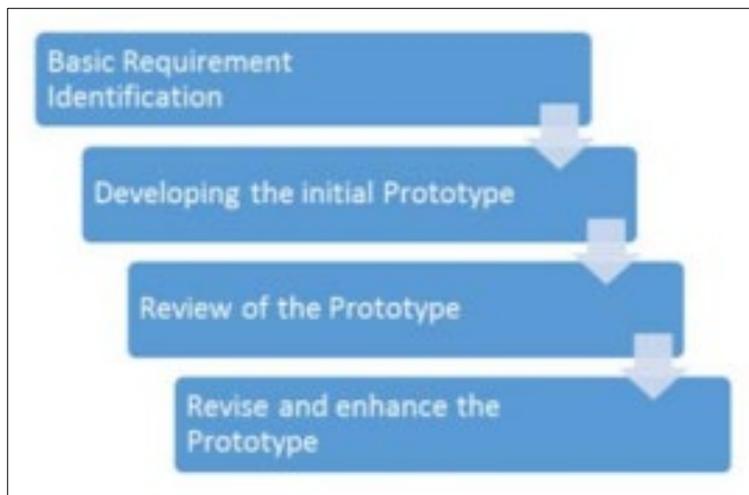


Figure 3: The phases in the prototype model

Based on Figure 3, there are four phases in the prototype model. The phases are starting with basic requirement identification, then followed by developing the initial prototype. The third phase is a review of the prototype and lastly is to revise and enhance the prototype.

Game Development Life Cycle (GDLC) Model

GDLC model is a process of developing games consisting of six phases which are initiation, pre-production, production, testing, beta and release (Krisdiawan, 2018).

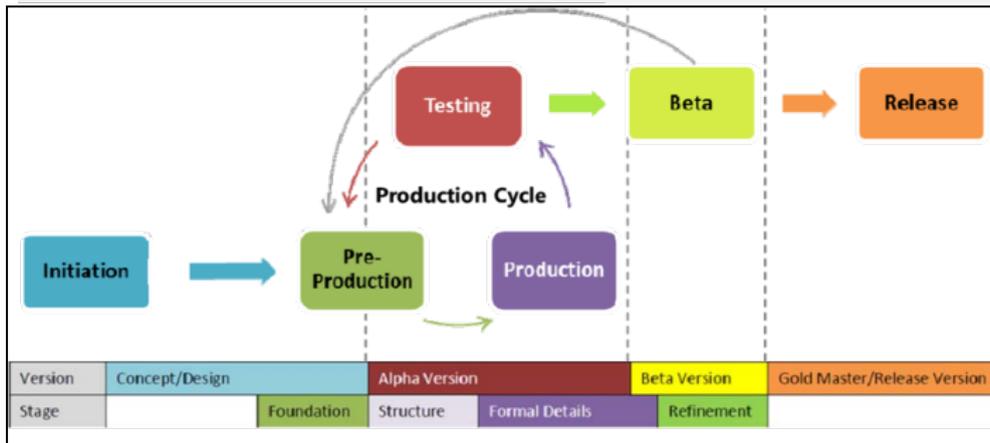


Figure 4: Phases in the GDLC model (Krisdiawan, 2018)

The first phase is an initiation process in determining a rough concept of developing games. The second phase is pre-production, which involves designing games. The next phase is the production which details the design of 2D graphic assets such as characters, backgrounds and props. The fourth phase is testing which involves a playtest to assess the functionality and difficulties that occur in the game developed. Next, the beta phase is performed on the entire games and requires experts in the fields either individual or group to make the assessment and give feedback. Lastly is the release phase which is the game will be marketed after being improved in the beta phase.

Therefore, the GDLC model was selected for this study as a guide for the ongoing product development process. This model was chosen since it has a more systematic phases sequence which is more convenient to understand and followed. In addition, a beta phase included in this model is very important and necessary for product development since it requires feedback from experts before the product is marketed.

Teaching Aids and E-games

Teaching aids (ABBM) are very important and proven to assist teachers in teaching and learning sessions. However, a study by Hashim (2015) found that there is a doubt regarding the quality of ABBM in the fields of technical education in Malaysia due to the lack of expertise among teachers to construct e-material. In the Faculty of Technical and Vocational Education, UTHM, there are various kinds of teaching aids (ABBM) particularly in the electric and electronic courses such as model, application and many more. Therefore, it is important to develop ABBM that in line with the latest technology such as Game-Based Learning (GBL).

The E-game wiring that wants to develop is emphasizing several important characteristics including technology, graphic design and learning domains (cognitive, psychomotor and affective). All characteristics were explained and the comparison of E-game wiring and existing ABBM also presented in Table 2.

Table 2: Comparisons between existing ABBM and E-games wiring

Features	Single Phase Installation and Wiring Model (Ting,2005)	Learning Application M-SPWTC (Isa, 2017)	E-game wiring
Technology	Model	Android	Android
Graphic	None	1D	2D
Cognitive	None	Students obtain information from descriptions in writing and pictures.	Students understand lessons based on the problem-solving process in the game.
Psychomotor	Students understand learning based on practical training by using models.	Using buttons on the display screen to search for information.	Using fingers on the display screen to play with the app.
Affective	None	None	Students can create competition with classmates or with themselves to get a good score.

Based on the table, it can be seen that the development of E-game wiring has its own advantages especially in terms of technology, graphic design and learning domains such as cognitive, psychomotor and affective. This new innovation becomes a new approach in developing teaching aids specifically in the electric and electronic courses.

3.0 Methodology

Methodology or better known as a research method that will be used to develop project processes with the selected design. The developer will focus on the methods during this study and the project is conducted. The methodology that developers will do is gradually by phase in the Game development Life Cycle (GDLC) phase model. This tool development involves phases such as the initiation phase, pre-production, production, and alpha testing, beta testing and release (Krisdiawan, 2018). Figure 5 shows the phase-in GDLC models.

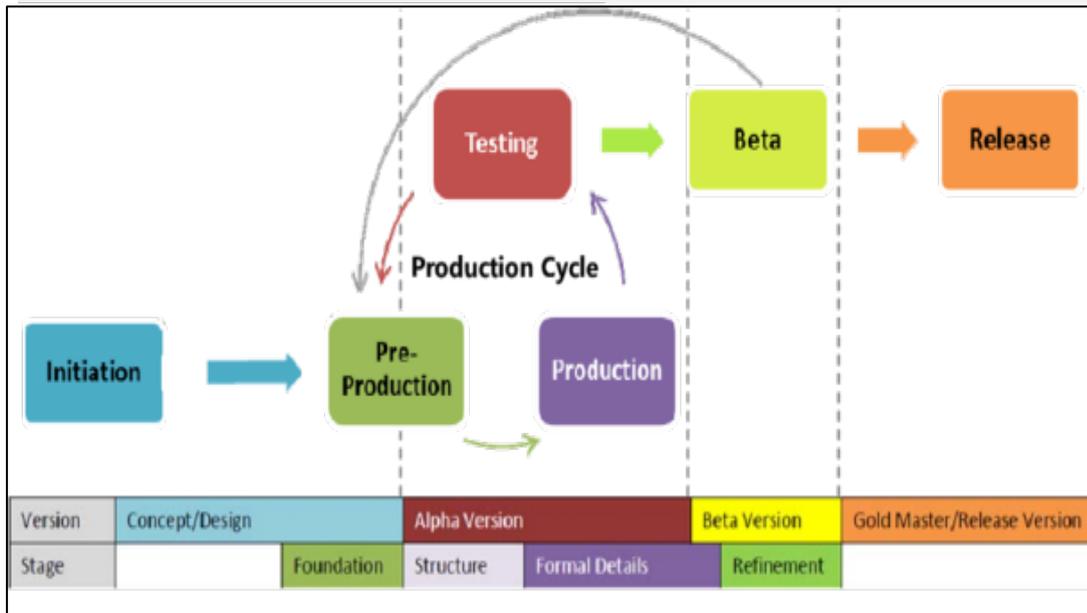


Figure 5: GDLC model phases

Based on Figure 5, it can be seen that the GDLC model has six phases. The phases are explained below.

Phase 1: Initiation Phase

The initial phase of these activities are phases where the researcher identifies the existing game, determines the title of the game, and the elements contained within the game and lists the hardware and software used in the development of the game application.

Phase 2: Pre-production

The pre-production phase is an important phase for the researcher before the start of the product, as it can give the researcher an initial impression. In this phase, the concepts and patterns of games that have been identified can be adapted into one storyboard. The generated storyboard will be used for application development during the production phase. This storyboard is a story line-up of games (screen IDs) from the homepage, settings app, games, and in-game games, media information that tells you the steps in using the app and notes for the use of additional icons

Phase 3: Production

At this stage of development is the phase where the E-game wiring application begins to develop using the hardware and software set in the beginning phase. This phase details the development and organization of assets and programming. The development and arrangement of these assets involve the background, music, specification buttons, and other objects in the

sequence specified in the game application navigation flow chart. The game application navigation flow chart is illustrated in Figure 6.

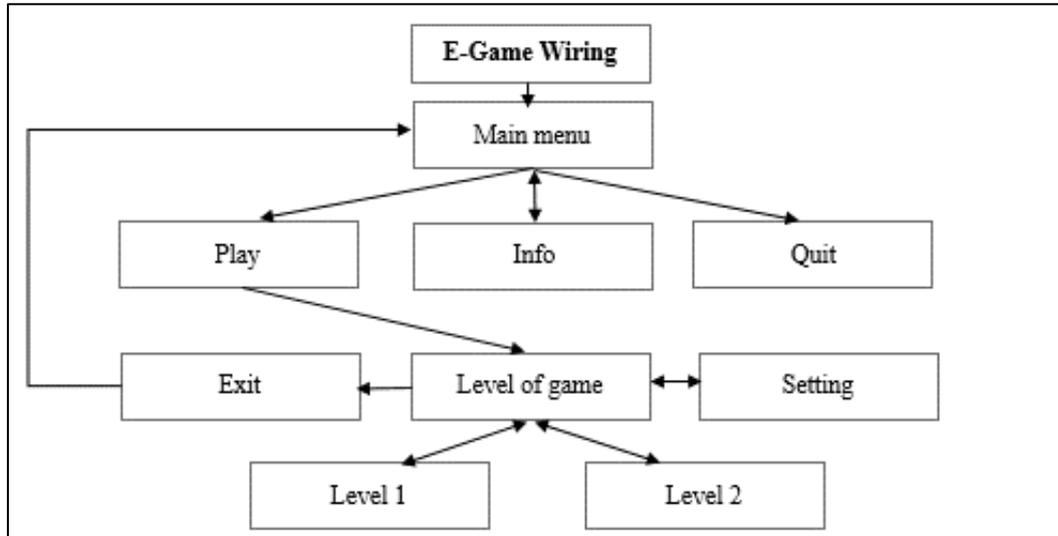


Figure 6: Game application navigation flow chart

Phase 4: Alpha testing

This alpha testing phase is the initial testing or testing phase performed before the product is tested on the user's target and created by the developer himself. Where in this phase of the game application scenes are completed, they are well tested for functionality such as button icons, sounds, and smoothness in the game. This process is done to ensure that there are no bugs that can cause interruptions to the smooth running of the game application

Phase 5: Beta testing

The beta testing phase is the final phase of testing where the application is fully tested on user goals. This beta testing phase is divided into two, open, and closed beta. Open beta testing is for testing to open target groups. While closed beta testing is for some experts familiar with the product being developed.

Phase 6: Release vision.

The final phase in this GDLC model is the release phase. This phase involves product marketing to the market by uploading e-game applications using the Android platform. However, this phase cannot be performed due to time constraints to perform until the broadcast phase.

4.0 Findings

The finding will be presented based on the objectives of this study which consists of designing, developing and testing the functionality of the game-based learning application.

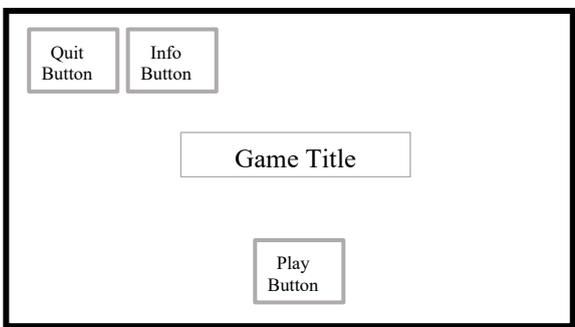
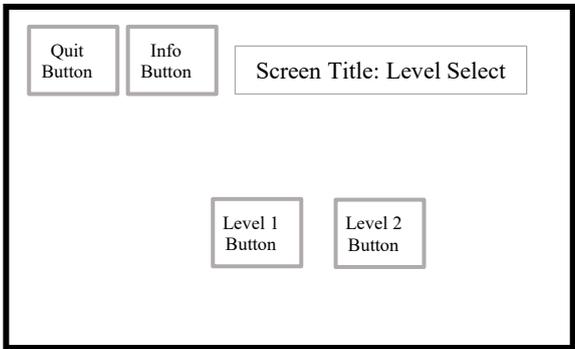
Designing a Game-based Learning Application

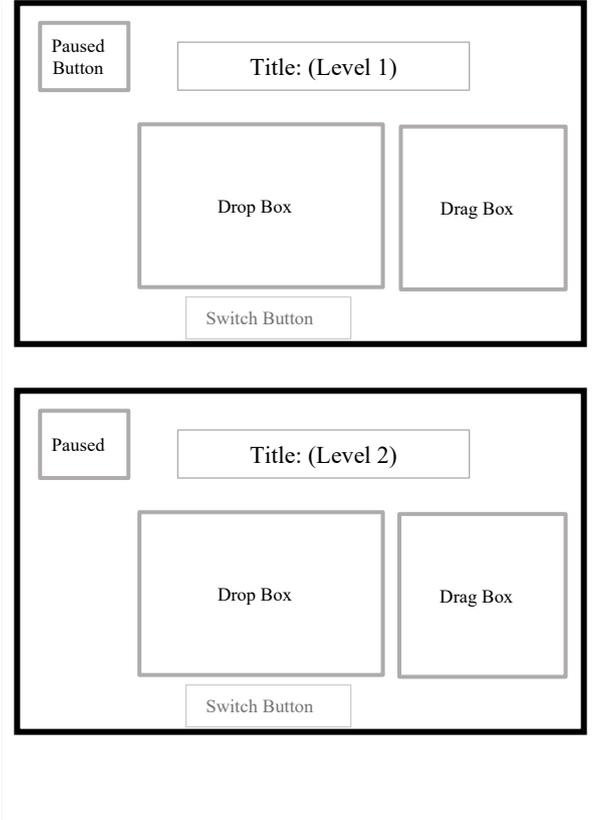
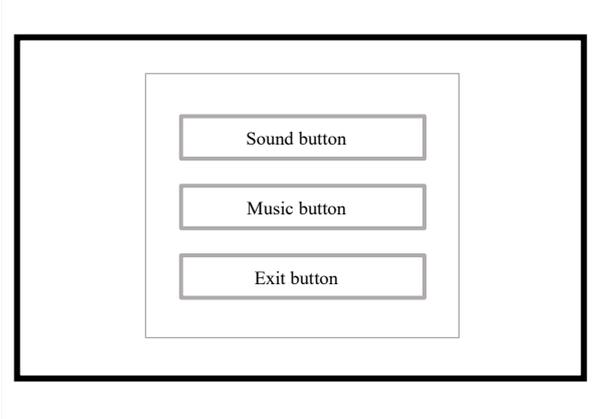
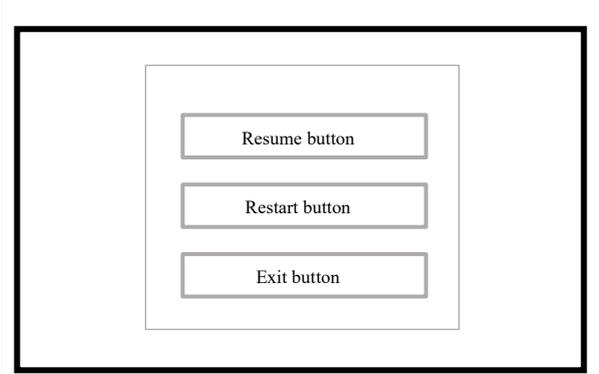
In this product development, storyboard development is a very important element in designing game-based learning applications. There are a few aspects that have been gone through to develop the storyboard including screen application design and design phases.

Screen application design

The screen application design shows the displays of the mobile device platform. In the screen design, there are few sections namely Main Menu Screen, Game Level Selection Screen, Game Level Screen, Settings Screen, Game Pause Screen, Game Score Screen. The design of each section was explained in Table 3.

Table 3: Screen application design of each section

Screen	Display	Description
Main Menu		<ul style="list-style-type: none"> ○ The play button is linked to the game level screen. ○ Quit button is used for users to exit the game ○ Music and sound help for user stimulation.
Game Level Selection		<ul style="list-style-type: none"> ○ Each level button (Level 1 button & Level 2 button) will link to the game level screen ○ The Exit button will send the player back to the Main Menu and the Setting button will display the settings screen. ○ The use of music and sound helps the user stimulation ○ Music and sound help for user stimulation

<p>Game Level</p>		<ul style="list-style-type: none"> ○ Players can choose the game characters in the Drag Box section. ○ Players are required to connect the points to the correct points by dragging the game character into the Drag Box to the correct position in the Drop Box according to the wiring arrangement in Practice 1 and 2 ○ When all the characters are placed in their position, the player is required to press the Switch button to go for the next level. ○ The Paused button will display the game pause screen
<p>Settings</p>		<ul style="list-style-type: none"> ○ The Sounds button allows the player to close and open the sound. ○ The Music button allows the player to open and close the music. ○ The Exit button allows the player to return to the previous view.
<p>Game Pause</p>		<ul style="list-style-type: none"> ○ The Resume button is used for players to return to the game after pausing. ○ Restart button for the player to repeat the game at that level. ○ The Exit button is used by the player to exit the game to the game level selection screen
<p>Game Score</p>		<ul style="list-style-type: none"> ○ Game Score was displayed whether it is correct or incorrect.

		<ul style="list-style-type: none"> ○ The Next Level button will connect to the Game Level Selection screen.
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Based on Table 3, there are six sections in the screen application display. The first section is the main menu screen. This section displayed the front page of the product application that includes text, background, link buttons and animation. The next section is a game level selection that provides various game levels that can be selected by the players. This screen also includes text, background and link buttons. For the game level section, the players are requiring to start playing the game application. The basis of this game is related to the practicality adopted in the course of electrical installation and wiring. The next section is the setting screen, in which the players are free to change the music and sound settings whether they want to turn on or turn off the music and sounds provided. Furthermore, there is also a game pause screen that appears when the players press the pause button in the game level screen. This screen contains a resume button to continue playing, a restart button to replay the game and an exit button to return to the game selection screen. The last section is the game score screen displayed when the players finish each game level. This screen consists of text, picture and a button to replay the game and a button to return to the game level.

Design phases

There are three design phases such as interface design phase, interaction design phase and content design phase. Each of these phases is designed to further deepen the process of developing this product. Further explanations of each phase are simplified in Table 4.

Table 4: The description of design phases

Phases	Description
Interface design	<ul style="list-style-type: none"> • It involves elements such as the arrangement of link buttons, the type and size of the text, the combination of colors and sizes for the background as well as the buttons, the form of display and so on. • Emphasizes the principles in the development of Android applications namely uniformity, clarity, and navigation. <ul style="list-style-type: none"> ○ Uniformity - to ensure that each display is almost the same and neat starting from the first screen display to the end. ○ Clarity - all the elements present in the screen display such as text, images or buttons are clear and can be seen from a normal point of view. ○ Navigation - is intended to allow users to select the screen that they want to target in this application.
Interaction design	<ul style="list-style-type: none"> • The phase to determine the requirements that will be used for the development of this mobile game application. • It is to assist developers in developing this product more systematically. • The result will make it easier for users to better understand the content of the game on their own. • With the available navigation, it is able to allow users to interact with this game application.
Content design	<ul style="list-style-type: none"> • This phase describes the information of the application to be developed, the arrangement of content required and planning on the journey in conveying the objectives of application development to the target users for learning comprehension. • Divided into two levels of games representing two types of practice in electrical installation and wiring courses which emphasize the correct wiring aspect by connecting each supply button with the correct button.

Therefore, based on Table 4, the interface design phase emphasized multimedia elements such as link button arrangement, font size and type, color combination and so on, while the interaction design phase includes a hierarchical navigation arrangement structure arranged by the developer to produce a flow chart that shows the position of each object in an Android game application or in other words it describes the screen arrangement and function of each symbol or object. In addition, the content design phase explains the item or content found in this game application that is the content on each screen display. In conclusion, this developed game application starts with the main menu screen that is streamlined with the use of appropriate multimedia animations and a link button to connect it to the next screen.

Developing a Game-based Learning Application

This phase involves the development process of all game application designs and assets based on storyboard design. It contains the development phases which are divided into several processes namely development software installation, game application framework setting, game and animation asset development, game control, audio development and integration. The process of developing a game-based learning application is shown in Table 5.

Table 5: The process of game-based learning application development

Process	Description
Development Software Installation	<ul style="list-style-type: none"> • Installation of the software needed in the product development process into the computer. • Software: <ul style="list-style-type: none"> ○ Unity as a game engine software ○ The visual studio is a programming language writing software to animate game assets.
Game Application Framework Setting	<ul style="list-style-type: none"> • This process includes to set the frame size or display for the <ul style="list-style-type: none"> ○ Display size in Unity: 1280 x 720 - landscape format. • Organizing folders by category to avoid mixing folders for programming languages, game assets, scenes and others.
Game and Animation Asset Development	<ul style="list-style-type: none"> • The developer set the background of the game application display, development of game assets and animation into the application development engine called Unity. <ul style="list-style-type: none"> ○ Background Selection <ul style="list-style-type: none"> ➤ The display of the first layer is the same for each screen. ➤ The second and third layers of the other screens have the almost same type but different. ○ Game Asset Animation Editing <ul style="list-style-type: none"> ➤ This process enables game assets to move or interact. ➤ Perform by selecting the desired type of animation on the unity game engine. ➤ Editing is needed for animation display which can be accessed via toolbar window and selection in the animation section. ○ Game Assets <ul style="list-style-type: none"> ➤ Includes the game characters ➤ Selected game assets are imported to the Unity game engine and will be edited. ➤ Editing is made using the sprite editor (provided by Unity software) to edit images and organize it into a scene according to the suitability of the game.
Game Control	<ul style="list-style-type: none"> • Involved programming of the game application <ul style="list-style-type: none"> ○ Using C++ in visual studio software

	<ul style="list-style-type: none"> ○ In Unity software – C++ and Javascript ● Programming for the main menu screen <ul style="list-style-type: none"> ○ The game screen of game levels 1 and 2 have drag and drop which has a complex programming language and has many language arrangements ○ This programming language connects the scene with other scenes as well as exits the game application. ● Programming for game selection screen <ul style="list-style-type: none"> ○ This programming language works to allow the buttons on the screen to interact with other screens. ○ Loadscene programming language used to call the screen selected ○ The name should be constant with the selected screen name in the build setting. ○ Navigation button: <ul style="list-style-type: none"> ➤ Exit → to the main menu ➤ Settings → to the settings screen ➤ Level 1 and level 2 → to the game level screen. ● Programming for paused panel screen <ul style="list-style-type: none"> ○ To pause the game ○ Developers need to set the game object first and set the Paused Game command. ○ This command will be adjusted to 0 seconds so that the time allocated for the game paused is 0 until the player presses the resume button. ○ Also include a command for the exit button ● Programming for a game level screen <ul style="list-style-type: none"> ○ It is to move the piece component at move system script ○ Used On Mouse command to allow the component to be moved to the local Position position which is the actual position of the component. ○ The reset Position command is to ensure that the moving component remains in position after the component is released.
<p style="text-align: center;">Audio Development</p>	<ul style="list-style-type: none"> ● After the selection of sound effects, the editing process is done on the sound to suit the game atmosphere. ● The audio editing process is using Audacity software and the editing results are imported into the unity game engine.
<p style="text-align: center;">Integration</p>	<ul style="list-style-type: none"> ● To integrate all the screens that have been generated and translated into one application that ready to use before thorough testing is done. ● This process cannot be done comprehensively because there are some elements that fail during this development process. ● However, this process is still carried out on the elements that are successfully developed such as the main menu screen, game level selection screen and settings screen.

Testing the functionality of Game-based Learning Application

In this finding, a test was performed by the developer in the alpha testing phase. The result of the test resulted in a design analysis of this developed game application. The analysis is based on the functionality of the multimedia elements used in the main menu screen, game level selection screen, level 1, level 2, and audio system.

A. Design analysis for the main menu screen

The design analysis for the main menu screen shows that the test is successfully achieved the expected results. All the buttons are well functioned and follow the game requirements. The result is shown in Table 6.

Table 6: The functionality of the multimedia elements for the main menu screen

No.	Testing	Expected Results	Actual Results	Pass / Fail
1.	<i>Quit</i> button	The display results show Quit	As expected	Pass
2.	<i>Info</i> button	Appear game info display	As expected	Pass
3.	<i>Play</i> button	The screen moves to the game level selection screen	As expected	Pass

B. Design analysis for level selection screen

The result of the design analysis for the level selection screen also shows that all the multimedia elements are well function and achieved the expected results. The result of the functionality of the multimedia element for the level selection screen is shown in Table 7.

Table 7: The functionality of the multimedia elements for level selection screen

No.	Testing	Expected Results	Actual Results	Pass / Fail
1.	Exit button	The screen returns to the main menu screen	As expected	Pass
2.	Setting button	Appear the settings view	As expected	Pass
3.	Level 1 button	The screen moves to the level 1 screen	As expected	Pass
4.	Level 2 button	The screen moves to the level 2 screen	As expected	Pass

C. Design analysis for level 1 of games

The next test is for design analysis for level 1 games. In this test, there is an error of the game result in which the decision could not be issued and made the game character error. The overall results for the functionality for the level 1 screen are in Table 8.

Table 8: The functionality of the multimedia elements for level 1 screen

No.	Testing	Expected Results	Actual Results	Pass / Fail
1.	Paused button	The pause display of the game appear, the game is paused, and the button on the display works	As expected	Pass
2.	Game character	The character of the game can be drag and positioned correctly	As expected	Pass
3.	Game results	The screen displays the results of the game	The decision could not be issued and made the game character error	Fail

D. Design analysis for level 2 of games

The next test is a design analysis for level 2 of games. The result shows that there is also an error of the game result element in which the decision could not be issued and made the game character error. The results for each element are shown in Table 9.

Table 9: The functionality of the multimedia elements for level 2 screen

No.	Testing	Expected Results	Actual Results	Pass / Fail
1.	Paused button	The pause display of the game appear, the game is paused, and the button on the display works	As expected	Pass
2.	Game character	The character of the game can be drag and positioned correctly	As expected	Pass
3.	Game results	The screen displays the results of the game	The decision could not be issued and made the game character error	Fail

E. Design analysis for the audio system

The last test is design analysis for the audio system. This analysis shows that the multimedia element is passed the test which means it well functioned. The result of this element is presented in Table 10.

Table 10: The functionality of the multimedia elements for the audio system

No.	Testing	Expected Results	Actual Results	Pass / Fail
1.	Games audio	Each display produces background music and a sound effect on each button	As expected	Pass

In the design analysis, there are five (5) parts of the design analysis discussed above namely the main menu screen, game level selection screen, level 1, level 2, and audio system. Instead of that, it can be seen at the part of the level of the game which is the game results are a failure. This is due to the result of the game is not appear when the player finishes the game, which may due to the unsuitable programming with the game design.

5.0 Discussion

The learning aid in the form of this simulation game should be developed today to solve the problems encountered in electrical installation and wiring courses. This statement is supported by Rahman (2016), simulation and games are more interactive than other classroom activities. This is because the simulation of the game is a trend that is very much in the interest of young people (Faudina, 2020). Improper use of ABBM causes students to focus less on teaching and learning. This statement was supported by Rahim (2018) who emphasized that less effective teaching methods would not be able to meet student satisfaction in teaching and learning sessions.

Therefore, this study developed a game-based ABBM called E-Game Wiring as one of the exciting and new learning aids in the teaching and learning process. Students will begin to explore on their own based on the skills learned in the classroom and will provide a new experience for students. Even this e-game can actively engage students by giving students self-control to solve puzzles for the practical purpose of one switch controlling one lamp and one controlling two lamps contained in the installation and electrical wiring course.

With this e-game application, students are able to design their own learning sessions anytime and anywhere. This is because the development of this e-game is based on the theory of constructivism, the learning that is knowledge based on one's own efforts without solving it from others. This is supported by Subakti (2017) where knowledge is the result of human interaction with their experience phenomena and their environment.



6.0 Limitation

From the analysis findings the functionality of each element in the E-game wiring game application. On the whole, the application works just as expected. However, there is also has limitation in this study which is related to time constraints. The researcher unable to perform beta testing on the experts due to the time constraints and the application of the developed game requires further refinement of developer perspectives before it is tested on the expert in this field.

7.0 Conclusion

The results of this study discuss the problems faced by students for electrical installation and wiring courses. Preliminary research shows that students often take longer to complete homework due to a lack of skills. In fact, some students often make mistakes in practical learning. In addition, the most commonly used method of teaching students is chalk and talk. Therefore, the E-game wiring game application is trying to be developed to address the problem. Multimedia elements are used in the development of this e-game wiring to help provide engaging graphics to users as they play. Overall, the multimedia elements used work well. But the rest still need to be refined for further assessment purposes before they can be turned to a user focus. Therefore, the third objective in this study was not met because there was still an error on the scoring decision screen. However, the first and second objectives have been met and need improvement so that they can be the best reference material for teachers and students in this specialty.



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