USING HEURISTIC EVALUATION TO IMPROVE THE USER INTERFACE OF HAPTIC TECHNOLOGY BASED NON-IMMERSIVE ENVIRONMENT

By

Teoh Xiao Pei

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF INFORMATION SYSTEMS (HONS)

BUSINESS INFORMATION SYSTEMS

Faculty of Information and Communication Technology

(Kampar Campus)

JANUARY 2020

UNIVERSITI TUNKU ABDUL RAHMAN

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DECLARATION OF ORIGINALITY

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ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to my supervisor, Mr Kesavan a/l Krishnan who has given me a topic which I interest as my final year project and bright opportunity to engage in UI design project with haptic technology. He will always give suggestion to me when I have faced problem during in doing my project.

Besides, a special thanks to a special person in my life for him unconditional support and love, but also give me suggestion and encouragement when I have hard times. Finally, thanks to all of my family members and friends who give me support throughout my university life.

ABSTRACT

The aim of the project is to create a 3D game of haptic technology which had to evaluate by heuristic evaluation. Nowadays, many designs of non- immersive environment are not fulfilled user's requirement. Therefore, this 3D game also will get the data but also experience from normal user and expert user to improve the environment of the 3D game to approach user's requirements. Besides, the heuristic evaluation allows us to identify the serious issues and offer a good management for designer to get an effective non- immersive environment redesign. The reason of using haptic technology in this 3D game, because most of the game are using keyboard and mouse to control it, and most of people have some gesture problem which cause by using incorrect gesture while using it. Throughout this project, the advantage of haptic technology will be exposed. Other than that, a haptic device will be use after this project complete. Haptic technology will get the electromyography from user to interact with non- immersive environment. Electromyography was originally coming from the medicine field but it can be used in the information technology field to create more advance technology to improve the quality of life of human beings. Finally, a 3D game of haptic technology which evaluate based on heuristic evaluation was generated.

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LIST OF ABBREVIATIONS

HCI   Human Computer Interaction

VUI   Virtual based User Interface

ID   Identity Document

AR   Augmented Reality

VR   Virtual Reality

3D   Three-dimension

EMG   Electromyography

EA   Electronic Arts

Chapter 1

Introduction

1.1 Problem Statements

Human Computer Interface (HCI) focus in designing interventions for system involving user and technology. In process to investigate more about HCI, problem statements were founded. "Common sense" was a problem when applied heuristic evaluation in a virtual based user interface (VUI). Programmer use their "common sense" when design in the VUI and forget the VUI need design based on user perspective. User not able to use the VUI when user does not understand the VUI (Iftikhar et al. 2018). It has a lot of user do not know how to use the VUI design by those programmers because it is too complicated to use and the design Is followed the programmers' preference.

Besides, colours used are element can help designer to grab the attention of user to exceptional events, but it also can create visual irritation while overuse (Saha et al. 2015). Some of the VUI designs have no colour contrast. So, users cannot see clearly what is the instructions on the VUI. For example, the background colour of the VUI is black in colour, while the words are brown colour.

Other than that, Consistency and standards should be applied throughout the content and interactions in VUI (Wong, 2019). Some VUI design is not standardize with others, such as the icon of the close button is not at the upper top right corner, so users may find it difficult to use. Moreover, some of the VUI design is not responsive. The frame of the VUI not customize when users use others device to view. It will occur scroll bar to for users to view all contents on VUI, users may difficult to view.

1.2 Motivations

The non- immersive environment will be evaluated by using heuristic evaluation because heuristic evaluation was a guideline for developer to follow for improve the design of environment. It was a principle for designer to develop an environment to approach user's requirement and perspective.

The reason of doing this project is because the game with haptic device was least and to improve the design of non-immersive environment. Most of the game was only using hands and fingers to control the keyboard and mouse to interact with interface. The health of user will destructive when using with a long duration. Besides, every user has their perspective with the design of non-immersive environment.

This project is possible to let user stand up and doing some gestures to interact with non-immersive environment by using haptic device, and improve the user interface by using heuristic evaluation. By using this haptic technology, user possible to do some exercise.

1.3 Project Scope

The project scope of this project is to deliver a user interface based on non-immersive environment which using heuristic evaluation to improve it. Therefore, a proper design of interface can be use by user by using heuristic evaluation. The haptic technology also has to apply in the user interface.

Besides, cognitive map will be including in the interface for user to know location of the player. Labelling will be consisting and it will emerge when player was near to the object. Way point function, question to answer, and answer of the question will emerge in the interface. Thus, user can make choice to use mouse and keyboard or haptic technology by use their hand to swipe ad garb to control the interface.

1.4 Project Objectives

I) To study the aspects of the heuristic evaluation in terms of non-immersive environment user interface.

II) To design the user interface of haptic technology based on heuristic evaluation.

III) To develop a user interface to understand the haptic technology in non-immersive environment.

IV) To examine the proposed non-immersive environment with haptic technology based on the heuristic evaluation.

1.5 Contribution and Impact

This project is exploring the heuristic evaluation in non-immersive environment. This project will benefit the society by letting them have a user centre design of interface and non-immersive environment. Some of the interface and non-immersive environment are lack of user centre design concept. So, this project will be using user experience and user centre to design a non-immersive environment.

Besides, they are many people desire have feel like to touch and control the object in a game not just using mouse and keyboard. Imagine that many people only using hands to brandish, the object in non-immersive environment will move in any direction. It can reduce the number of people with back pain and increase the number of exercises. Thus, haptic technology also includes in this project.

1.6 Project Background

This project is about exploring on how heuristic evaluation to improve the user interface of haptic technology based on non-immersive environment. A design of non-immersive environment will be created by using heuristic evaluation and apply haptic technology with it. Heuristic evaluation can be a review of VUI's design. By using heuristic evaluation, it helps to identify the problem of the user interface of the software. It also encapsulates the usability principles to examining and judging the design of VUI.

Besides, haptic technology will be applying in this project. Haptic technology was a technology that apply a sense of touch through vibrations, motion or force by touch to interact and control with computer. It has been different field such as industrial, medical and non-immersive environment.

Chapter 2

Literature Review

2.1 Understanding Heuristic Evaluation

Heuristic evaluation provided a series of usability principle for the programmer to exam and judge the VV in the first-rate guarantee for user to use. It was developed by Jakob Nielsen and Rolf Molich which was principle for programmer applied when designing VUI. According to Nielsen (1995), heuristic evaluation is a usability engineering method for finding the problem in VUI when designing process. Besides, heuristic evaluation has its strengths and weaknesses when programmer applied.

2.1.1 Principle of Heuristic Evaluation

A list of ten VUI design guidelines consisted in heuristic evaluation was established in year 1990. There is considerable overlap between Nielsen and Molich's heuristics and Ben Shneiderman's 'eight golden rules' (Wong 2018). These ten rules were continuous using until today. By using these principles, it helped to improve usability, utility and desirability of VUI design.

  The first principle of heuristic evaluation was visibility of system status. The system should always inform the status about the visibility status within a reasonable amount of time. User can know the current status in any time, place when their system around. For instance, the percentage of the battery remain in phone or laptop, the notification from the social media, the information about the data usage of phone. These allow user to better decision making when access current status accurately and more information translated by the system that user interact with. A lack of information often equates to a lack of control (Harley 2018). User cannot decide decision to accomplish their goals with uninform current status.

  Secondly, the principle of match between system and the real world was listed in heuristic evaluation. This is because find familiarity was the nature of human beings. User will understand when the system using familiar language rather than system-oriented language. Programmers should never assume that their interpretations and

understanding of words or objects match with users (Kaley 2018). An importance concept is programmers not users, using the users' mindset when designing VUI. Users understand easily what was the important information that shared when it adopted familiar belief, ideas and values which was meaningful. Besides, programmers applied the principle by using the concept of familiarity with real world objects and activities. Human beings have capability on utilized existing knowledge to learn an interface naturally. Users have theories about their past experiences with real world objects and activities, and demonstrated it from physical world to digital world. Users will enjoyable with familiarity.

Thirdly, user control and freedom are one of the importance principles in heuristic evaluation. A design of VUI includes redoing and undoing previous actions offer convenient for users. For instances, system had 'pop up' an alert message for user before doing transaction, because user may regret when buying product online. User can cancel the transaction which was undo action when user regret. User can have a redo action when want to refill in the information before confirm the transaction. It will alleviate repentance of users by having this principle.

Fourthly, the consistency and standards of a VUI design was recognized usability evaluation in heuristic evaluation. The graphic elements and terminology of VUI are maintained across in platform that was similar all over the system. For example, an icon should not represent different design and concept when using different screen. Users can easily understand the design of interfaces element with a design standard. A successful design of interface will have extensive and comprehensive checklists on every page. Besides, a formal standards inspection of all interface design is a significant for new designs to review. Designer may update the system continuously, so a living document under control and manage was importance. User majority supported tools and templates which easier to comply. Therefore, an interface which usability concerns was related with standards.

Fifthly, a proper VUI will implement error prevention when under designing process. This design minimizes the potential error make by user. It prevents user make mistakes before doing confirmation. Designers can include helpful constraints in VUI. It can be a good strategy by giving clearly information or rules when user to resolve rather than

limit user's options. Offer suggestion also one of the methods can be conduct in error prevention. When user searching information or product online, it may occur slip type error which was typo error. The interface will show up the suggestion for user search their needed information effectively. Therefore, offering suggestions, utilizing constraints, and being flexible to prevent unconscious errors (Laubheimer 2015).

Sixthly, recognition of user was rather than recall them when they using the VUI. Recognition refers to familiarity, while recall related with details from memory (Budiu 2014). When designing the VUI, designer minimize user's memory load. The visibility of instruction was needed, and information or message was easy retrievable. This is because, user should not to memorize the information or content when using VUI. Recognition in VUI was user to recognize and make choice with available commands or available platform. It is also having a recall in VUI which is login. User need to remember their ID and password when login to some interface such as Facebook, Instagram, online banking, and others. The buttons, navigations, and other elements can be name clearly to easy user for access interface.

Seventhly, flexibility and efficiency for user when using VUI. The function of interface has speed up interaction with user. A shortcut commands efficient user done their action in a short period of time rather than using mouse. Because system may not detect the connection of mouse. User able to customize interface which suitable with them. Besides, user can make something by saving for future use. Thus, it was convenient for user, and it easy cater by inexperience and experience user.

Eighthly, an VUI which aesthetic and minimalist design was one of the important principles. An interface with a relevant content or information was a significant for user. If content was not related with title, user may receive incorrect information and knowledge. An avoid unrelated between content and title was a responsibility of designer. Therefore, all unnecessary information should not include in VUI, because it may restrict the memory of user to learn relevant knowledge.

Ninthly, the VUI design should help users recognize, diagnose and recover from errors. The system should always help to recover the error message. There was not every user understand technical terminology, designer should always understand the position of

user. Therefore, it should provide dialogue to inform user the error and the solution to fix the error. Besides, the error message should express in plain message which user know the meaning and empathy to ensure the translation are correctly.

Tenthly, the principle of heuristic evaluation was help and documentation. All of the system will provide help and documentation. The icon or button placed in the area that was easy for user to look at. It was better for designer provided with appropriate help document online and offline about the system. These help document may consist the question that navigate by the user and solution for answering user's issue.

Finally, these ten principles of heuristic evaluation were a useful and usability for designer designing VUI. As a professional designer should include this principle in their interface.

2.1.2 How to Conduct Heuristic Evaluation in User Interface

Heuristic evaluation will be demonstrated in a proper interface. A question about how to conduct heuristic evaluation in VUI may occur in some inexperience designer's mind. Heuristic evaluation has an issue conduct by one user to do because it is difficult to identify all of the problem in interface. Therefore, a few of user which different people can find all the problem easily. Before implement the heuristic evaluation, understanding user was a step to help in next step. Designer have to define target audience and the achievement from the interaction of them. It will be allowed communication and finding aggregated after evaluators have completely evaluation. The result of evaluations recorded in written report or documentation as a formal record have advantage when present it.

The observer has the responsibility to exam and judge the design of interface are related with user's action in user's testing. The observer cannot exam based on only one user. So, they need to collect the different result of different user. There will be a session for observer to answer questions from evaluator. The analyse work will be conducted when all the result was collected. The comparison between the content and design of interface and list of heuristic evaluation conducted repeatedly. A final result

of the analyse will be recorded. The report consists of severity rating was marked, to show the numbers of problems identified was fixed.

2.1.3 Strength of Using Heuristic Evaluation

Many of designer have using the heuristic evaluation to test their interface. They may have some impressions and feedback when using this evaluation. Some of the designer recommended to others after they have experience with it. Therefore, many researches were about the strength of using heuristic evaluation.

The strength of the heuristic evaluation was it can provide feedback to designer with fast and relatively inexpensive method. Many people prefer quick result rather than the result need to do in more time. This is because, many people do not have patience for waiting. A feedback which need to use some period to collect will have to more time and money. If in business era, it was not an efficient and effective way for company to take more time and money to receive feedback.

Besides, the designer can obtain the feedback early in designing process. They can change the design during designing phase, to minimize the risk of error after the interface was completed. The interface can achieve the needed of the user easily. If user have any changes about the design or other requirement, designer can on the spot to change and update the design of interface.

Next, heuristic can help suggest the best corrective measures to designers when assign correctly. It can help the designer focus their attention on certain issues. The problem that was faced will be fix when based on heuristic evaluation. The heuristic was as a standard for designer to follow when they designing interface by minimize or fix the problems.

Moreover, designer can use heuristic evaluation together with other usability testing methodologies. For instance, Ben Shneiderman's eight golden rules. It was convenient and save time for designer to test interface with other usability testing methodologies together.

Finally, these was the some of the strength of using heuristic evaluation. Heuristic have given many convenient and knowledge to designer when they design VUI. A good interface will have high usable value when it applied with heuristic evaluation.

2.1.4 Weakness of Using Heuristic Evaluation

Everything in this world are not the prefect as while as heuristic evaluation. It has a strength and it also have the weakness. Therefore, many researches were done about the weakness of it.

The weakness of using heuristic evaluation was designer need requires knowledge and experience to apply the heuristic effectively. A knowledgeable designer knows the suitable design and elements of the interface, and achieved the requirement request by user. For example, they design the function and icon of the interface was easily to understand and use by the user.

Next, the selection of appropriate heuristic will affect the interface. If designer make wrong decision which was choosing unsuitable heuristic, certain usability problems may be overlooked. Thus, designer need to speed more time to find solutions and to fix it. So, they making a right choice was very importance to minimize the problem or error.

Besides, it was not suitable for complex interface. A few amounts of evaluator will be use in heuristic evaluation. So, they may identify more minor issues and fewer major issues. This will affect the interface will not fix accurately, because it only fixes the minor issues not fix in the main and importance issues.

Moreover, designer aggregate the result by using multiple experts. The expert in using heuristic evaluation was hard to find, the number of experts only have few. It was a much simpler to find only one expert, but it needs to find multiple. The price to hire experts was very expensive.

Finally, these was the some of the weakness of using heuristic evaluation. There may have solution to overcome the weakness of it.

2.2 Understanding Haptic Technology

Haptic technology was a tactile feedback technology to control and interaction with computer application by applying touch sensation. Touch sensation was applied by using vibration, motion or force. Haptics can be used in creation virtual reality (VR), 3D environment, AR and immersive environment. It can be enhancing the remote control of machine and device. It receives the data from the sense of touch by hands and other parts of body to interaction with computer device.

   Besides, haptic can to train the people in exercise the muscle when using it especially the elderly and patients which have muscular dystrophy. It also can be used for game for user to have feel as well as user see when interact with computer device. Haptics can connect with single or multiple haptic device to use. For example, user play badminton with others user in same screen or with another computer user somewhere else in the world by using remote control or other haptic device. Both of the user which play together with different screen will see the moving ball and feel impact of the ball when they swing or position the badminton racket.

   Nowadays, there was many haptics' device produce to interact with different design of interface. User have to wear device on their hand if they want to use hand to interact with object when they were using haptic technology. For example, glove use for haptic technology.

Figure 2.2.1 The Glove Use for Haptic Technology

   Besides, there are a lot of AR glasses and development kits have been introduced in order to match the haptic technology. User allow to look the 3D object in virtual world easily was the objective of AR glasses.

Figure 2.2.2 Example of AR glasses

As many people know, haptic technology mostly was use in video game, there also have other usage was applying well in their field. For example, some professional using haptic technology to do experiment about the modelling scene and object contexts for human action retrieval.

2.2.1 Electromyography

Electromyography (EMG) normally for the medical field to evaluate the health condition of muscle and nerve cells. By using EMG, doctors can check the patients whether have muscle or nerve dysfunction. As Moores & Cirino (2018) pointed out EMG help doctors to diagnose muscle disorders, nerve disorders, and disorders affecting the connection between nerves and muscles.

There was two type of electromyography which was intramuscular EMG and surface EMG. To detect electrical activity of the muscle, intramuscular EMG involves inserting the needle electrode into muscle while surface EMG was placing electrode on the skin instead of muscle.

The motor neurons have ability to send electrical signals, it need to place a small sensor on the skin to assess which called surface electrodes. Next, a sensor called needle electrodes to evaluate electrical signals. In order to evaluate muscle activity when at rest and contracted, it need to insert into muscle tissue.

Figure 2.2.3 Example of performing EMG test and EMG data

Therefore, computer application can detect the sensation when user wear a haptic device and touch the object of the real object because applied the concept of EMG, and connect to haptic technology. When the user's muscle moving, the data will be collected to the computer device. After that, the result will be shown.

2.3 Understanding on Myo Armband

Myo armband is one of the haptic technologies that control the non -immersive environment by reads the user muscle movement. It was light and comfortable to wear although in a period of time. It reads the data when user doing some hand gesture. Myo armband have some of the technical features and functionality.

2.3.1 Gestures

Myo armband have gestures to control the non-immersive environment by correct the EGM of the user. Every gesture has specific function. The fist action of Myo armband can to hold the object in non-immersive environment from on direction to another direction. The wave left action represent the camera direction move to the left for user to view different direction of non-immersive environment. When user wave their hand to right, the camera direction moves to right. To put the object down which hold by user, user can do the action of fingers spread to put down the object. The double tap actions to connect Myo armband. Myo armband can set the function in others gesture.

Fist   Wave Left   Wave Right   Fingers Spread   Double Tap

Figure 2.3.1 Gesture of Myo Armband

2.4 Interaction Between Haptic Technology and Non-immersive Environment

This will be described how the haptic technology connect to non- immersive environment.

2.4.1 Haptic Technology in Video Game Industry

According to Dybsky (2017), Arcade game manufacture in order to take attractive people to play at arcade centre, they start to think the level up immersive of existing game controllers in 1970s. Thus, they come out with the idea of haptic technology. They create 3 screens, X/Y- directional yoke, and 1 pedal merge with vibrotactile feedback to allow players in the experience of rumble of a car. Sony also introduce controller for the PlayStation which was DualShock in after some years (Dybsky 2017).

  In the technology developed era, haptic technology had introduced many types of haptic device to provide feedback. For example, ForceWear Vest. It was a haptic suit consists force feedback device that can convert audio signal into vibrations through electromagnetic actuator technology (Dybsky 2017). When player playing game, they can feel a punch or a kick if they wear it. The advanced of this vest was some action taking outside the field of view of the wearer also can be felt. It can increase the immersion of wearer by stimulate gunshots, slashing and blood flow sensations when playing shooter games. According to Palan (2010), military teams can be training by using this kind of device, and making video gaming more immersive.

2.4.2 Non- immersive environment

Non- immersive environment is a type of VR environment. Non-immersive environment which use desktop system and it does not require highest level of graphics performance. So, the lowest cost of VR solution can be used for many applications. Non- immersive environment can be interacted with conventional device such as mouse and keyboard or may 3D interaction device such as DataGlove.

There not only has non- immersive environment, it also has others type which is semi-immersive environment and immersive environment. Semi- immersive environment consists of a large, concave screen, projection system and monitor to experience. It also involves high end computer graphics. An example of semi-immersive environment was flight simulator.

Immersive environment which fully immersive with VR systems. Many people know that it need to wear a Head Mounted displays (HMD) to connect with VR systems to perform immersive environment. HMD can provide stereo, bi-ocular or monocular images by placed small monitors in front of each eye. It provided 360 degree of view for user to look in any direction.

2.5 The Comparison of Existing System

Two of the existing system with haptic technology based on non-immersive environment will be discuss about their design of the user interface. These 2 existing systems was Arcade Shooting Game and Grand Slam Tennis Wii.

2.5.1 Arcade Shooting Game

Arcade Shooting Game was a haptic technology based on non-immersive environment. It was a machine game and majority placed in the arcade centre or gaming centre. It needs using method of coin-operated for people to play. Besides, player will control and interact the interface by using light gun.

The UI design of Arcade Shooting Game had achieved some of the principle of heuristic evaluation. It allows player control and freedom. Player can use the light gun to shot when target come in any position. Player also can have choice to choose the number of players. For instance, play by one or two players. Next, it was consistency and standards for player to play the shooting game by press the button to start or choose some choice in the interface. Besides, the design of interface was recognition rather than recall. Arcade Shooting Game was a simple machine, and easy for player to control. Player does not need to remember the procedure how to play the game.

Figure 2.5.1 Example of Arcade Shooting Game

2.5.2 Grand Slam Tennis for Wii

Grand Slam Tennis was a tennis video game, develop by EA Canada and initially released for the Wii. According to Bozon.M (2009), Grand Slam Tennis allows for a lot of different gameplay options, with everything from Wii MotionPlus to regular Wii-mote support, nunchuk schemes and standalone remote-only play. User enable to control and interact the interface by using Wii MotionPlus.

The VUI design of Grand Slam Tennis was more close-fitting with heuristic evaluation rather than Arcade Shooting Game. This is because, the visibility of system status allow user to follow the latest result or status. For instance, the result of the tennis will be display when the match was on going. Next, Grand Slam Tennis was match between system and the real world. It was almost similar with the tennis's competition in real world. Besides, it allows user control and freedom when access this system. User can make decide the option of game play mode, select prefer character, and others.

The design of VUI also consistency and standards. The elements and icons are design and place reasonable. Moreover, the design of interface was recognition rather than recall. It was easy for user to access and understand when using Wii remote control. Lastly, help and documents was including in design interface of Grand Slam Tennis. The beginner has learned and understanding the game with the instruction for beginner. It also saved the record until the latest result appear.

Figure 2.5.2 Example of Grand Slam Tennis for Wii

Arcade Shooting Game	Grand Slam Tennis for Wii
- User Control and Freedom - Consistency and Standards - Recognition Rather than Recall	- Visibility of System Status - Match Between System and the Real World - User Control and Freedom - Consistency and Standards - Recognition Rather than Recall - Help and Documents

Table 2.5.1 The Comparison Between Existing System by Using Heuristic Evaluation

Chapter 3
Proper Method or Approach

3.1 Design Specifications

Every project has proper guideline or procedure to work properly. There be on very intimate terms include as an individual or in a team, it also needs proper procedure in order to allocate parts of the project among the group member. Therefore, methodologies used, work procedure, and tools that need to use for the whole project will be discuss in this topic.

3.1.1 Methodologies and Work Procedure

The methodologies used in the system development life cycle was iterative model and methodology of VR development. Iterative model is a development which incremental, iterative, and fast. The output of the system will be work better when using iterative model after duplicate it a few times.

The first stage to develop in iterative model is planning. During the planning stage, a project plan needs to scheme by include all effort need to complete and to achieve the expectation output. A plan of financial also need to include in the project plan to estimate the to estimate the budget needed of the project, to prevent over budget. In order to complete the project before the due date, the timeframe of the project have to plan prudently to make compatible in duration for each of the stage.

In the following stage which is analysis and design stage, questions of the questionnaire will be create, and a survey section will be conduct to receive the opinion and suggestion of the people in order to improve the project by achieving their requirements. This survey can be doing online or by distribute the survey paper around 7 to 10 users for user perceptions and expert group to validate the system based on heuristic evaluation. An analysis work will be conduct when all the requirement received, and doing a statistic to all the question to be aware of the majority of people's opinions and requirements. A logical design and physical design need to include in this stage. A logical design is a conceptual, abstract design. So, an approximate design needs

to create for decide how the system work, and defining the types of the information needed. Flow chart or flow diagram is one of the examples of logical design. In physical design, a decision making about the design of the interface will be conduct to achieve an easy to use, functionable and refinement interface.

In the next stage which is building the system, a begin to do coding and build the system. When the system builds, the requirement will be conduct to achieve the scope and objective of the project. Besides, the decision of all the design's pattern will be implemented in this stage.

After the coding stage was completed, a testing will be progress. An inspection will be conduct whether the system has any bug when execute the system. By doing this testing, it can prevent the system with bug release.

The next stage which is evaluation which after testing stage. It is an importance stage in system development lifecycle. In this stage, system will be evaluated to figure out how the system can become more better and make the system become flawless after the repeat in every stage.
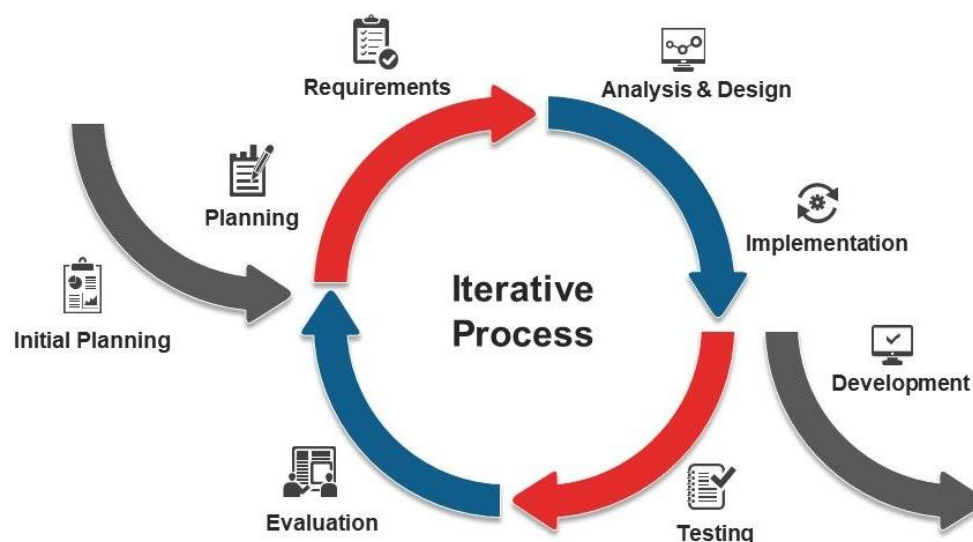

Figure 3.1.1 Iterative Model

Another methodology which is methodology of Haptic development. This methodology used for the connection of interface and haptic technology. In this model development process, it includes database, haptic model, process simulation, and productivity assessment. The database design will collect the data needed in this system. All the interface design, and function will be conduct in process simulation. Haptic model which will get connection with haptic technology, and it able to control the system.
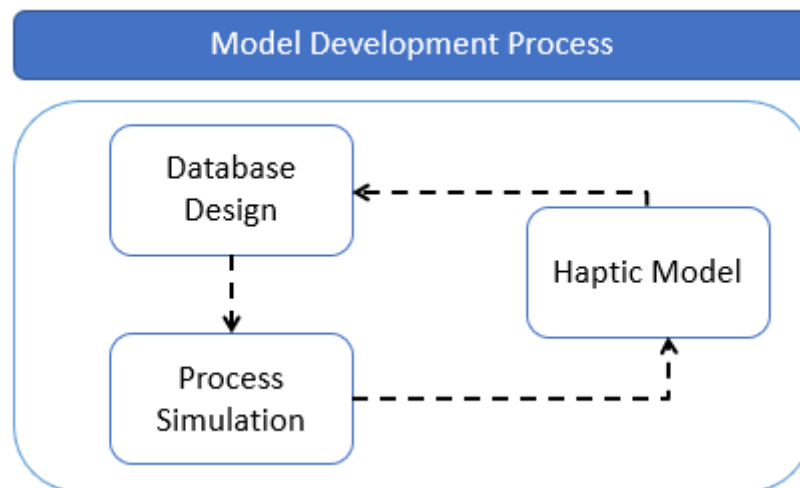
Figure 3.1.2 Methodology of Haptic Development

To develop this project, an VUI of haptic technology will be creating and implement the heuristic evaluation to improve the design of VUI. Before build the VUI, a questionnaire will be conduct to understand the user requirements by asking about the functional requirement and non-functional requirement about the VUI. This questionnaire will distribute to 2 group of users which is ordinary user and expert. This is because, ordinary user and expert may have different kind of perception. By understanding user perception and expert review, have an idea to design the usability, utility and desirability VUI with using heuristic evaluation.

This project will conduct by using VRID methodology which stand for Virtual Reality Interface Design. It includes two phase which is high level design phase and low-level design phase. High- level design act as conceptual guidance to get specify solution of interface design. The output of high-level will become the input of low-level design phase. The fine-gained detail of presentation from high-level will provided by low-level

design phase, and it provide detail to guide become formally presented. A set of design specification will be the output of low-level design phase, and it also ready implemented.

VRID methodology will work together with methodology of heuristic evaluation. Identify goals, expectations, knowledge, background and experience of the typical user to develop an access of use. A user's mental model will be portrayed with a set of appropriately objective. Next, a consideration of access the site by record the path, potential problems and impressions of designer. Besides, taking screen shots of the problem pages and paste into a file by using Powerpoint when rerun the path. Finally, writing annotate of screen shots by circle and describe the sources of problem, and allocate a severity rating.
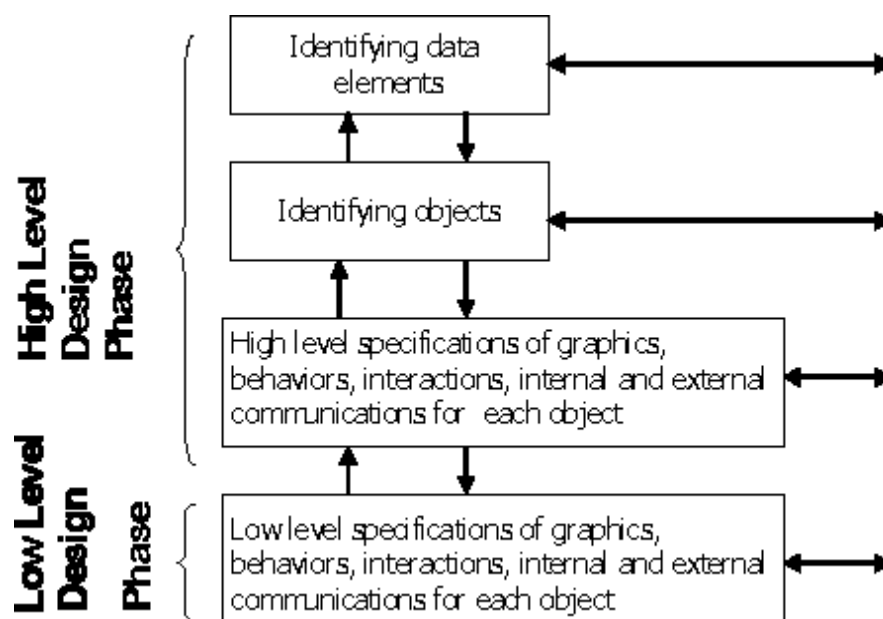
Figure 3.1.3 VRID methodology
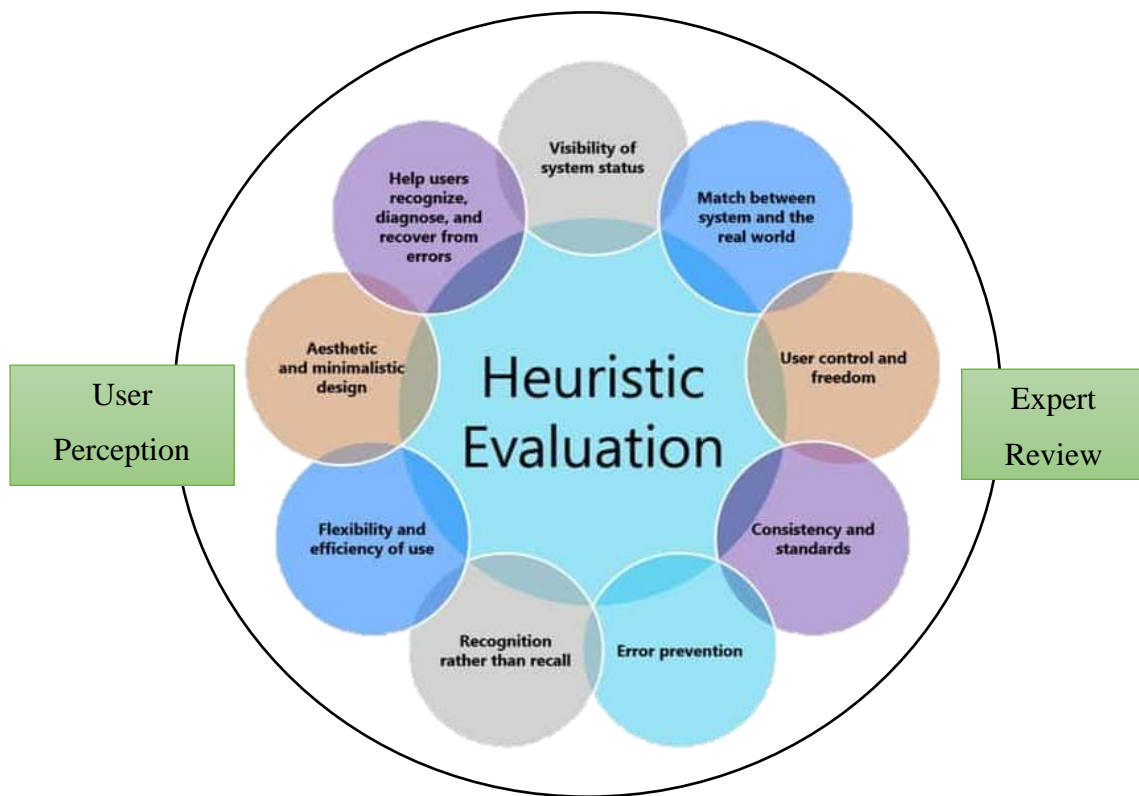
Figure 3.1.4 Heuristic Evaluation

3.1.2 Tools

The software to using for creating the VUI of haptic technology is Unity. Unity was cross-platform game engine for designer to create the game. The hardware to using is Myo armband. It was a gesture controller of actions on the computer based on the contractions of muscle and movements of arm. An VUI of haptic technology will be developed by using this software and hardware. Besides, a laptop is needed to connect Myo armband and the VUI created by using unity software. Lastly, Visual Studio is used to programme for the function needed in the VUI.

Figure 3.1.5 Myo Armband

3.2 System Flowchart

Figure 3.2.1 Flowchart for Myo Connection

Figure 3.2.2 Flowchart for Main Menu
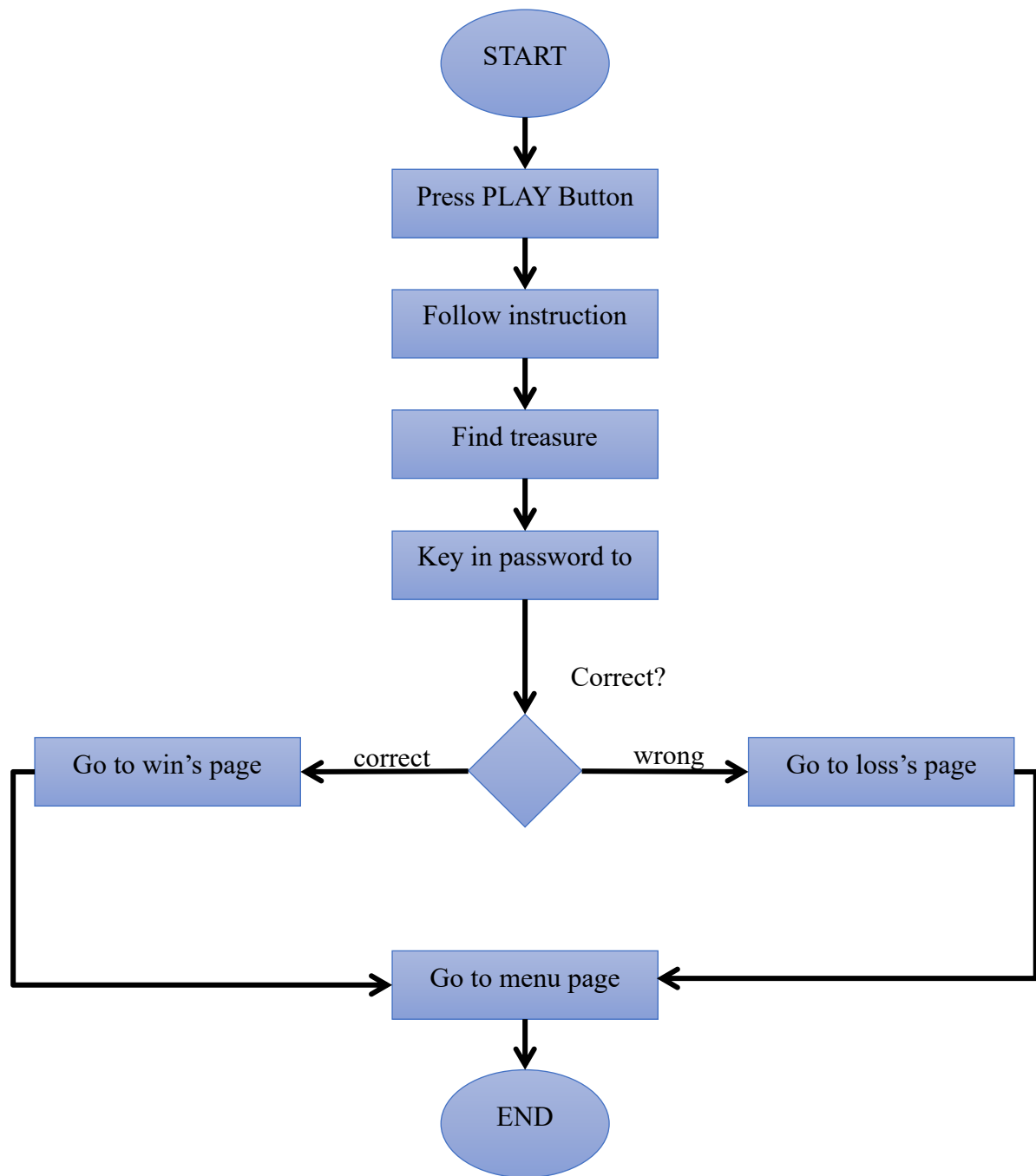
Figure 3.2.3 Flowchart for "PLAY" Button

```
                    ┌─────────────┐
                    │    START    │
                    └─────────────┘
                           │
                           ▼
                    ┌─────────────┐
                    │ Press QUIZ  │
                    └─────────────┘
                           │
                           ▼
      ┌───────────▶┌─────────────┐◀───────────┐
      │            │Answer Question│           │
      │            └─────────────┘             │
      │                   │                    │
      │                   ▼                    │
  ┌────────┐  True/    ◆◆◆◆◆   True/    ┌────────┐
  │Correct │◀─False?──◆     ◆──False?──▶│ Wrong  │
  └────────┘           ◆◆◆◆◆            └────────┘
                         │
                         ▼
                  ┌─────────────┐
                  │Back to menu │
                  └─────────────┘
                         │
                         ▼
                  ┌─────────────┐
                  │     END     │
                  └─────────────┘
```
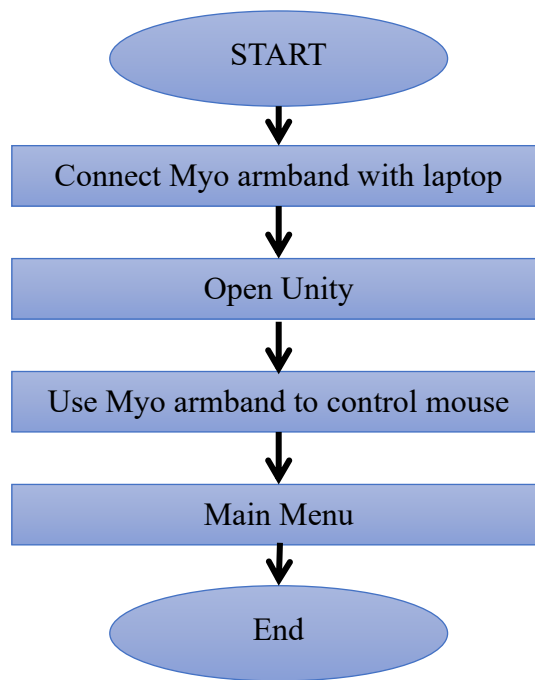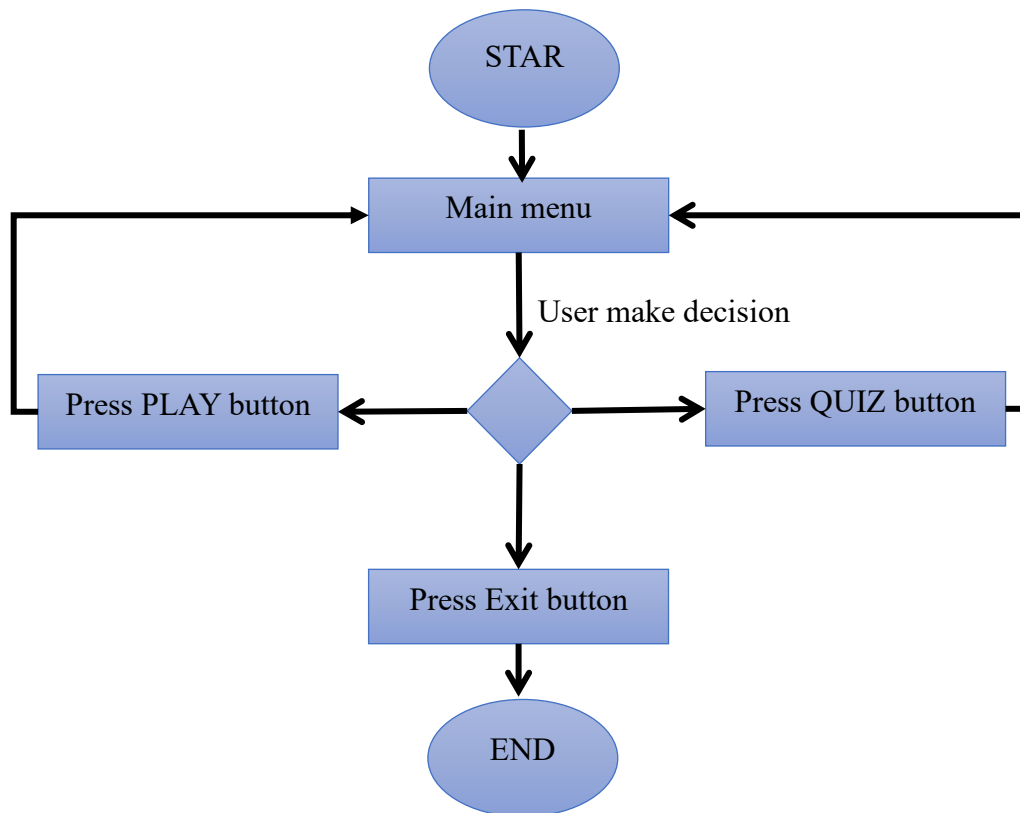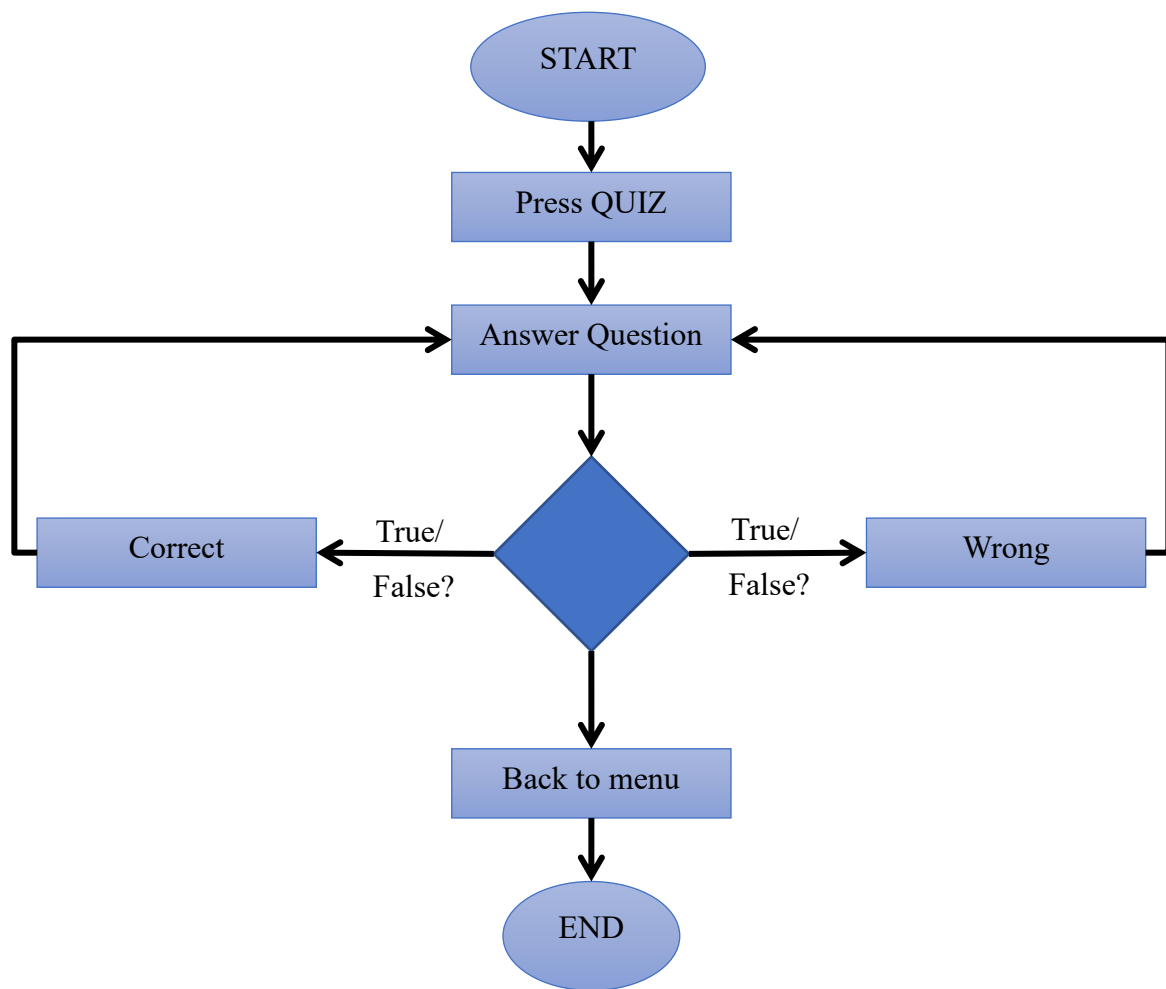
Figure 3.2.4 Flowchart for "QUIZ" Button

3.3 System Design

The design of non-immersive environment is using unity software to do it. In unity, many objects can be developed such as 3D environment. This is the simple game that control by Myo Armband. Therefore, the simple game is in the form of 3D. The user can move the camera in unity by using Myo Armband. The game also can be control by keyboard and mouse. All of the actions are using C# language to develop it because unity supported by C#. Before to create the non-immersive environment, the low and high-fidelity prototype will be used. The low -fidelity prototype was sketched by using pencil and paper. The high- fidelity prototype was developed by unity which closest resemblance to the result which based on low-fidelity prototype.

Low- fidelity prototype
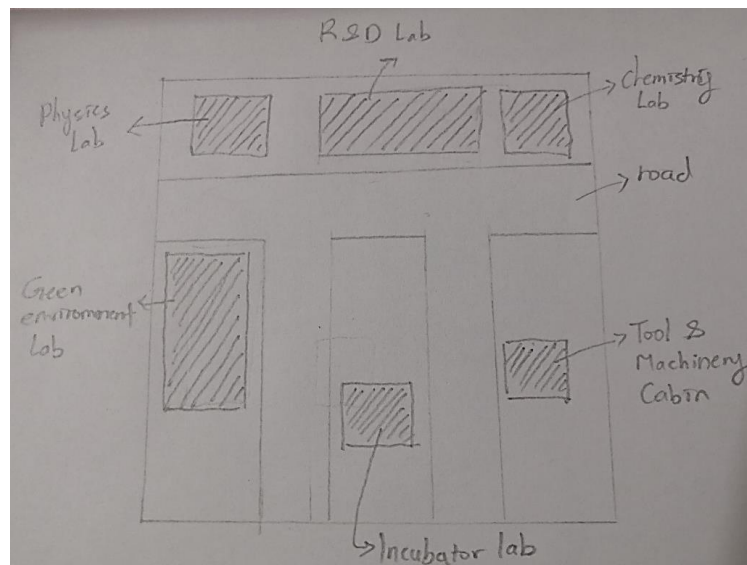
Figure 3.3.1 Low- fidelity prototype1

From figure 3.3.1, it is a temporary sketch of the idea of the overall 3D environment in cognitive map form. Laboratory environment will be performed in this 3D environment. Some laboratory, different type of tree and plant, road, and other decoration will be created.
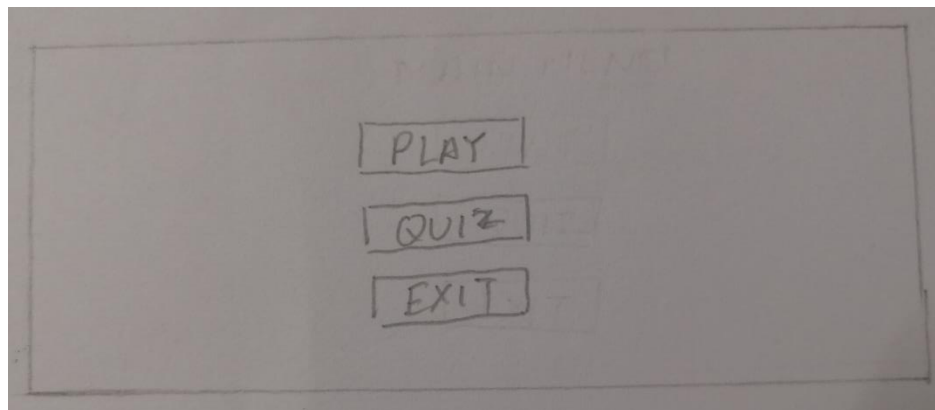
Figure 3.3.2 Low- fidelity prototype 2

Based on figure 3.3.2, it an idea of main menu design. It is in 2D form. In this main menu, it contains three buttons, such as "PLAY", "QUIZ" and "EXIT" button. User can make decision to choose which button to click.
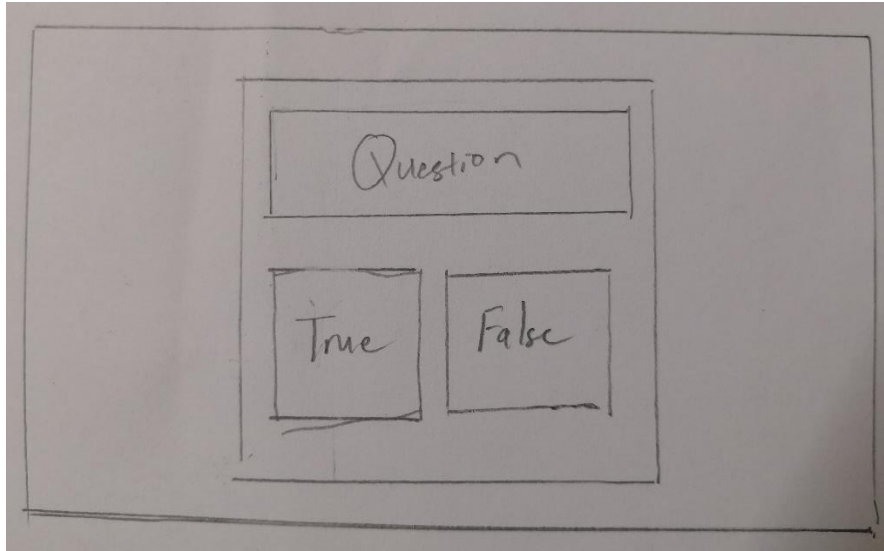
Figure 3.3.3 Low- fidelity prototype 3

From figure 3.3.3, it is a simple design for question. It is in 2D form. Every question
has "TRUE" and "FALSE" button. User can choose the answer by click the "TRUE"
or "FALSE" button.

High- fidelity prototype

Figure 3.3.4 High -fidelity prototype 1

Based on the figure 3.3.4, it was a 2D form of main menu. User can click the "PLAY","
QUIZ" and "EXIT" word. User can click "PLAY" to play the game which to find
treasure. Besides, "QUIZ" for user to answer some question. User can click "EXIT" to
exit the game.

Figure 3.3.5 High -fidelity prototype 2

In figure 3.3.4, it was a 2D cognitive map of high-fidelity prototype that developed by unity. The function of this cognitive map is to get the location of the player. When the player moves, the mark as a player will also move. From the map, it also displays all the location of 3D object which created in the environment.

Figure 3.3.6 High -fidelity prototype 3

In figure 3.3.6, it was a 3D form of environment which capture from the top. From the top, it can clearly saw that there have six different type of building which include R&D laboratory, chemistry laboratory, tool & machinery cabin, incubator laboratory, green environment laboratory, and physics lab. Besides, it includes different type of plant and tree. Moreover, some decoration such as bas, wood street lamp and other involve in the environment.
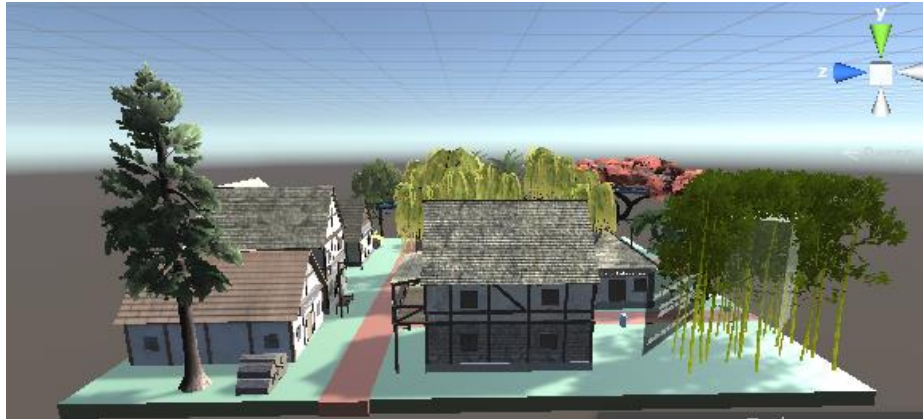
Figure 3.3.7High -fidelity prototype 4

Based on figure 3.3.7, it was 3D form of environment which capture from the side. There was a blue colour cylinder, it represents the player, the reason select blue colour is because it will display clearly in the cognitive map. The main colour chosen of building is brown colour and white colour. The colour used of the road is brown colour, and the ground used green colour. The overall colour will be balance when there has a light based and dark based colour in the same environment.

Figure 3.3.8 High -fidelity prototype 5

In the figure 3.3.8, there are not only have different type of building, there also have different type of the plants and trees, such as bamboo trees, willow tree, Japanese maple tree, palm tree, alder tree, and others.

Figure 3.3.9 High -fidelity prototype 6

Based on figure 3.3.9, it contains some character inside this game. There characters will give some hints when the cursor spot on them. They also have involved some animation.

Figure 3.3.10 High -fidelity prototype 7

Based on figure 3.3.10, this is the environment of R&D Lab which is one of the building in the game. Inside this environment contain different type of object such as black board, tables, chairs, books, notice board, laptop and others. Player can go inside to this environment and find the hints to get treasure such as from the black board and others. The main colour used for this environment is brown colour.

Figure 3.3.11 High -fidelity prototype 8

From figure 3.3.11, this is the environment of Chemistry Lab. Player can get some hints from this area. There are many objects contain in this environment such as chemical's tool, cabinets, black board and others.

Figure 3.3.12 High -fidelity prototype 9

Form figure 3.3.12, it is interface for user to answer questions. From the interface, it includes question but also two buttons with red and blue colour for "TRUE" and "FALSE". The reason of using blue colour for "TRUE" button and red colour for "FALSE" button is because when people get a correct or good result, it will display blue colour, while people get red colour when get wrong or unsatisfied result. It was become the impression of human being.

3.3 Implementation Issues and Challenges

Every user has their "sense of art". So, it has a difficulty to achieve every user's requirements. Some of the user prefer dark series of colour as the background colour, but some user prefer bright series of colour as the background colour. The several perspectives about the arrangement and design of the element also a challenge when doing this project. It need use some time to develop the element in non-immersive environment which achieve users' requirements.

Besides, unity has to use coding for the object to get action, it may have some bugs occurred. So, the bugs may take some time to solve. The method to write the programming was a challenge to get the expectation output. The primitive objects were lack because it only provides cube, sphere, capsule, cylinder and a plane. One of the challenges is that need to use these limited primitive objects to build an object, it need do some adjustment of objects, such as wall of a building. Therefore, it may spend some time to build a building.

The problem with Myo armband is that EMG sensors are not very sensitive so user need to exert a certain amount of force on the arm in order for Myo armband to sense the gesture performance, it need to spend some time to only keep performing the same gesture. The USB port must face towards the wrist when wearing the Myo armband. The gesture performed may be inverted when the Myo armband was not facing to the arm.

3.4 Timeline

The project will use two semesters to complete. For first semester, a simple non-immersive environment design will be created and doing survey to get the feedback.

For the second semester, the interface design will be improve based on the survey feedback, involve all the function in the environment, and get connection with haptic technology.
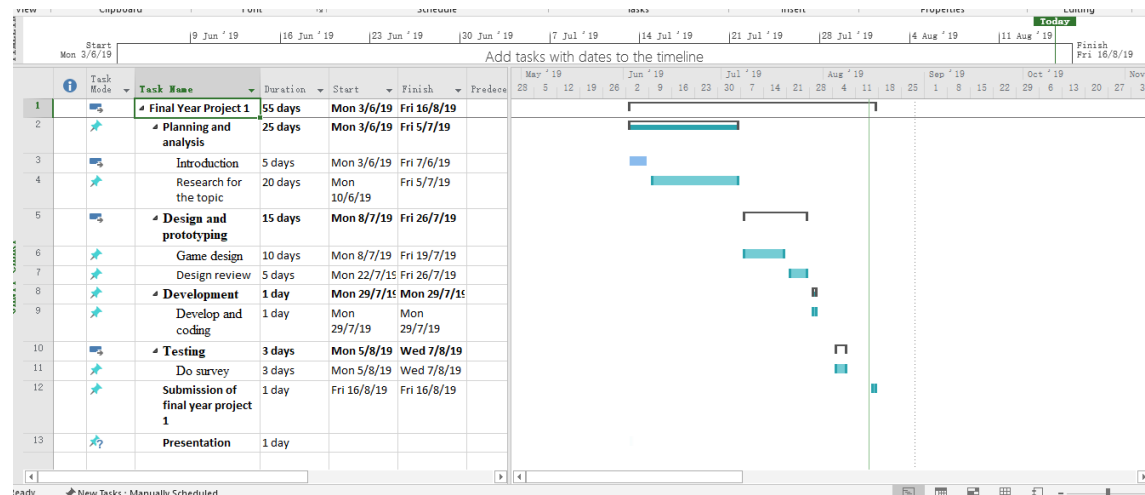

Figure 3.4.1 Estimated timeline of project 1
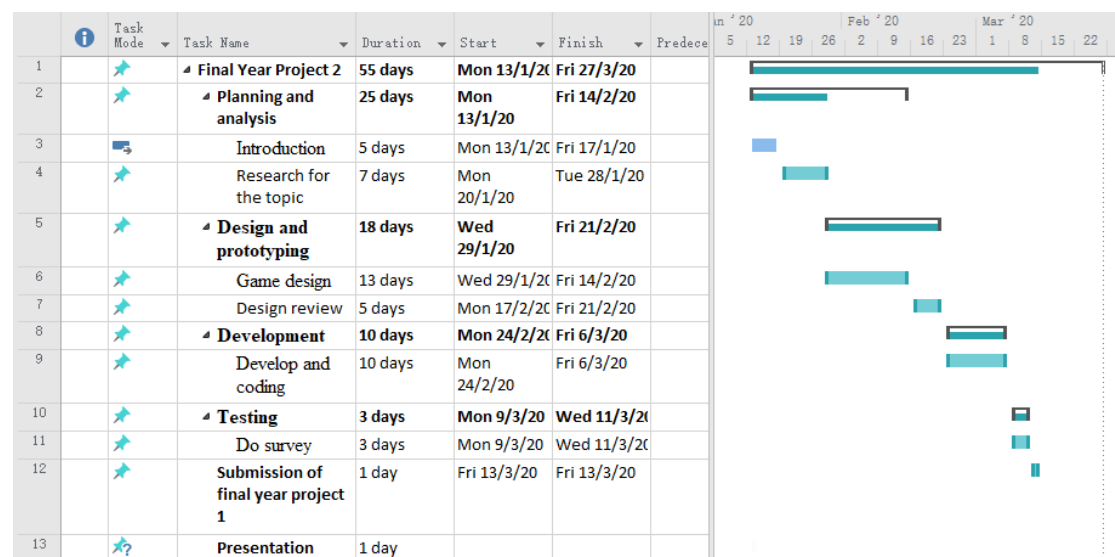
Figure 3.4.2 Estimated timeline of project 2

Chapter 4

Development and Implementation

4.1 Implementation

Before develop the game, download unity but also visual studio software from the internet, and install them to the laptop. Open unity software after it has done installing and start creating the environment. The purpose of develop game is to improve interface design based on heuristic evaluation but also in order to control by using Myo armband. The game content includes main menu, game environment, and quiz interface which for user to answer the question.

The main menu has simple design which contain three clickable words such "PLAY", "QUIZ" and "EXIT". The player in the game environment is a first-person view, and there are a lot of object in the environment, and the user can find the treasure by collecting hints given in the environment. The user can move camera around, and click something by using the Myo armband. There is no time limitation for player to find out the treasure, and open the treasure by get the correct password. The quiz interface which for user to answer the question. It contains around 10 question which related to the game environment. All the actions in the game will be using C# programming language to create because unity is developed by C# so there are many actions need supported by C#.

Figure 4.1.1 Menu designing interfaces

The background used in the figure 4.1.1 is downloading from the internet. The reason used this background image is the design of the is simple and have similarity colour with game environment which is brown colour and is wood element. The hexadecimal of button's text colour used contain four colour which is #FDCA23FF, #FD5A17FF, #DFDFDFFF, and #FDCA23FF. Each of the button have supported by C# script which change scenes when user click on it.
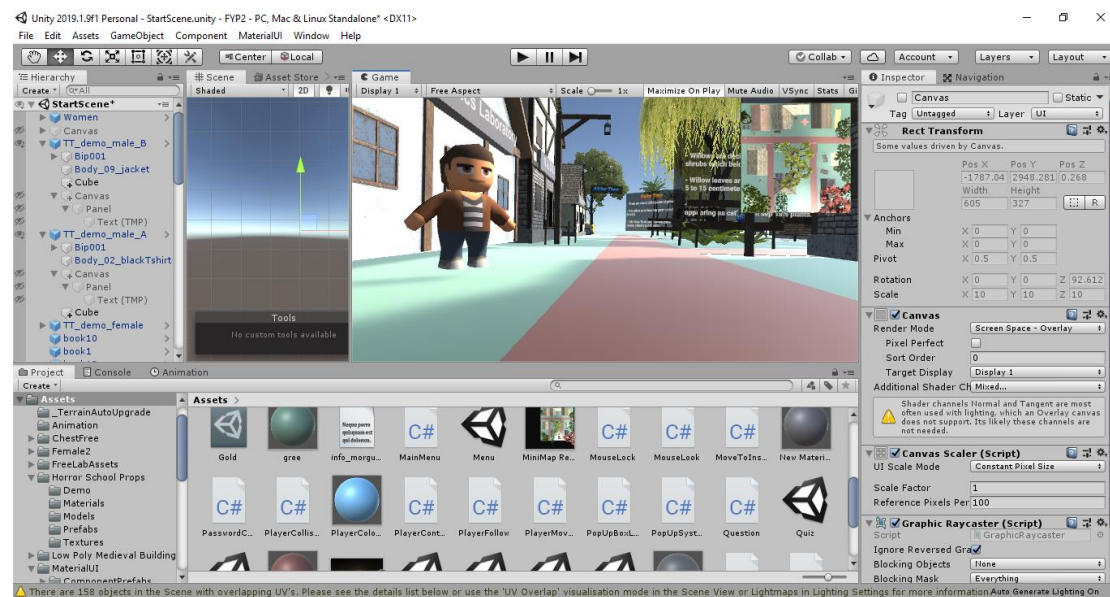
Figure 4.1.2 Game designing interfaces

Inside the game environment, it including many of object. Most of the object can be created in the unity by downloading the asset in the assets store, then import the assets in to the unity, and drag it into the environment. Besides, some material can be created and choose the desire colour by drag it into the object. After that, the arrangement of the object in the environment by using the cursor to drag and changing the position, size and rotation.

The player inside the game environment is a cylinder which is blue in colour. The reason to choose the blue colour for the player is to let the mark of the player in the cognitive map can be more clearly. In order to make the player as first-person view, the camera is placed into the player. Inside the environment, there are some character involve in it, the character of the figure 4.1.2 is one the character. The characters inside the environment have contain animation and action.
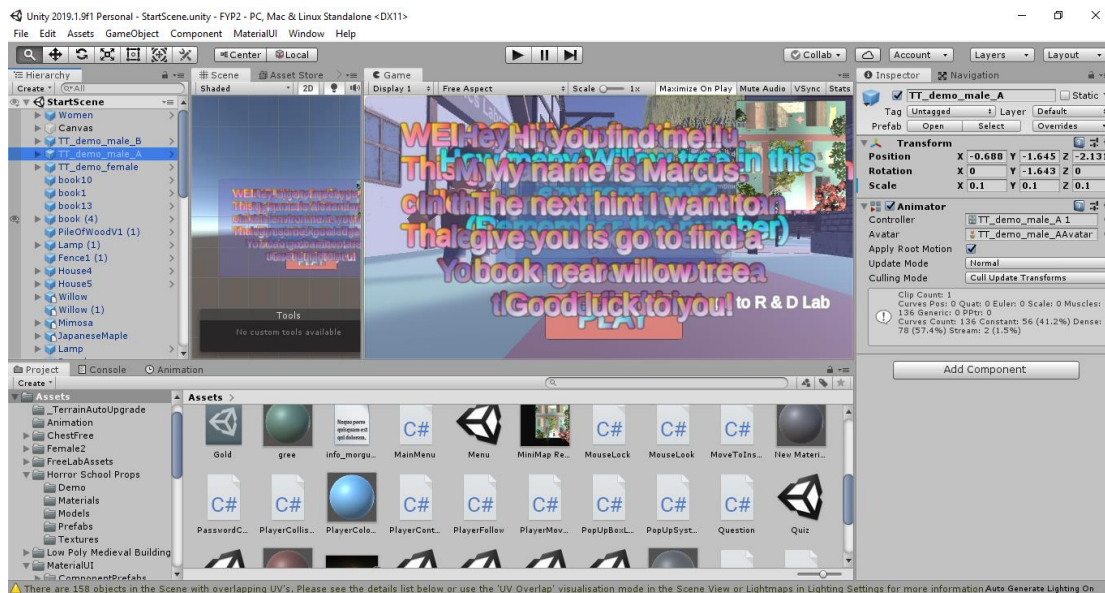
Figure 4.1.3 Game designing panel

Besides, there will be some panel will display when the cursor moves over the object. The figure 4.1.3 was show before start the game, all the panel duplicate together and display in the environment. After start the game, the panel will display only the cursor moves over the object. The text colour and in each of the panel are different, every colour of the panel is also different. But, all of the text font is similar. In order to display the panel when cursor move over the object, a C# script and an invisible object was created, the invisible object will place in the object which have to display panel. After that the C# script will put inside the invisible object, and drag the panel into the invisible object. The player can walk around by using keyboard button and look around by using Myo armband to collect hints to find the treasure.
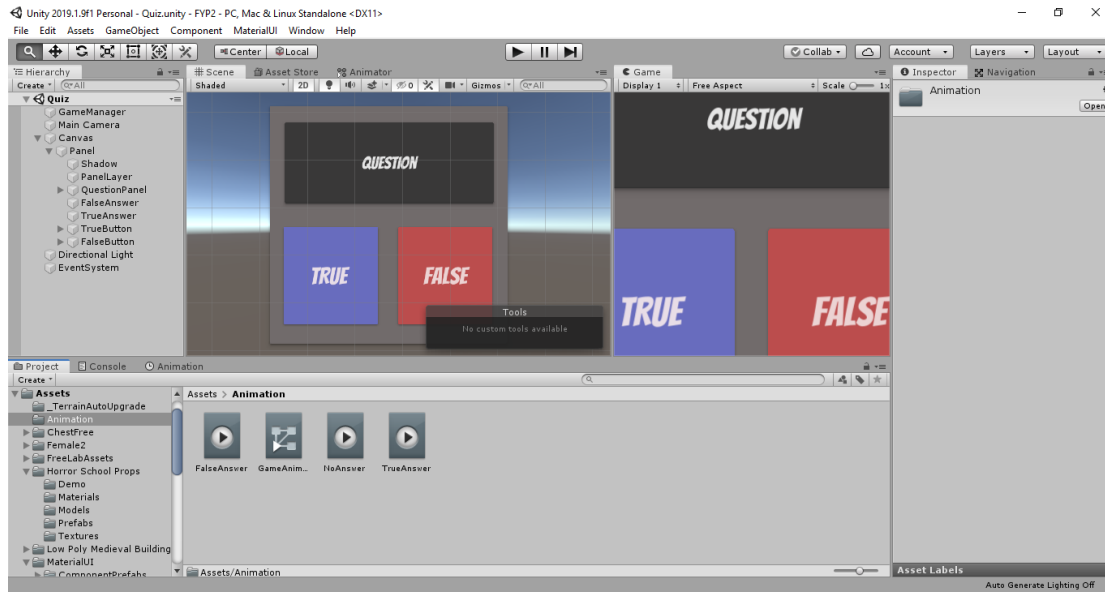
Figure 4.1.4 Quiz designing interface

Furthermore, quiz interface has developed in the environment. It includes question's panel and two button which is "TRUE" and "FALSE" button. The text font of the question's panel and button are same. The colour used for the button is red and blue. Player can answer the question by click the button. Whatever the player clicks which button, the button will move to beside and it will display answer either correct or wrong of the button chosen. After that, the next question will be display on the panel. The animation in the asset in figure 4.1.4 was the animation used for the button. C# script also develop to let the question will be display accordingly and check the answer whether correct or not.
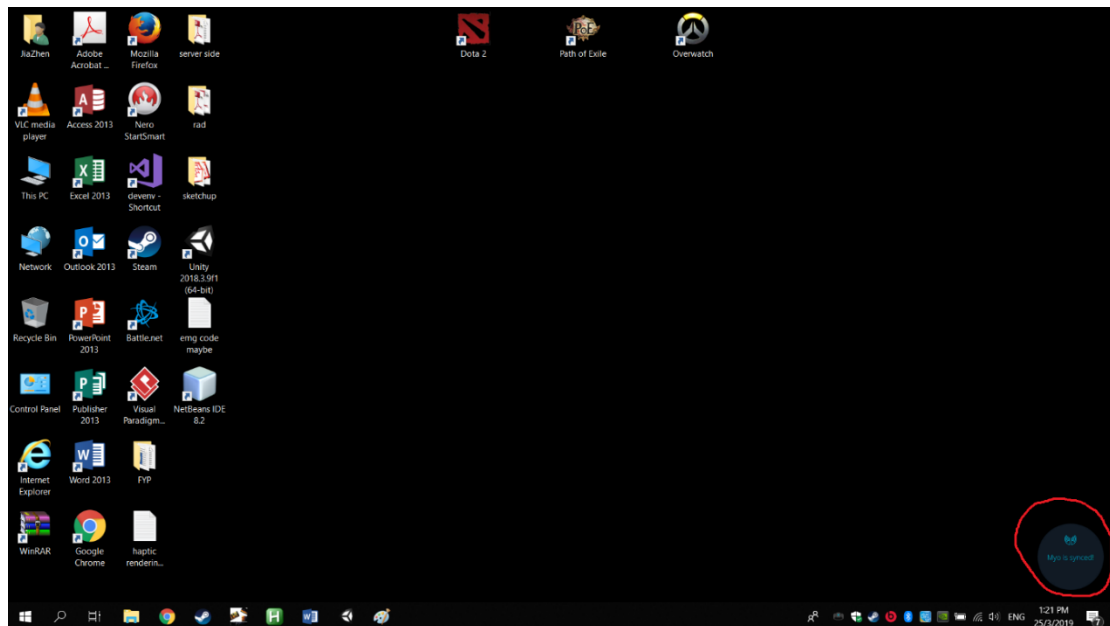
Figure 4.1.5 Sync Myo armband

Before using Myo armband to control mouse cursor, it needs to synced with the laptop first. Therefore, the user can perform gestures and actions. First of all, User need to run Myo connect application and plug in the wireless connector into the USB of the laptop. After that, the Myo symbol will display at the bottom right of the screen after a message will be pop out to remind user to wave out gesture to sync the Myo armband which shown as in figure 4.1.5.
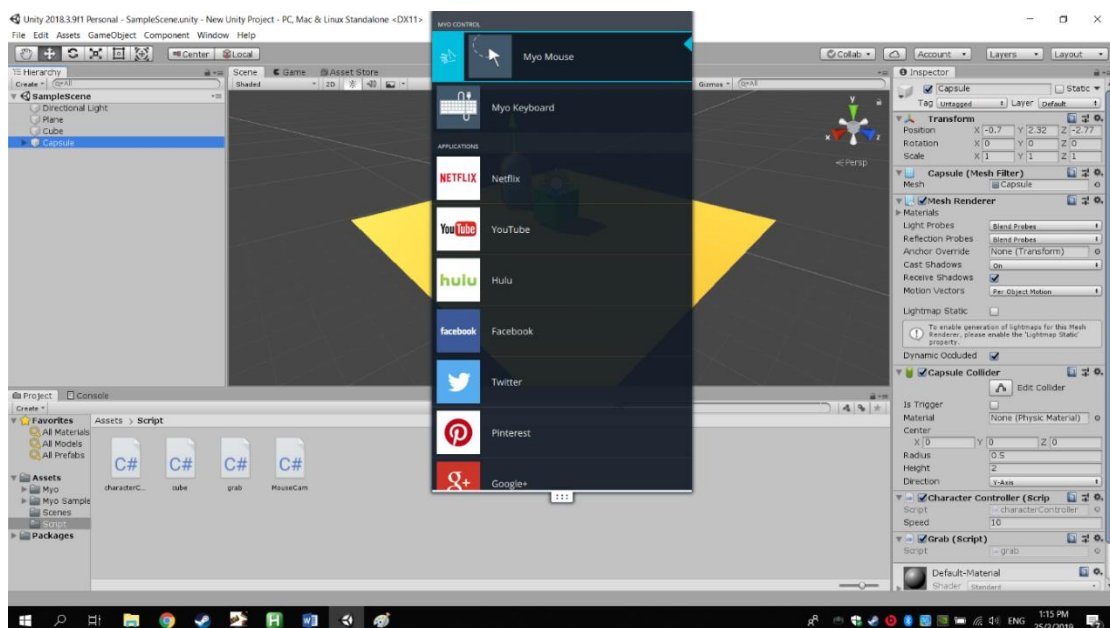
Figure 4.1.6 Use Myo armband to control mouse cursor

User raise up the hand which wearing Myo armband and perform a fist gesture to drag down the menu in figure 4.1.6 after user has synced the Myo armband with laptop. User can use Myo armband to replace mouse to control the mouse cursor when Myo mouse in the menu selected. Before start the game, Myo connect file from the Thalmic Labs need to downloaded and Myo armband need to connected with laptop by using Bluetooth. After that, user can use Myo armband to interact with laptop. In order to connect with unity, Myo SDK file also need to downloaded and put the file into the unity. Therefore, Myo armband can interact with the environment.

4.1.1 Questionnaire

Before develop the 3D environment, survey question distributes to normal users. The environment will be developed based on users' perception. Survey question also distributes to another group of people which is expert's user after done some 3D environment development. The design of environment will be improve based on expert's perception. Survey question based on heuristic evaluation will be conducted to get the review by twelve user and six expert people.

4.1.2 Analysis
<u>User's Perception</u>

This survey's result is from user's perception. The analysis will be conduct by using radar chart to perform. From this radar chart will to improve the non-immersive environment to approach the user's requirement and user's perspective.

1) **Visibility of non-immersive environment status**
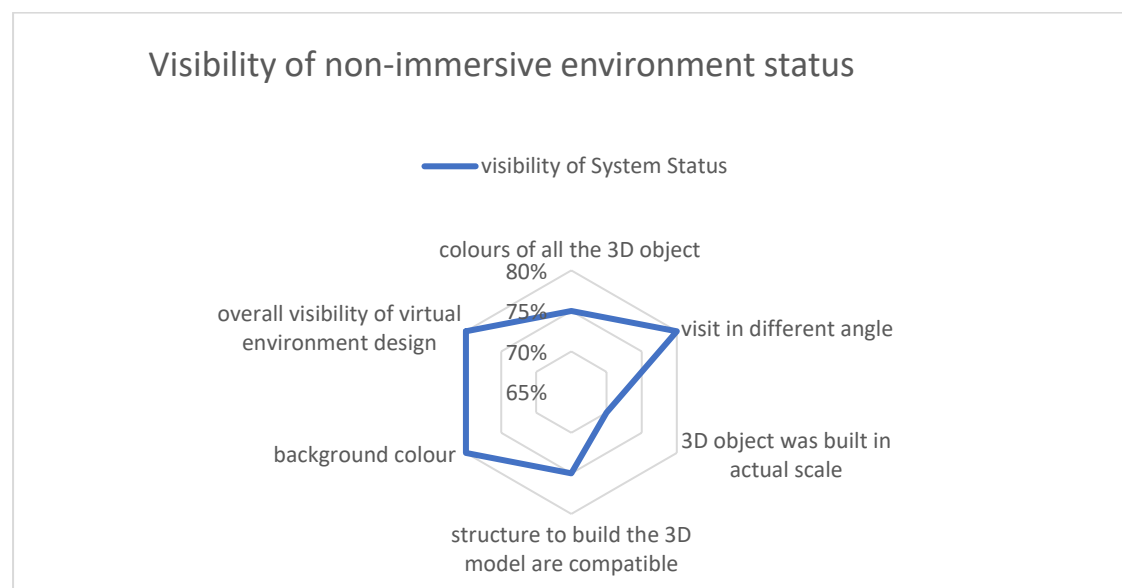
Based on the visibility of system status, 75% respondents said that the colours of all the 3D object had properly choose. Another 25% respondents said that can use some colours which is attracting people. Besides, the 3D model can visit in different angle is importance because it can view the overall looks of the model. 3D object was built in minimize by multiple than actual scale. 80% of respondents agree with the background

colour was suitable in non-immersive environment. 20% of respondents disagree with the background colour because it looks ordinary. The overall visibility of virtual environment design can be improving with create more objects to abundant the non-immersive environment.

2) Match between System and Real World
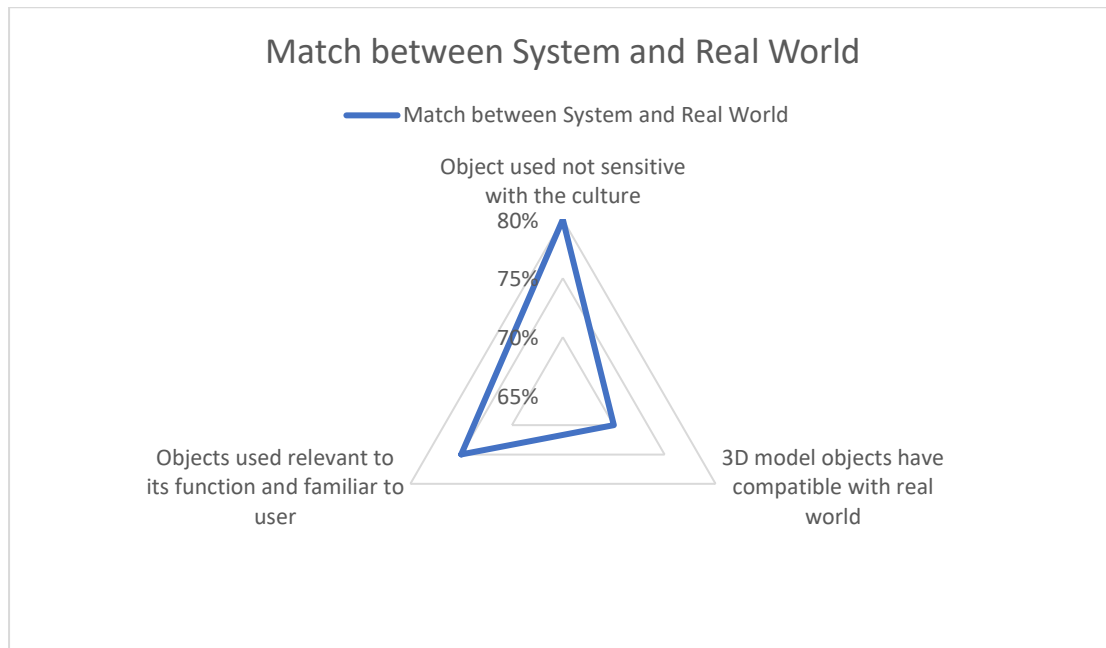
Based on the match between system and real world, 70% respondents said that some objects such as facility and furniture in the house are compatible with real world. Another 30% of respondents said that the mountain not build like in real world. Objects used in non- immersive environment are more relevant to its function and familiar to user. A recommendation is the cube which cinnabar colour can be replace by a human. The objects used in non- immersive environment are not sensitive with the culture.

3) **User Control and Freedom**

User Control and Freedom
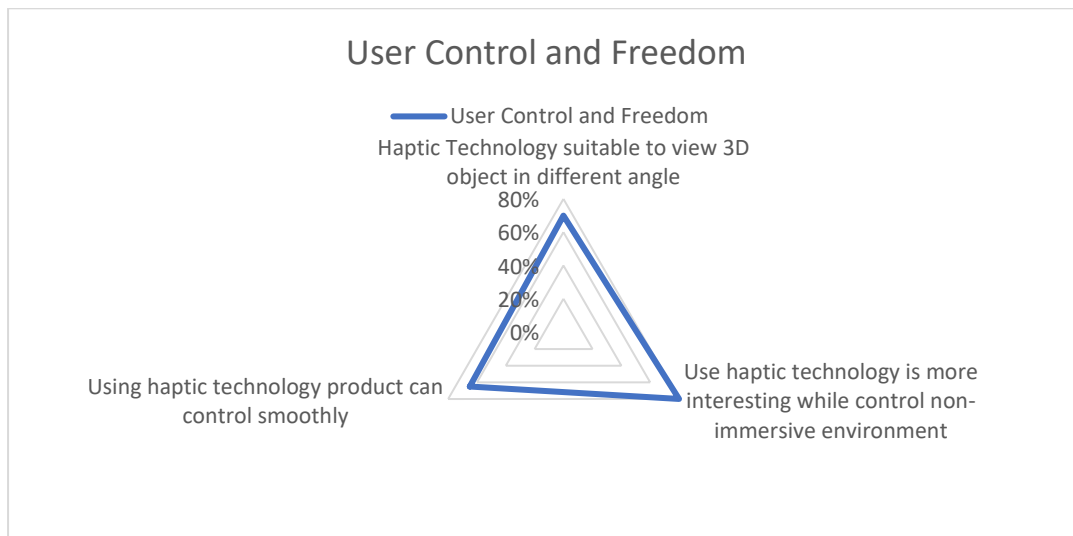
Based on the user control and freedom, 70% respondents said that haptic technology suitable to view 3D object in different angle. This is because user can use hand gesture to view the non- immersive environment. Another 30% respondents disagree with the haptic technology suitable to view 3D object in different angle. The reason is there also having other method to control the non- immersive environment such as using keyboard and mouse, not necessarily need to use haptic technology, but also not every user has more capital to buy the haptic technology to control non- immersive environment. There are 80% of respondents said that using haptic technology can increase the user interesting while control non- immersive environment, because it was a fresh knowledge for some user. Only 65% of respondents agree that using haptic technology product can control smoothly. However, there are 35% respondents disagree that using haptic technology product can control smoothly because the device has a risk that cannot detect or connect well while using it.

4) Consistency and Standard

Consistency and Standard

── Consistency and Standard

3D objects move back when user press down arrow

80%
78%
76%
74%
72%

Haptic technology is better than using keyboard to control the...

3D objects move forward when user press up arrow

3D objects move right when user press right arrow

3D objects move left when user press left arrow
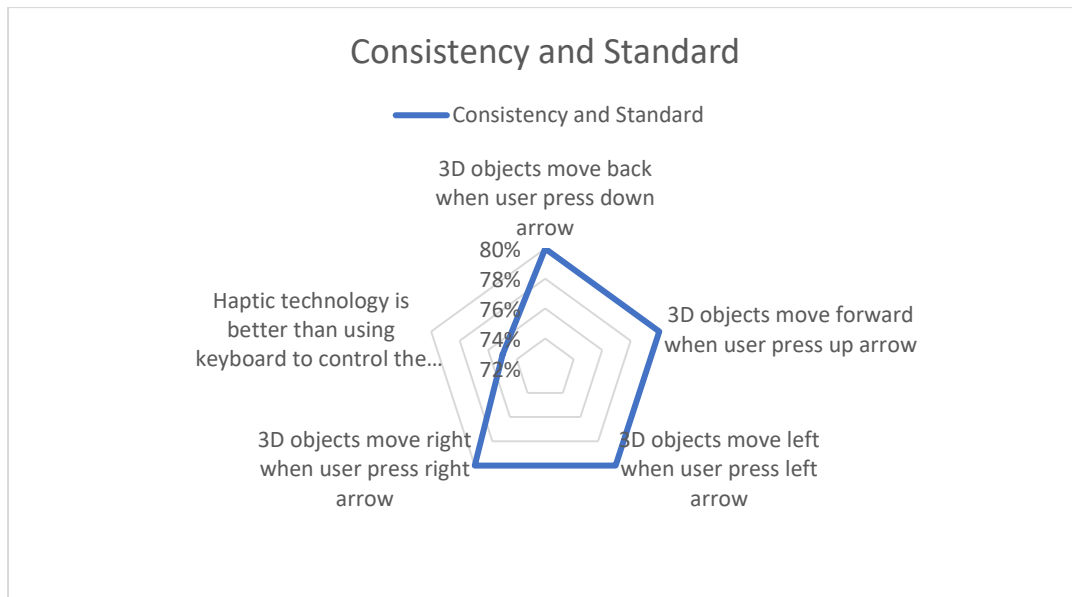
Based on the consistency and standard, there are 80% respondents said that the control of using keyboard are consistency and standard to move up, down, left and right. There are 75% respondents said that using haptic technology is better than using keyboard to control the non- immersive environment because it can increase the exercise rate of the arm and hand not only fingers, but also user will improve their memory become deeper when there has done some gesture. Another 25% of respondents disagree that using haptic technology is better than using keyboard. The reason is they are customary using keyboard to control, they feel not adapt to use it.

5) **Error Prevention**
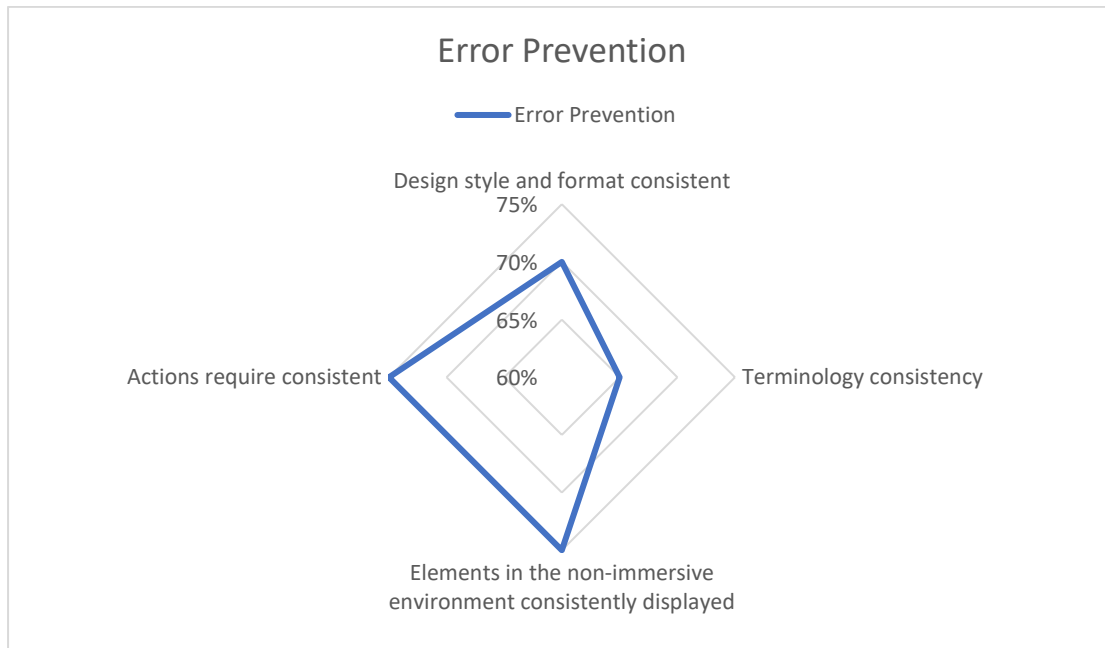
Error Prevention

Based on the error prevention, 70% respondents said that the design style and format are consistent such as user will not confuse with the objects, but another 30% respondents said that in 3D non- immersive environment design was pay attention about the innovation not about design style and format. The terminology use is consistency to prevent the user avoid by error. There are 75% of respondents said that the elements in the environment consistently displayed and does not have any objects that are running position. Another 25% respondents said that there are only few objects so cannot see whole picture whether all elements can consistently display. The actions require is consistent.

6) **Recognition rather than Recall**

Recognition rather than Recall

——— Recognition rather than Recall

Instruction easy to retrieve

75%

70%

65%

60%

Highlighting to get user's attention

Haptic Technology easy to retrieve
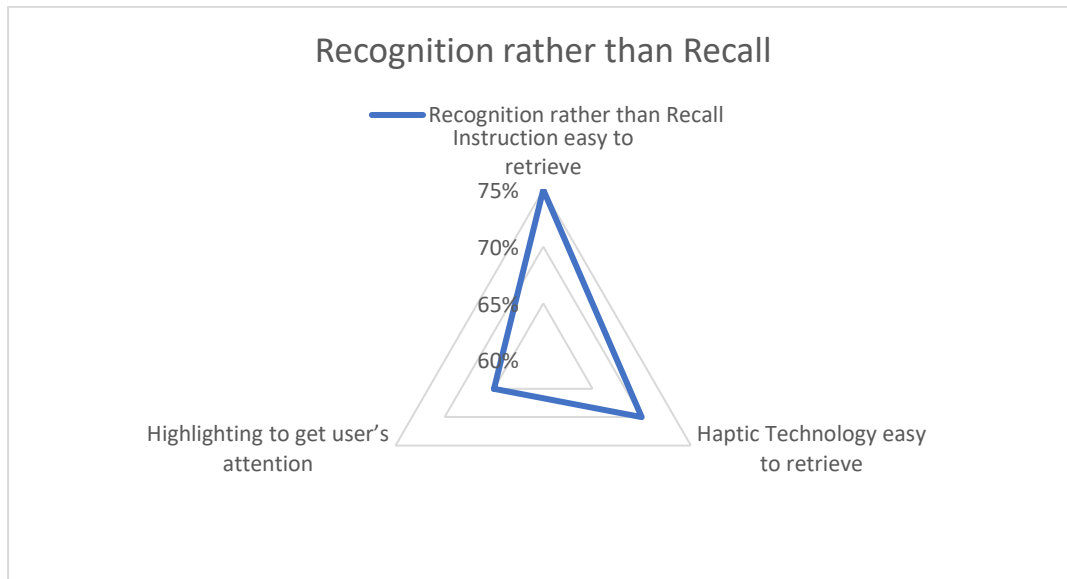
Based on recognition rather than recall, 75% respondents said that an instruction easy to retrieve is importance because user can prevent the error occur. Another 25% respondents said that user can more recognize when user grope by themselves. There are 70% of respondents said that using haptic technology easy to retrieve because it only needs use some specific gesture to control the environment. The highlighting objects will get user's attention.

7) **Flexibility and Efficiency of Use**

Flexibility and Efficiency of Use

——— Flexibility and Efficiency of Use

Non-immersive environment easy to navigate

80%

60%

40%

20%

0%

Haptic technology product was difficult for user to use

Connection of haptic technology easy to navigate
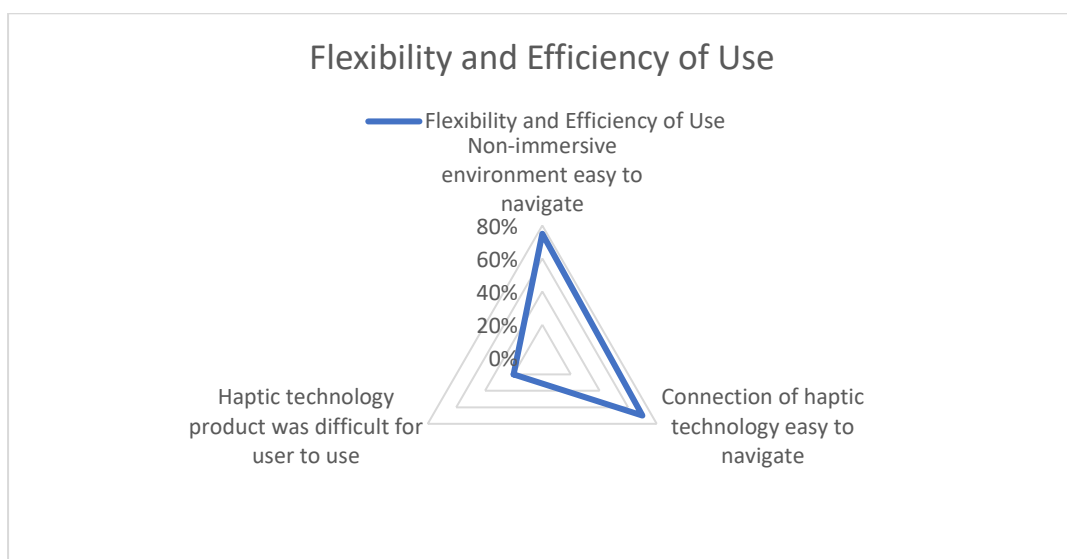
Based on the flexibility and efficiency of use, 75% respondents said that non-immersive environment easy to navigate because user can view in any direction of environment. 70% respondents agree that connection of haptic technology easy to navigate because it just need connect with USB and it will have logo represent connection of the haptic technology. There have 20% of respondents said that haptic technology was difficult for user to use because some of the user does not have idea how to use the haptic technology.

8) **Page layout, Aesthetic and Minimalist Design**
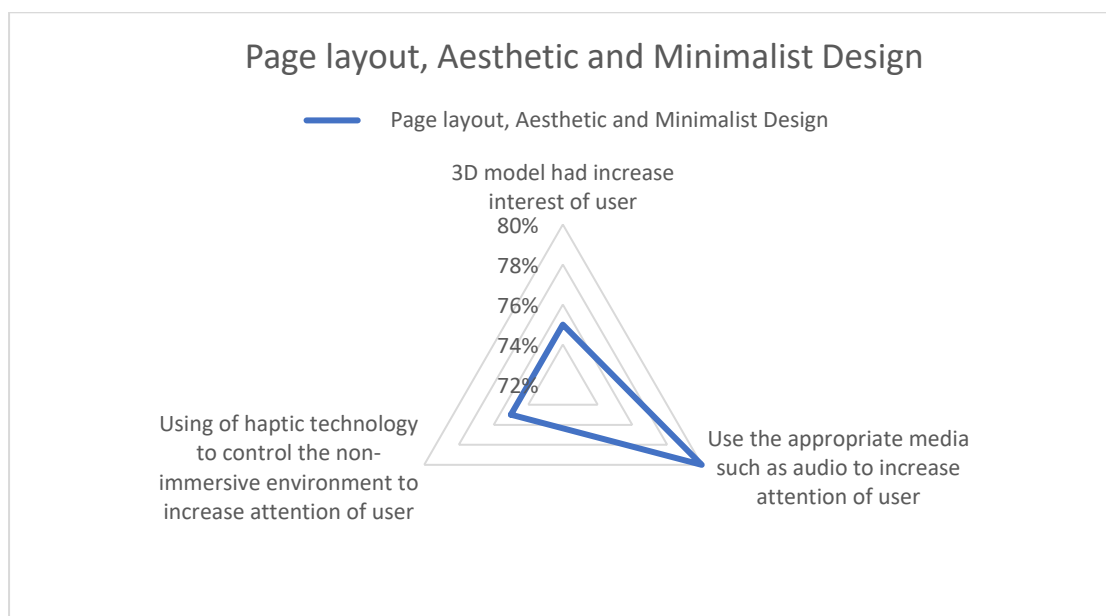
Based on the page layout, aesthetic and minimalist design, 75% respondents said that 3D model had increase interest of guest. The reason is 3D model can move around. There are 80% of respondents suggest that use some appropriate media such as audio to increase attention of guest because soundtrack set the mood and fills the heart of guest. Haptic technology can increase attention of guest because it has more interaction with user.

9) **Help and Online Documentation**
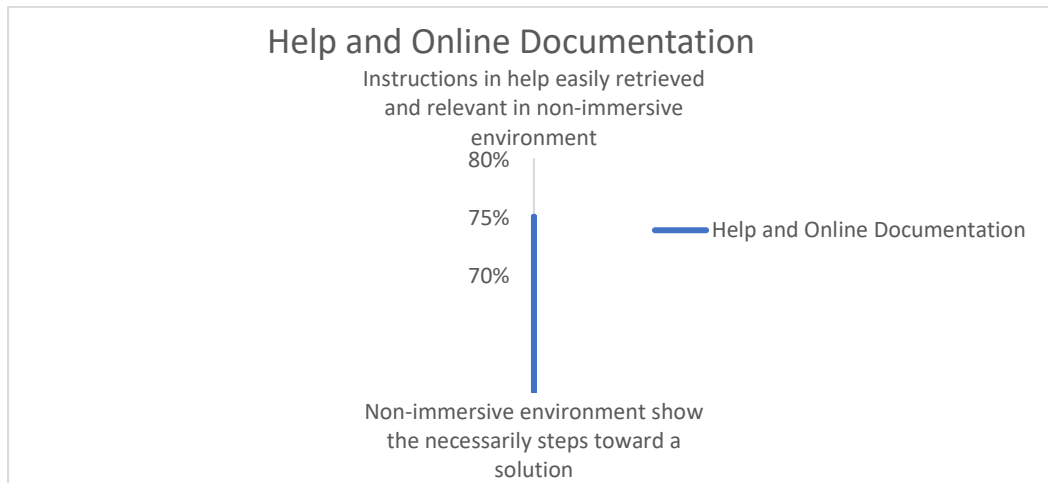
Based on help and online documentation, 75% respondents said that having instruction in help easily retrieved and relevant in non- immersive is importance for user convenient. A necessary step toward a solution need to show for user to give solution when they face problem.

10) **Help User Recognize, Diagnose and recover from Error**
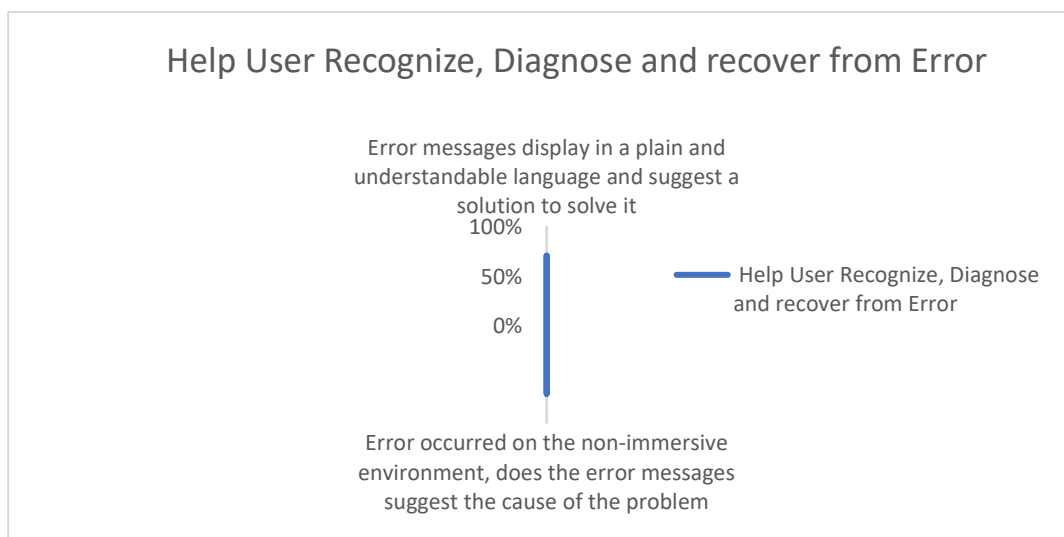
Based on help user recognize, diagnose and recover from error, 70% respondents said that error messages display in a plain and understandable language and suggest a solution.

Expert's perception

This survey's result is from expert's perception. The analysis will be conduct by using radar chart to perform. From this radar chart will to improve the non-immersive environment to approach the expert's requirement and expert's perspective.

1) **Visibility of non-immersive environment status**
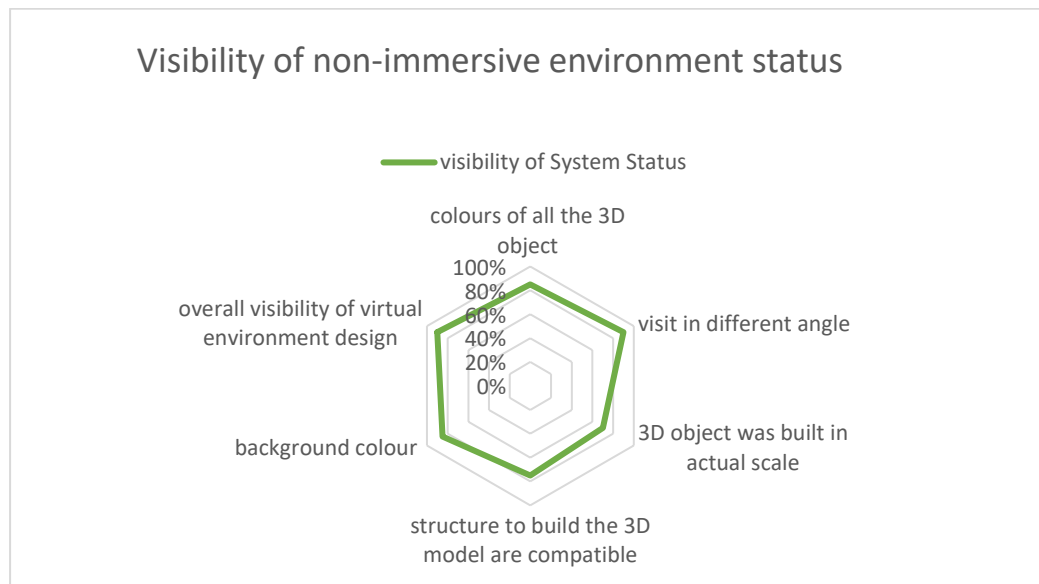
From the visibility of non-immersive environment status, 85% of respondents said that colour of 3D object of the environment is important because every colour will affect the overall view of the interface and the colour choose, and the colour used for the object need reasonable and on the real life. There are 90% of respondents consider that player need to visit in different angle by moving around especially for the 3D environment. 70% of respondents repute that 3D object need to build in actual scale is because object will be look more actual compare with the real object. Besides, there are 75% of respondents said that the structure to build the 3D model need compatible is because objects need to arrange and doing planning before create object in the environment. There are 85% of respondents consider that the background colour importance is because the background colour is act as foil which to improve interaction of the objects in the environment. Furthermore, 90% of respondents repute that the overall visibility of virtual environment design will affect user's attention to play the game again and again. Therefore, overall visibility of the environment is importance for the user which first time play it.

2) **Match between System and Real World**

Match between System and Real World
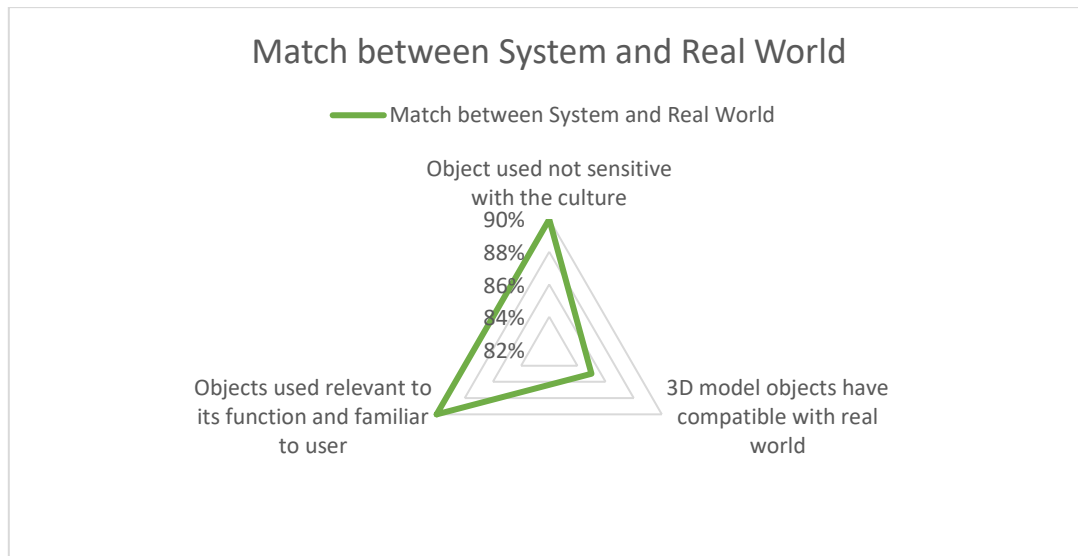
Based on the match between system and real world, there are 90% of respondents consider that object used need to not sensitive with the culture because it may be illegal and break the law in real life. 85% of the respondents said that the 3D objects used in the environment need compatible with real world, such as the shape and structure of the chair and table in school need similar with the real world. Besides, 90% of respondents repute that the function used of the objects need to relevant and familiar to user, such as the relevant function for the character is walking around in the environment.

3) **User Control and Freedom**

User Control and Freedom
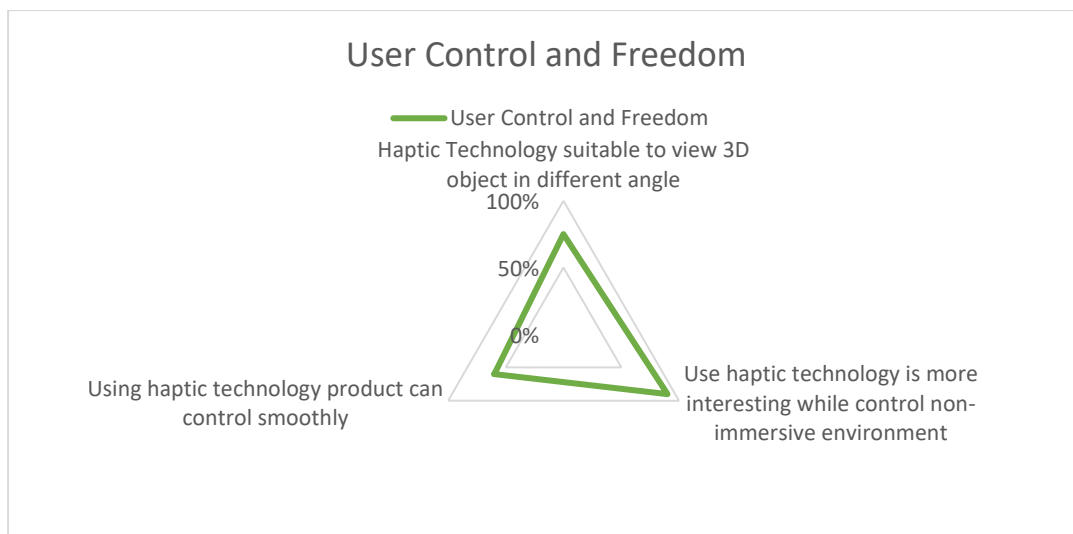
From the user control and freedom, there are 75% of respondents said that haptic technology suitable to view 3D object in different angle because it will become more interesting. Besides, 90% of the respondents consider that use haptic technology is more interesting while control non- immersive environment comparing with using mouse and keyboard because user will fell fresh when using haptic technology. Furthermore, 60% of respondents consider that using haptic technology product can control smoothly. But, 40% of respondents consider that haptic technology product may not control smoothly because it may have connection problem.

4) Consistency and Standard
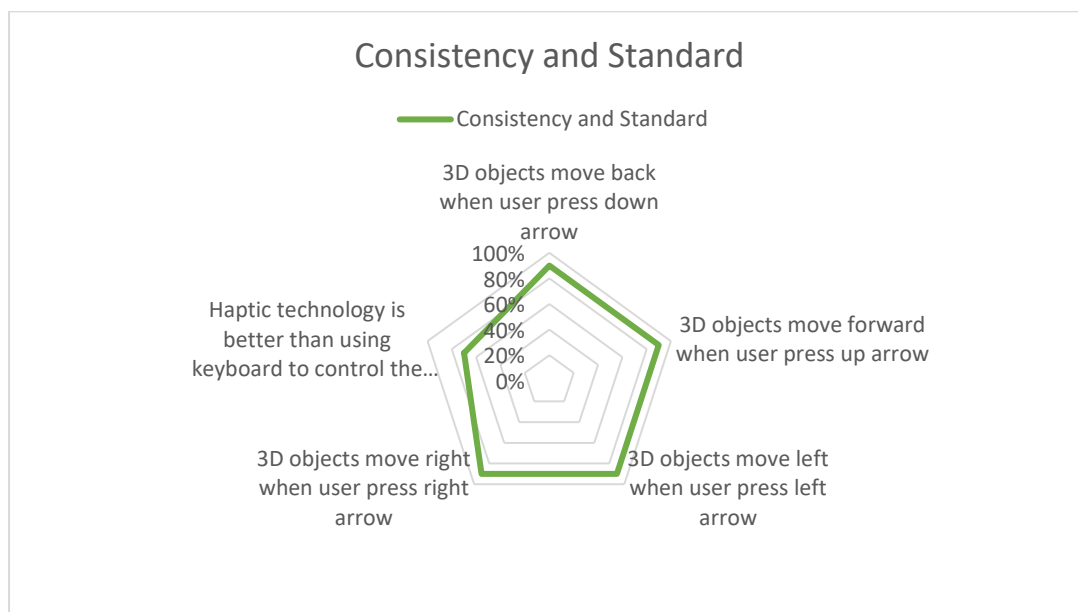
Based on the consistency and standard, there are 90% of respondents consider that the movement of the 3D objects based on the arrow press, such as when user press up arrow, player will move forward. Besides, 70% of respondents consider that haptic technology is better than using keyboard and mouse to control non-immersive environment, because user will increase muscle exercise of the body's area when using haptic technology rather than using keyboard and mouse only exercise for hand and fingers. However, there are 30% of the respondents think that haptic technology maid have connection problem and decrease the smoothness when user using the haptic technology to control.

5) **Error Prevention**
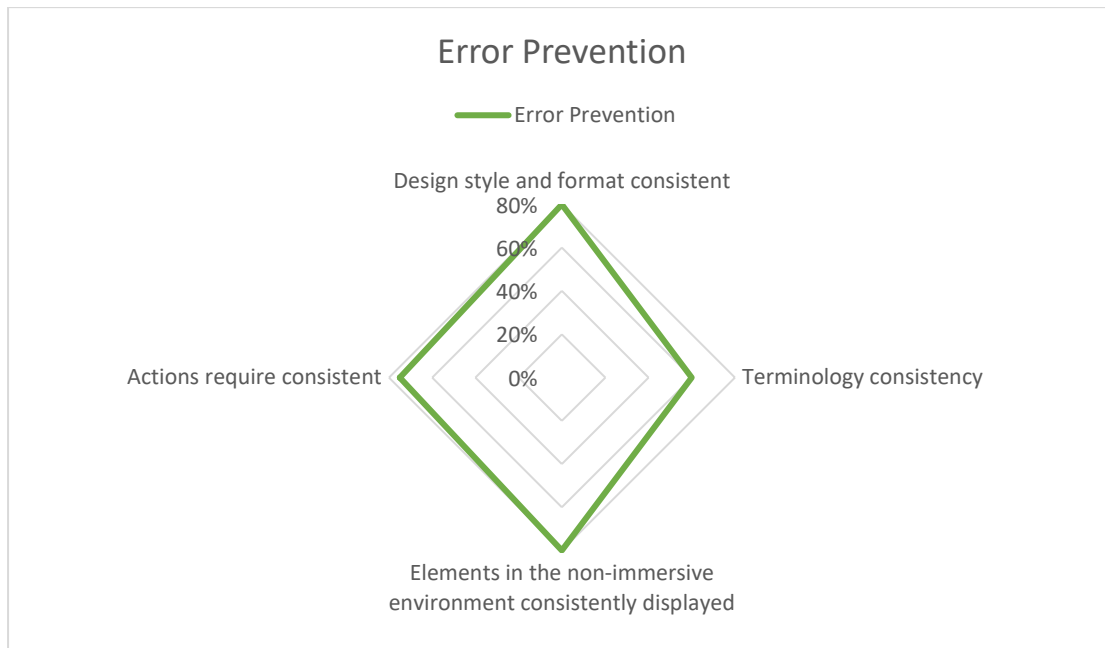
Error Prevention

From the error prevention, 80% of respondents consider that design style and format need consistent in the interface design, because every use have usual practice with it such as the close button place in the top right corner. There are 60% of respondents believe that terminology of the interface need consistency to prevent user avoid by error. Besides, 80% of respondent consider that elements in the non- immersive environment need consistently displayed to prevent the elements running position when running the interface. There are 75% of respondents believe that actions require consistent.

6) **Recognition rather than Recall**

Recognition rather than Recall
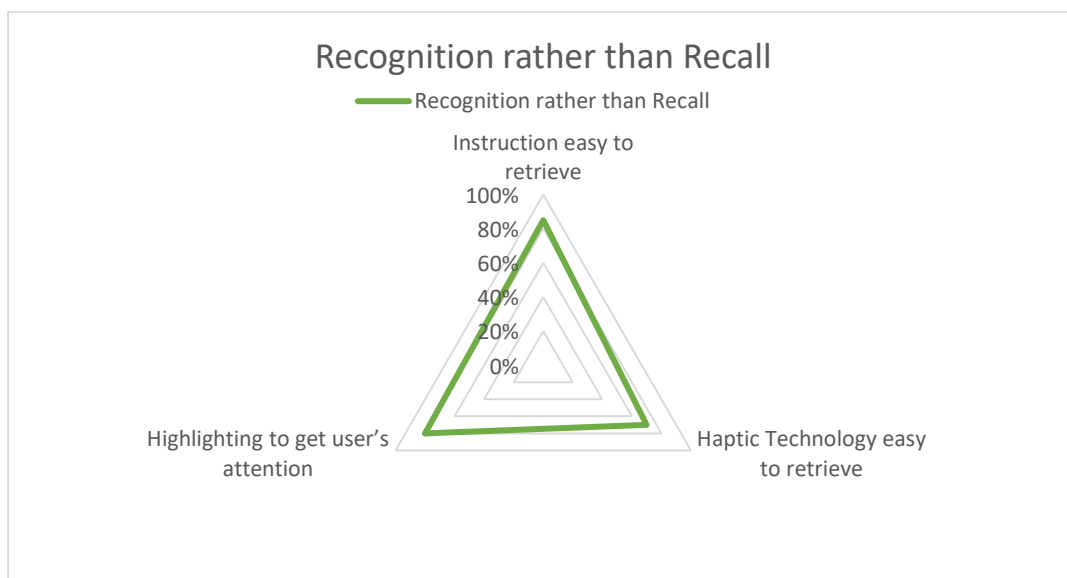
Based on the recognition rather than recall, there are 85% respondents consider that instruction will easy for user to retrieve and prevent misunderstand. Besides, 70% respondent belief that using haptic technology easy for user to retrieve by using some specific gesture such as fist gesture and other to control the environment. Furthermore, there are 80% respondents consider that highlighting will increase the user's attention for the user to know what is the next action need to take.

7) <u>**Flexibility and Efficiency of Use**</u>
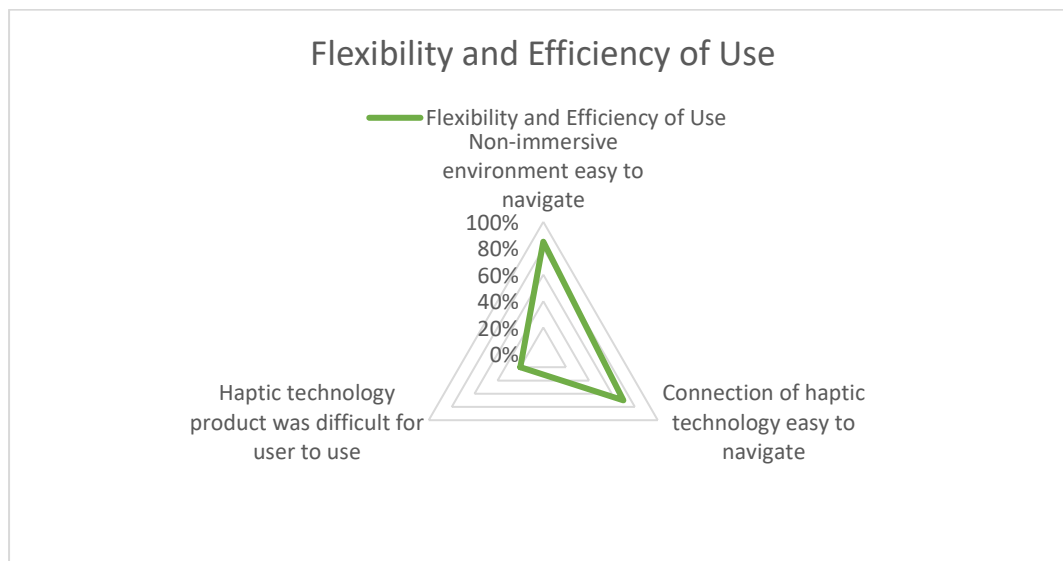
From the flexibility and efficiency of use, there are 85% of respondents consider that environment need for user easy to navigate in different angle and direction such as player can move around and look around in the environment. 70% of respondents agree that connection of haptic technology easy to navigate because it only need USB connection and haptic technology application to connect. Besides, there are 20% of the respondents consider that haptic technology product was difficult for user to use because haptic technology product maid has error occur when connect with some software.

8) Page layout, Aesthetic and Minimalist Design

Page layout, Aesthetic and Minimalist Design
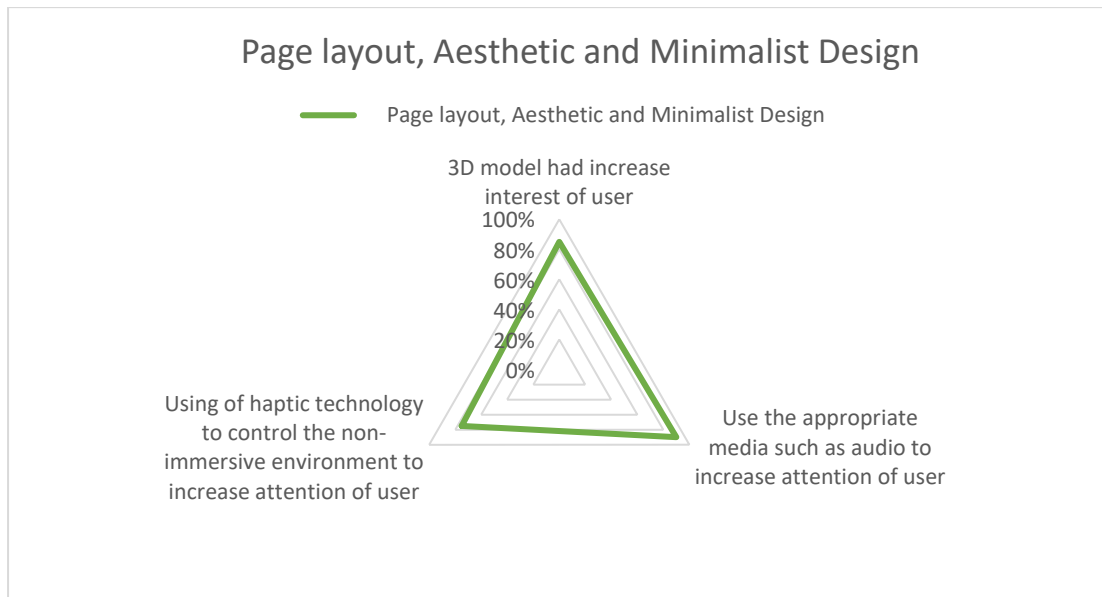
Based on page layout, aesthetic and minimalist design, 85% of respondents consider that 3D model had increase interest of user because user can view 3D model with different position, and it have different appearance or shape in different position such as building in 3D model have windows in the front but in behind does not have windows. 90% of respondents agree that use appropriate media will increase attention of user such as audio. User will increase attention to the interface when user's mood will be happy when listen to audio which is nice and suit for the environment. Besides, there are 75% of respondents agree that using haptic technology to control the non-immersive environment to increase attention of user.

9) Help and Online Documentation

Help and Online Documentation
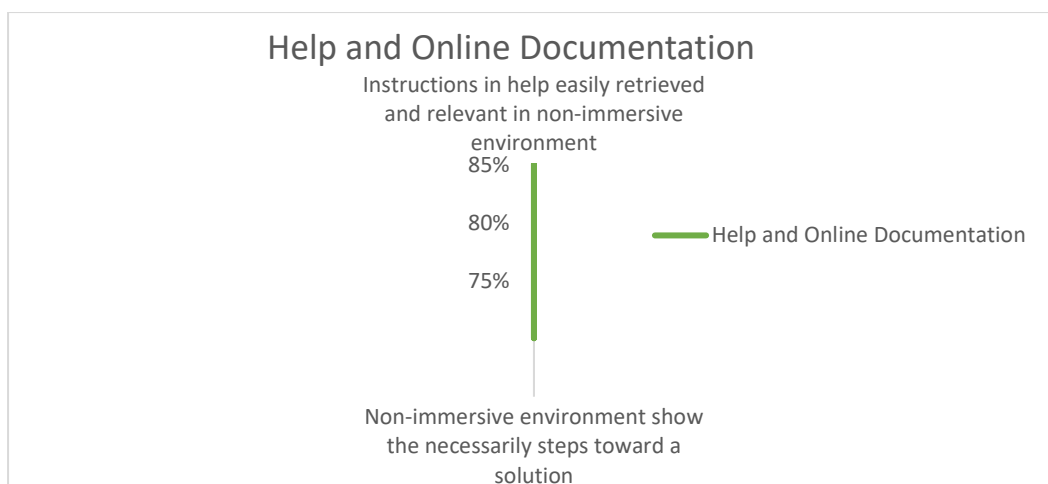
Based on help and online documentation, 85% respondents agree that instruction will help user easily retrieved and relevant in non-immersive because it will increase the easy to use the system. Besides, there are 80% respondent consider that necessary step toward a solution need to provide in the environment for user have reference to know how to solve problem when face some problem.

10) Help User Recognize, Diagnose and recover from Error
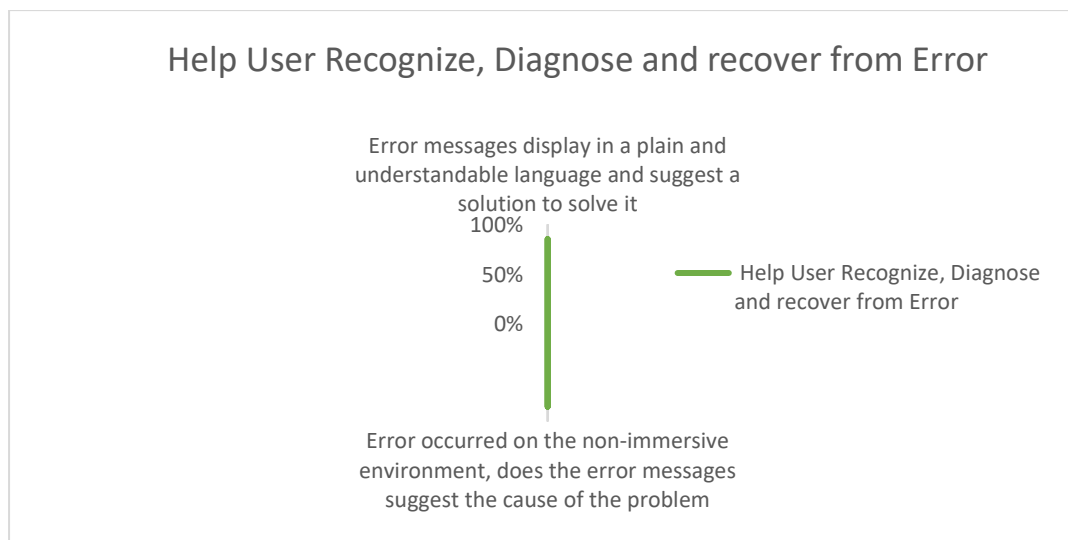
Based on the help user recognize, diagnose and recover from error, 85% respondents agree that error message need to display in a plain and understandable language which include suggested solution to solve the error. Besides, there are 85% respondents agree that error messages need to display the cause of the problem when error occurred.

Chapter 5

Testing and Evaluation

5.1 Method Used for Testing

The method used for the testing is usability testing. It is to identify usability problem and obtaining usability measurement. Usability evaluation is a method which refer to user experience. User will give feedback when interact with the system. The reason using usability testing is because it provides a better user experience and it can identify problem areas within the environment which may not have been obvious.

There are five participants participated in this testing. All the participants are instructed to wear Myo armband to control the environment and get user experience. User doing testing on the main menu, play the game, and quiz to get user experience by using Myo armband. After that, they need to do the usability testing by answering survey question based on heuristic evaluation. Data of the evaluation testing will be collected after user done the answering survey.

After all the data is obtained, a data analysis will be conducted. A table and graph of each principle of heuristic evaluation which include user data with survey question. After that, average percentage of each survey question will be calculated, but also the average percentage of each heuristic evaluation's principle.

5.2 Testing Hypothesis

Before getting the result, there are few hypothesis are to be expected.

1. User interface design which based on heuristic evaluation will be better.
2. The environment's design which based on user's perception and expert's perception will better.
3. All participants will have better sensation when using Myo armband.
4. Interaction environment by using haptic technology will be more interesting compare to using mouse device.

5.3 Result

After following the proposal plan of project, the project can be executed successfully. The game has put many affect and time to meet the expectation. The game can be run without any problem and can be controlled by using Myo armband. The game has also been run several times just to test it and make sure there is no other problem or bugs found and fulfil the surveys of heuristic evaluation.

Iterative model has enabled the process of completing the project become faster. This is because the project will be tested after being planned and designed so the problem can be found out easily and found the solution to fix it or make some changes but did not affect the scope of the game. After the problem has been found, the project will be gone through the same process again until there is no more problem and then finally the result is obtained.

5.3.1 Analysis of evaluation testing

Average of each heuristic evaluation's principle

Evaluation testing will be doing based on the user done interaction with the game, and answer the question whether the game have fulfilled with heuristic evaluation's principle. There are five participants participated in this testing.

0% = Strongly Disagree	25%= Disagree	50% = Nature	75%= Agree	100%=Strongly Agree

1) **Visibility of non-immersive environment status**
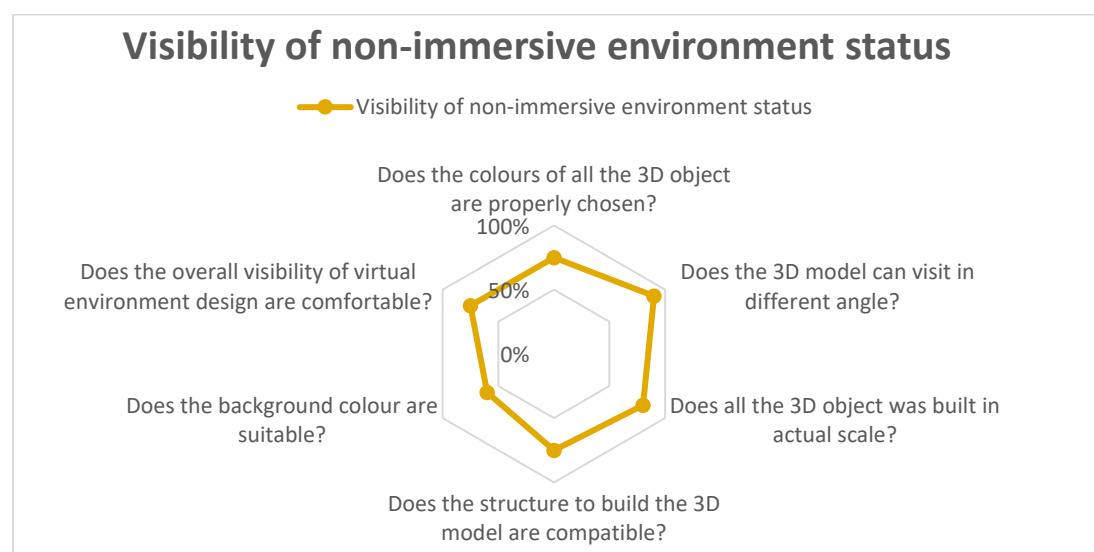
	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Does the colours of all the 3D object are properly chosen?	**100%**	**75%**	**75%**	**75%**	**50%**	**75%**
b) Does the 3D model can visit in different angle?	**100%**	**100%**	**100%**	**75%**	**75%**	**90%**
c) Does all the 3D object was built in actual scale?	**75%**	**75%**	**75%**	**75%**	**100%**	**80%**
d) Does the structure to build the 3D model are compatible?	**75%**	**75%**	**75%**	**75%**	**75%**	**75%**
e) Does the background colour are suitable?	**50%**	**50%**	**75%**	**50%**	**75%**	**60%**
f) Does the overall visibility of virtual environment design are comfortable?	**75%**	**75%**	**75%**	**75%**	**75%**	**75%**

Table 5.3.1 Visibility of non-immersive environment status

Based on the table 5.3.1, the average percentage of the participants which agree that the colour have properly choose for all the 3D objects in the environment is 75%. This number of percentages have achieved with user's perception but slightly below to expert's perception. They consider that the colour used for the 3D object can be more perfect. 90% of the participants approve that player in the environment can visit in different angle and position. They can move the camera of the player to look around and walk to different position. Compared to the user and expert user's perception, the system has performed a good condition for the player able to view in different angle.

Besides, 80% respondent consider that the 3D object which build was actual scale in the environment. The percentage of result have more than the both user's perception around 10%. The result is similar with both user's perception for the 3D modal's structure are compatible. However, there are 60% of the respondent approve that the background colour is suitable. This result is not meet the expectation for both users. So, the background colour needs to make some change to suit with the environment. The overall environment design only has 75% of respondent consider that is consider, and it does not meet the achievement of the both users.

2) Match between System and Real World
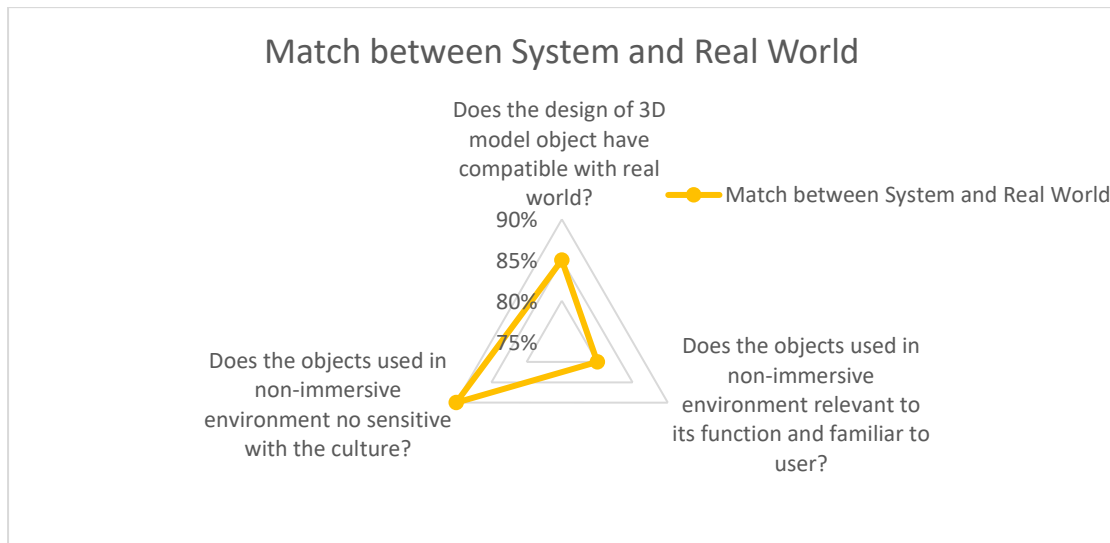
	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Does the design of 3D model object have compatible with real world?	**100%**	**100%**	**75%**	**75%**	**75%**	**85%**
b) Does the objects used in non-immersive environment relevant to its function and familiar to user?	**100%**	**75%**	**75%**	**75%**	**75%**	**80%**
c) Does the objects used in non-immersive environment no sensitive with the culture?	**100%**	**100%**	**75%**	**75%**	**100%**	**90%**

Table 5.3.2 Match between System and Real World

Based on the observation to table 5.3.2, there are 85% respondents approve that the 3D model object has compatible with real world. 80% of the agree that the object used have relevant to its function and familiar to user in the non- immersive environment. The result illustrates that no objects in the system are sensitive with the culture which have 90% of respondents agree with that. The result of the match between system and real world are in the expectation between user's perception and expert's perception.

3) User Control and Freedom

	User					
	1st	2nd	3th	4th	5th	Average
a) Does using haptic technology suitable to view 3D object in different angle?	75%	75%	75%	75%	75%	75%
b) Does the non-immersive environment which can be transformed on particular action when user perform specific gesture while use haptic technology is more interesting?	75%	75%	75%	75%	75%	75%
c) Does using haptic technology product can control smoothly?	100%	75%	75%	75%	75%	80%

Table 5.3.3 User Control and Freedom

From the table 5.3.3, 75% of the respondents approve that haptic technology suitable to view 3D object in different angle. There are 75% agree that using haptic technology is more interesting after they transformed on particular action when perform specific gesture. Besides, there are 80% respondents approve that haptic technology can control smoothly. Therefore, only using haptic technology is more interesting is not meet the expectation of both users' perception.

4) Consistency and Standard
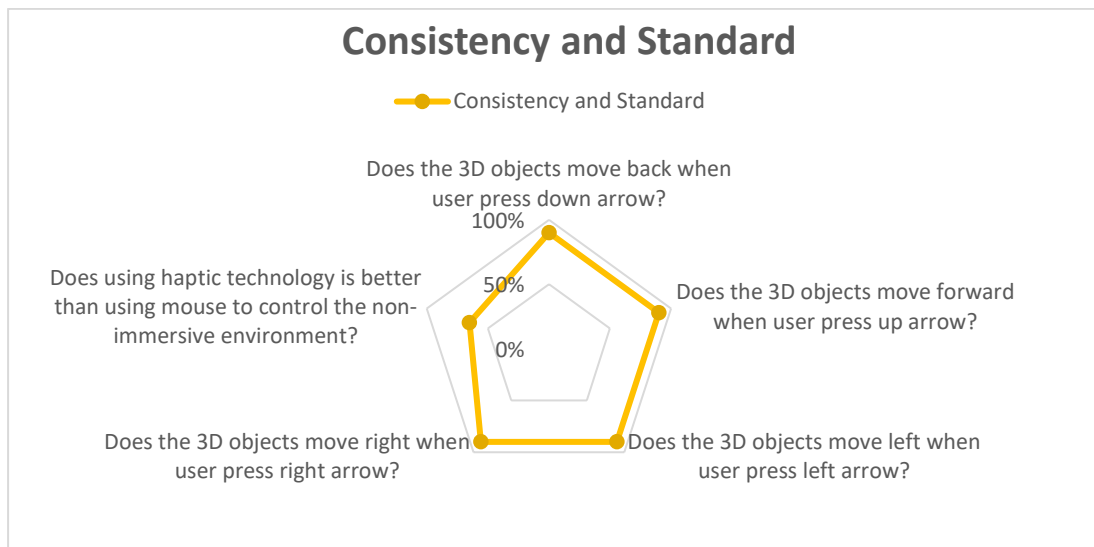
	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Does the 3D objects move back when user press down arrow?	**100%**	**75%**	**100%**	**100%**	**75%**	**90%**
b) Does the 3D objects move forward when user press up arrow?	**100%**	**75%**	**100%**	**100%**	**75%**	**90%**
c) Does the 3D objects move left when user press left arrow?	**100%**	**75%**	**100%**	**100%**	**75%**	**90%**
d) Does the 3D objects move right when user press right arrow?	**100%**	**75%**	**100%**	**100%**	**75%**	**90%**
e) Does using haptic technology is better than using mouse to control the non-immersive environment?	**75%**	**50%**	**75%**	**75%**	**50%**	**65%**

Table 5.3.4 Consistency and Standard

Based on the table 5.3.4, 90% of respondents approve that the player can move different position when user press the arrow button keyboard. Besides, player in environment illustrate smoothly when user press arrow button, and player will move to specific location when user press specific arrow button. However. There are 65% of respondents agree that haptic technology is better than using mouse to control the non- immersive environment. Therefore, the result for the control environment by using haptic technology is better compare mouse is lower than both user's perception. They consider that haptic technology needs to detect the gesture and take some second for the confirmation to control environment than mouse.

5) Error Prevention
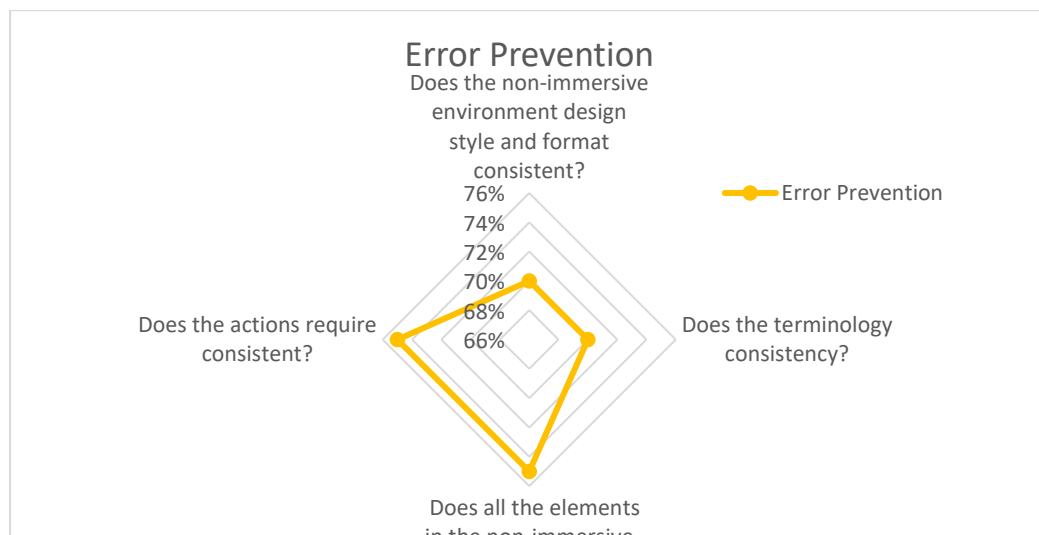
	User					
	1st	2nd	3th	4th	5th	Average
a) Does the non-immersive environment design style and format consistent?	75%	75%	75%	50%	75%	70%
b) Does the terminology consistency?	75%	75%	50%	75%	75%	70%
c) Does all the elements in the non-immersive environment consistently displayed?	75%	75%	75%	75%	75%	75%
d) Does the actions require consistent?	75%	75%	75%	75%	75%	75%

Table 5.3.5 Error Prevention

Based on the table 5.3.5, 70% of respondents approve that style and format of environment design is consistent. There are 70% respondents agree that the system have consistency terminology after testing. 75% of respondents consider that the element in the environment consistently displayed, and the action require consistent. Compare with the both users' perception, the result is almost similar.

6) Recognition rather than Recall
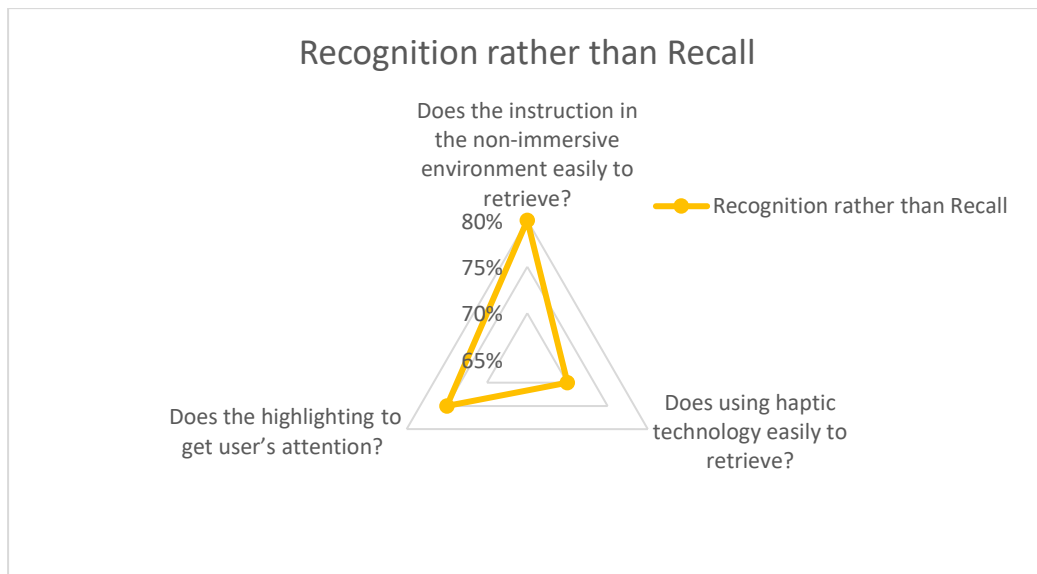
	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Does the instruction in the non-immersive environment easily to retrieve?	**75%**	**100%**	**75%**	**75%**	**75%**	**80%**
b) Does using haptic technology easily to retrieve?	**75%**	**75%**	**50%**	**75%**	**75%**	**70%**
c) Does the highlighting to get user's attention?	**75%**	**75%**	**75%**	**75%**	**75%**	**75%**

Table 5.3.6 Recognition Rather than Recall

Form the table 5.3.6, 80% of respondents approve that the instruction creates in the environment easily to retrieve. There are 70% of respondents agree that haptics technology easily to retrieve in the environment. Besides, 75% of respondents consider that highlighting in the system can get user's attention easily. Therefore, the result of each in the recognition rather than recall are in the expectation with both user's perception.

7) **Flexibility and Efficiency of Use**
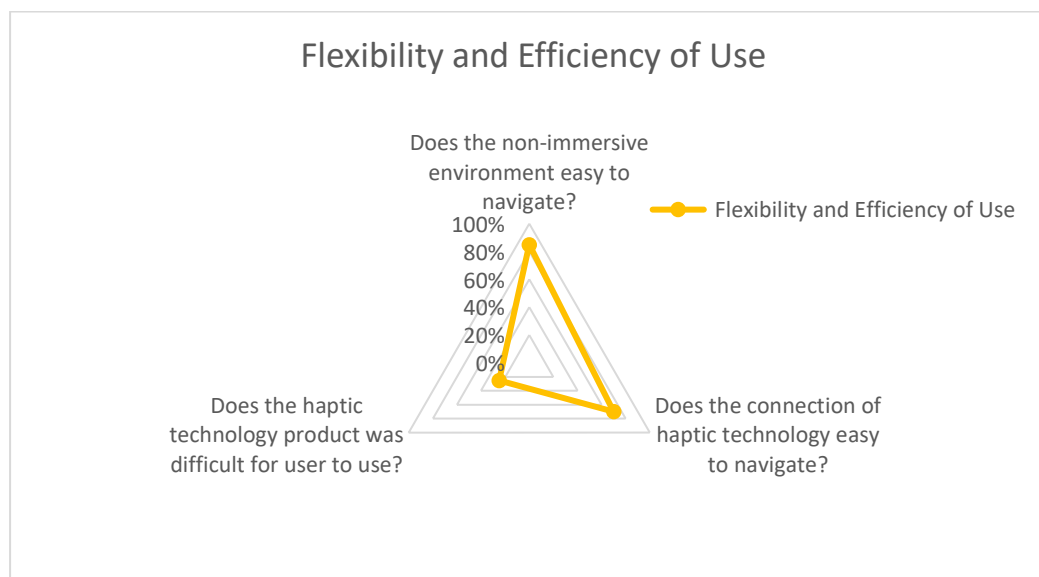
	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Does the non-immersive environment easy to navigate?	**75%**	**100%**	**100%**	**75%**	**75%**	**85%**
b) Does the connection of haptic technology easy to navigate?	**75%**	**75%**	**50%**	**75%**	**75%**	**70%**
c) Does the haptic technology product was difficult for user to use?	**25%**	**25%**	**25%**	**25%**	**25%**	**25%**

Table 5.3.7 Flexibility and Efficiency of Use

Based on the table 5.3.7, there are 85% of respondents approve that the environment is easy to navigate after doing testing. Besides, 70% respondents agree that the connection of haptic technology easy to navigate in the environment. Furthermore, 25% respondents consider that haptic technology product was difficult for user to use. However, the result has increase 5% compare to both users' perception is because not each of the user familiar with haptic technology.

8) Page layout, Aesthetic and Minimalist Design
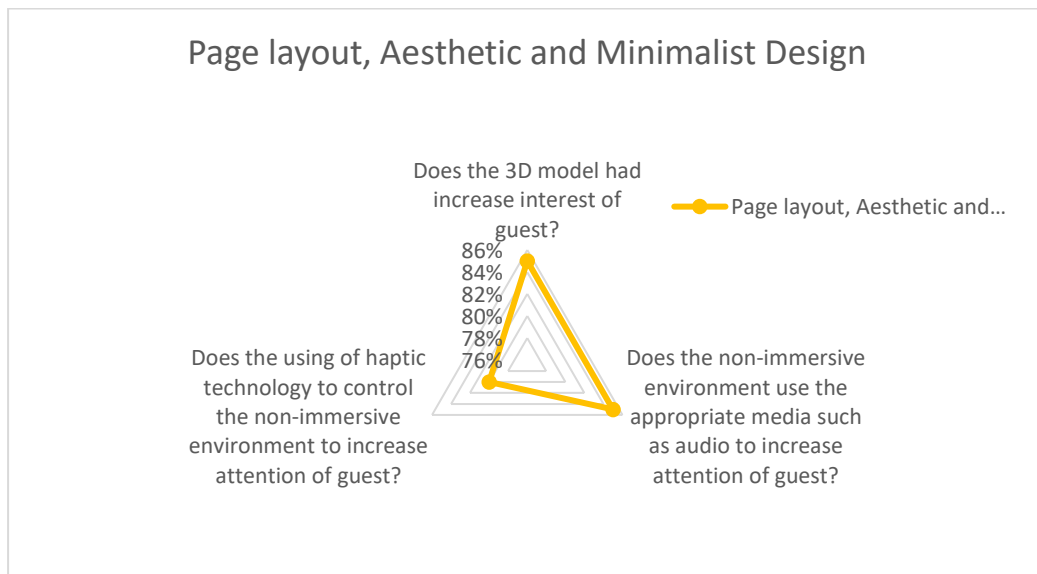
	User					
	1st	2nd	3th	4th	5th	Average
a) Does the 3D model had increase interest of guest?	75%	100%	100%	75%	75%	85%
b) Does the non-immersive environment use the appropriate media such as audio to increase attention of guest?	75%	75%	100%	75%	100%	85%
c) Does the using of haptic technology to control the non-immersive environment to increase attention of guest?	75%	75%	100%	75%	75%	80%

Table 5.3.8 Page layout, Aesthetic and Minimalist Design

Based on the table 5.3.8, 85% respondents approve that 3D model had increase interest of user. They also agree that media in the environment such as audio will increase the attention of the user. Besides, there are 80% of respondents said that using haptic technology to control environment will increase attention of user. The result has increase 5% compare to both users' perception is because not each of the user have chance interact with haptic technology.

9) Help and Online Documentation

	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Does the instructions in help easily retrieved and relevant in non-immersive environment?	**75%**	**50%**	**75%**	**75%**	**75%**	**70%**
b) Does the non-immersive environment show the necessarily steps toward a solution?	**75%**	**50%**	**75%**	**75%**	**100%**	**75%**

Table 5.3.9 Help and Online Documentation

Based on the table 5.3.9, 70% respondents agree that instructions in help easily retrieved and relevant in non-immersive environment. There are 75% respondents approve that necessarily steps toward a solution have show in the environment. However, the result of help and online documentation does not meet the expectation when comparing with both user's perception.

10) Help User Recognize, Diagnose and recover from Error
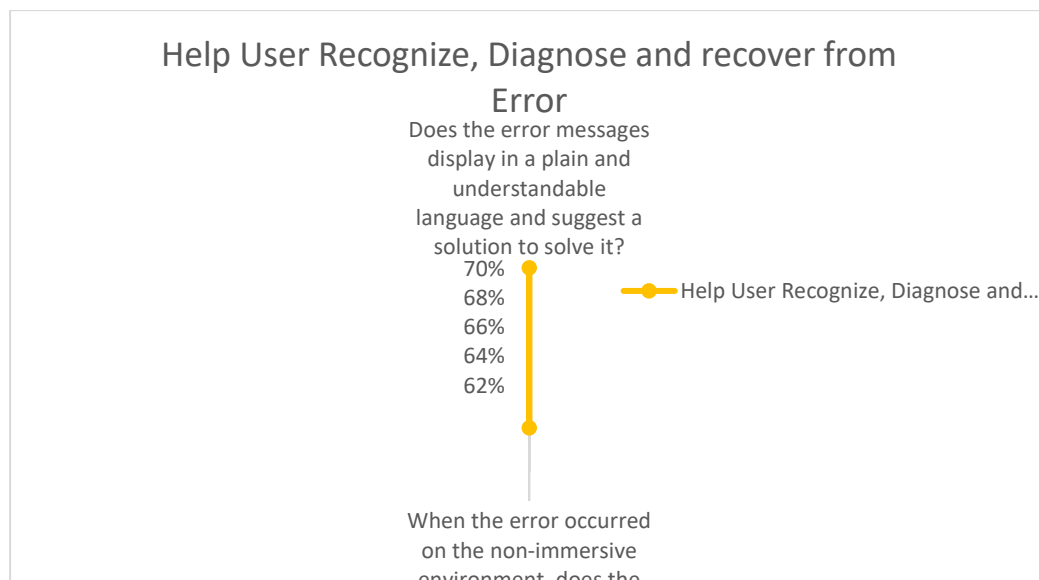
	User					
	1st	**2nd**	**3th**	**4th**	**5th**	**Average**
a) Do the error messages display in a plain and understandable language and suggest a solution to solve it?	75%	50%	75%	75%	75%	70%
b) When the error occurred on the non-immersive environment, does the error messages suggest the cause of the problem?	75%	50%	75%	75%	50%	65%

Table 5.3.10 Help User Recognize, Diagnose and recover from Error

From the table 5.3.10, there are 70% of respondents approve that error messages display in a plain and understandable language and suggest a solution to solve it. 65% of respondents agree that error messages suggest the cause of the problem when error occurred. However, the result of help User Recognize, Diagnose and recover from Error does not meet the expectation when comparing with both user's perception.

Overall average percentage of heuristic evaluation

The overall average percentage of heuristic evaluation is the final result of whole system with the heuristic evaluation. The formula used for the overall average percentage is using the total number percentage of each question divide by number of questions. A graph and table will be conducted. The x- axis of the graph is the principle of heuristic evaluation, and y- axis is the number of percentages.
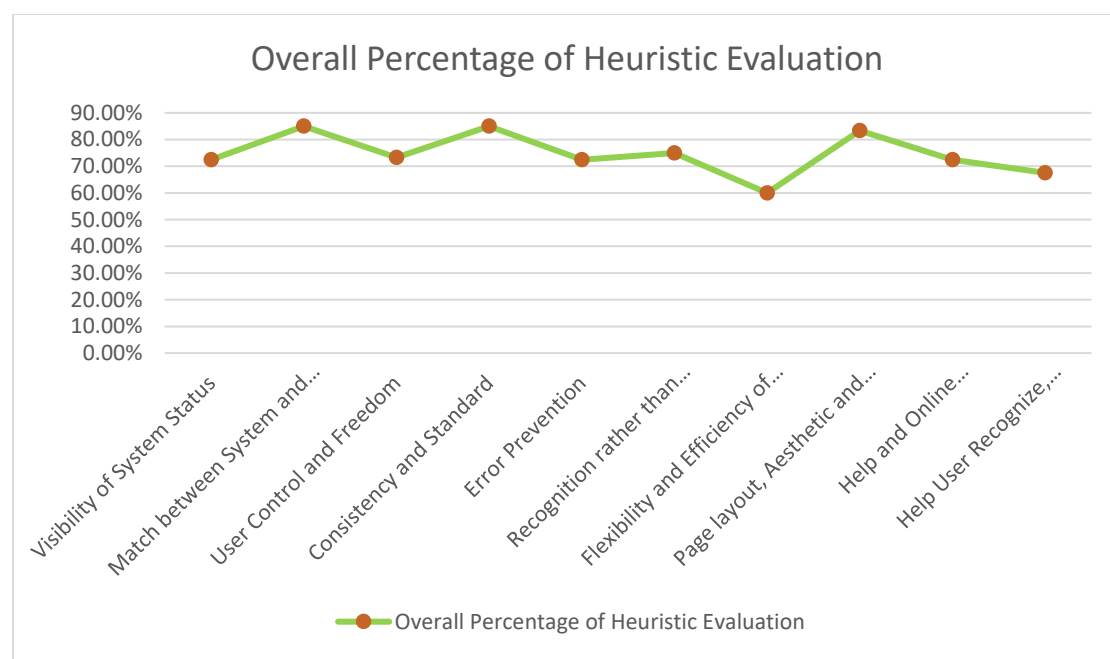
Heuristic Evaluation's principle	Overall Percentage
Visibility of System Status	72.5%
Match between System and Real World	85%
User Control and Freedom	73.3%
Consistency and Standard	85%
Error Prevention	72.5%

Recognition rather than Recall	75%
Flexibility and Efficiency of Use	60%
Page layout, Aesthetic and Minimalist Design	83.3%
Help and Online Documentation	72.5%
Help User Recognize, Diagnose and recover from Error	67.5%

Table 5.3.11 Overall average percentage of heuristic evaluation

Based on the 5.3.11, the overall result of the non-immersive environment is better. The percentage of some principle in heuristic evaluation emerge that lower than other principle. It has a difficulty to get all the principle perform in system or environment with 100%. Therefore, the design of user interface has improved by using heuristic evaluation.

1. For the first hypothesis, there are more than 60% of participants in the graph overall average percentage of heuristic evaluation have shown that the design of user interface will improved when designing based on heuristic evaluation. Therefore, the first hypothesis is true.

2. From the analysis in the usability testing, the environment's design which based on user's perception and expert's perception will be better but difficult to fulfil expectation of each of the user. This is because every user has different perception in the design of environment.

3. The vibration from Myo armband and control the things in non- immersive environment just by using hands, participants felt interested with haptic technology. The reason they can detect the vibration is because the absolute threshold of sensation is over 50%. Thus, third hypothesis is true.

4. When the participants know that they need to do testing using Myo armband, they are felt surprised with it. Besides, the vibration from the Myo armband and interaction with non- immersive environment increase the interest of them. Therefore, the last hypothesis is also true.

Chapter 6
Conclusion

   As a conclusion, heuristic evaluation is a method to evaluate VUI interface but also in non- immersive environment which effective and efficiency. The principle of heuristic evaluation needs to follow when doing evaluation. The problem when design the non- immersive environment is that it has a difficulty to fulfil every user's requirement in hundred percent. The reason is every user have their own "art sense" and different perspective on one thing. Therefore, there are not have perfect design for every user.

   To understand the requirements and perspective of users, a survey will be conducted by six experts. From the expert's recommendation and survey data, the requirement of normal user perspective is more clearly. It helps the design of non- immersive environment will be improve and more closet to requirement. After the prototype of the project are complete, another survey will be conduct for normal user to test the result whether fulfil user's perspective.

   In this project, it not only focuses on non- immersive environment design but also haptic technology. Haptic technology will grow rapidly in future market when it done develop. It will replace mouse and keyboard to control non- immersive environment in future because it can control faster than keyboard and mouse. By using haptic technology, the training workshop in different field will be very interesting such as medical, military and education field.

  Besides, the 3D non-immersive environment will improve continuously until closet to user's requirements. The non- immersive environment will connect with haptic technology to increase the interesting of user and to probe the capability of haptic technology. From the result, design of user interface will improve when designing based on heuristic evaluation.

   Moreover, the Myo armband is using the EMG data to read and response to the user gesture while user is wearing the Myo armband. Basically, EMG is the electrical activity produced by the skeletal muscles and Myo armband is made up of eight pods of rectangular shape that circle around, each pod contains one electromyography sensor so Myo armband can get the user EMG data. User will know the Myo armband is working normally when it generates vibration.

At last, heuristic evaluation is a powerful way for developer to evaluate in a short time. Developer can design their own non-immersive environment based on experience when they have done many works and done some survey. Besides, non-immersive environment and haptic technology was a project for people deserve to do some research.

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Appendices

Questionnaire

1 = Strongly 2 = Disagree   3 = Nature   4= Agree   5= Strongly
Disagree   Agree

1) Visibility of non-immersive environment status

	1	2	3	4	5
c) Does the colours of all the 3D object are properly chosen?					
d) Does the 3D model can visit in different angle?					
e) Does all the 3D object was built in actual scale?					
f) Does the structure to build the 3D model are compatible?					
g) Does the background colour are suitable?					
h) Does the overall visibility of virtual environment design are comfortable?					

2) Match between System and Real World

	1	2	3	4	5
a) Does the design of 3D model object have compatible with real world?					
b) Does the objects used in non-immersive environment relevant to its function and familiar to user?					
c) Does the objects used in non-immersive environment no sensitive with the culture?					

3) User Control and Freedom

	1	2	3	4	5
a) Does using haptic technology suitable to view 3D object in different angle?					
b) Does the non-immersive environment which can be transformed on particular action when user perform specific gesture while use haptic technology is more interesting?					
c) Does using haptic technology product can control smoothly?					

4) Consistency and Standard

	1	2	3	4	5
a) Does the 3D objects move back when user press down arrow?					
b) Does the 3D objects move forward when user press up arrow?					
c) Does the 3D objects move left when user press left arrow?					
d) Does the 3D objects move right when user press right arrow?					
e) Does using haptic technology is better than using keyboard to control the non-immersive environment?					

5) Error Prevention

	1	2	3	4	5
a) Does the non-immersive environment design style and format consistent?					
b) Does the terminology consistency?					
c) Does all the elements in the non-immersive environment consistently displayed?					
d) Does the actions require consistent?					

6) Recognition rather than Recall

	1	2	3	4	5
a) Does the instruction in the non-immersive environment easily to retrieve?					
b) Does using haptic technology easily to retrieve?					
c) Does the highlighting to get user's attention?					

7) Flexibility and Efficiency of Use

	1	2	3	4	5
i) Does the non-immersive environment easy to navigate?					
j) Does the connection of haptic technology easy to navigate?					
k) Does the haptic technology product was difficult for user to use?					

8) Page layout, Aesthetic and Minimalist Design

	1	2	3	4	5
a) Does the 3D model had increase interest of user?					
b) Does the non-immersive environment use the appropriate media such as audio to increase attention of user?					
c) Does the using of haptic technology to control the non-immersive environment to increase attention of user?					

9) Help and Online Documentation

	1	2	3	4	5
a) Does the instructions in help easily retrieved and relevant in non-immersive environment?					
b) Does the non-immersive environment show the necessarily steps toward a solution?					

10) Help User Recognize, Diagnose and recover from Error

	1	2	3	4	5
a) Does the error messages display in a plain and understandable language and suggest a solution to solve it?					
b) When the error occurred on the non-immersive environment, does the error messages suggest the cause of the problem?					

VIRTUAL BASED USER INTERFACE OF HAPTIC TECHNOLOGY

INTRODUCTION

Heuristic evaluation provided a series of usability principle for the programmer to exam and judge the VUI in the first-rate guarantee for user to use. Haptic technology was a tactile feedback technology to control and interaction with computer application by applying touch sensation.

OBJECTIVE

I)   To study the aspects of the heuristic evaluation in terms of non-immersive environment user interface.

II)   To design the user interface of haptic technology based on heuristic evaluation.

III) To develop a user interface to understand the haptic technology in non-immersive environment.

IV)   To examine the proposed non-immersive environment with haptic technology based on the heuristic evaluation.
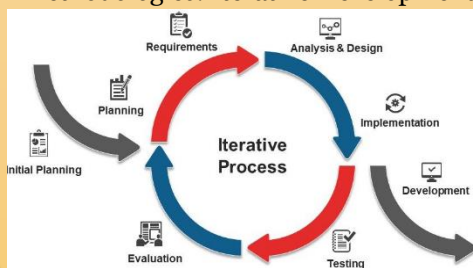
STUDENT:

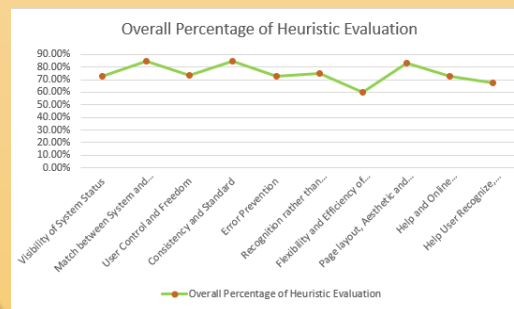TEOH XIAO PEI

SUPERVISOR:

MR. KESAVAN A/L KRISHNAN

METHODOLOGIES

Methodologies: Iterative Development

RESULT

Overall Percentage of Heuristic Evaluation

CONCLUSION

The principle of heuristic evaluation needs to follow when doing evaluation. The problem when design the non- immersive environment is that it has a difficulty to fulfil every user's requirement in hundred percent. By using haptic technology, the training workshop in different field will be very interesting

FYP2

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  Signature of Supervisor   Signature of Co-Supervisor

  Name: Kesavan a/l Krishnan   Name:_____

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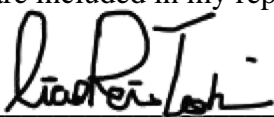# UNIVERSITI TUNKU ABDUL RAHMAN
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