Interactive Augmented Reality Aided Learning Application for Physics Education

By

See Wen Kai

A REPORT

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONOURS)

Faculty of Information and Communication Technology
(Kampar Campus)

JAN 2022

UNIVERSITI TUNKU ABDUL RAHMAN

REPORT STATUS DECLARATION FORM

Title: Interactive Augmented Reality Aided Learning Application for Physics Education

Academic Session: JAN2022

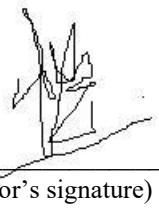
I SEE WEN KAI

(CAPITAL LETTER)

declare that I allow this Final Year Project Report to be kept in

Universiti Tunku Abdul Rahman Library subject to the regulations as follows:

1. The dissertation is a property of the Library.
2. The Library is allowed to make copies of this dissertation for academic purposes.



(Author's signature)

Verified by,

Lee Chen Kang

(Supervisor's signature)

Address:

35, Jalan Makmur 34, Taman

Damai Jaya, Skudai, 81300,

Johor, Malaysia.

Ts Dr Lee Chen Kang

Supervisor's name

Date: 22nd April 2022

Date: 22/4/2022

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

UNIVERSITI TUNKU ABDUL RAHMAN

Date: 22nd April 2022

SUBMISSION OF FINAL YEAR PROJECT

It is hereby certified that ***See Wen Kai*** (ID No: ***18ACB04713***) has completed this final year project entitled "Interactive Augmented Reality Aided Learning Application for Physics Education" under the supervision of Ts. Dr. Lee Chen Kang (Supervisor) from the Department of Information Systems, Faculty/Institute* of _____ , and _____ (Co-Supervisor)* from the Department of _____, Faculty of Information and Communication Technology.

I understand that University will upload softcopy of my final year project in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

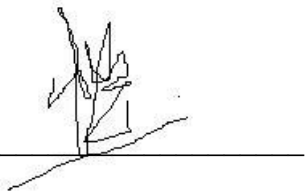
Yours truly,

_____

See Wen Kai

DECLARATION OF ORIGINALITY

I declare that this report entitled "**Interactive Augmented Reality Aided Learning Application for Physics Education**" is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature : 

Name : See Wen Kai

Date : 22/4/2022

ACKNOWLEDGEMENTS

I would like to express my sincere thanks and appreciation to my supervisors, Ts. Dr. Lee Chen Kang who has given me this bright opportunity to engage in an AR development project. It is my first time to explore in AR field and learn a lot in development of an application. A million thanks to you.

To a very good friend in my life, Tan Jie Nan, for his patience, unconditional support, and love, and for standing by my side during hard times. Finally, I must say thanks to my parents and my family for their love, support, and continuous encouragement throughout the course.

ABSTRACT

In the era full of information technology, Augmented realities (AR) become quite important technology that use in education similarity physics studies also adopt AR in to their learning. In Physics learning, majority of the students faced some difficulties in visualizing the Physics concept. The learning application for physics learning are not so popular, and most of the learning application available did not follow professional interface design. Furthermore, Lack of Augmented reality aided components found in physics learning application. Based on the problem statements stated, this project would like to study the usage of augmented reality technologies in aided the Physics learning by develops an AR based learning software for Physics education and evaluate the effectiveness the AR based software can support the learning of Physics ideas and theories. The learning application can improve student's Physics subject study performance. Students are welcome AR technology and agree with the statement given AR element applied in the learning application can enhance the visualization. The main target user for this project will be the Form 4 Science Stream student currently taking Physics subject. The methodology uses to develop the system will the ADDIE model. There will be total 5 modules will be developed which are lecture module, tutorial module, quiz module , experiment module and AR module. The three main development platform are Vuforia, Unity, Android Studio. Contribution and significance for this project will focus on learning application, good interface design and AR in education.

TABLE OF CONTENTS

TITLE PAGE **i**
REPORT STATUS DECLARATION FORM **ii**
FYP THESIS SUBMISSION FORM **iii**
DECLARATION OF ORIGINALITY **iv**
ACKNOWLEDGEMENTS **v**
ABSTRACT **vi**
TABLE OF CONTENTS **vii**
LIST OF FIGURES **x**
LIST OF TABLES **vi**

CHAPTER 1 INTRODUCTION **1**
1.1 Introduction 1
1.2 Background 2
1.3 Problem Statement 3
1.4 Objectives 4
1.5 Scope 5
1.5.1 Lecture module 5
1.5.2 Tutorial module 5
1.5.3 Experiment module 6
1.5.4 AR learning module 6
1.5.5 Quiz module 6
1.6 Contribution and Significance 7
1.7 Target Audience 8

CHAPTER 2 LITERATURE REVIEW **9**

2.1 AR definition 9

2.2 AR Issues 9

2.2.1 Benefits 9

2.2.2 Limitations 9

2.3 Applications of AR 10

2.4 Usage of AR in Physics 10

2.5 Comparisons of similar AR applications 11

2.5.1 Physics Lab 11

2.5.2 PhET Simulations 14

2.5.3 Physics Studio 17

2.5.4 Physics App 20

2.5.5 The Physics Machine: Physics Classroom and Tools 22

2.6 Summary of the Similar Applications (Comparison Tables) 24

2.7 Resolved Solution 25

2.8 User-centred Design 25

2.9 Users Requirements Gathering 26

2.9.1 Survey Questionnaire 26

2.9.2 Data collection and analysis 27

2.9.3 Discussions 50

CHAPTER 3 METHODOLOGY AND SYSTEM DESIGN **51**

3.1 Overview 51

3.2 System Requirements 51

3.2.1 Software Requirements 51

3.2.2 Hardware Requirements 52

3.3 ADDIE model 53

3.3.1 Analysis 53

3.3.2 Design 54

3.3.3 Development 54

3.3.4 Implementation 55

3.3.5 Evaluation 55

3.4 System Flow Diagram 56
3.5 Storyboarding Design 57
3.6 Project Planning 67
3.6.1 Project 1 67
3.6.2 Project 2 67

CHAPTER 4 DEVELOPMENT 68

4.1 Overview 68

4.2 Development Process 68
4.2.1 Pre-authoring Process 68
4.2.1.1 Process of Creating and Editing Text 68
4.2.1.2 Process of Creating and Editing Graphics 71
4.2.1.3 Process of Creating and Editing Animations 73
4.2.1.4 Process of Editing Audio 74
4.2.1.5 Process of Editing Video 76

4.2.2 Authoring Process 79
4.2.2.1 Splash screen design 79
4.2.2.2 Main Menu Module 82
4.2.2.3 Quiz Module 84
4.2.2.4 Tutorial Module 85
4.2.2.5 AR Module 89

4.2.3 Post-authoring Process 93

CHAPTER 5 TESTING, RESULTS & DISCUSSIONS 94

5.1 Overview 94
5.2 Method of Testing 94
5.3 Testing Analysis 95
5.4 Results and Discussion 117

CHAPTER 6 CONCLUSION 118

6.1 Overview 118
6.2 Research Findings 118
6.3 Problems Faced 119
6.4 Knowledge Gained 120
6.5 Limitations 121
6.6 Future Enhancement 122

REFERENCES 123

APPENDICES

A.1 Questionnaire Survey Design 127
A.2 System Testing Questionnaire 134

POSTER 137

WEEKLY LOG 138

PLAGIARISM CHECK RESULT 150

FYP 2 CHECKLIST 152

LIST OF FIGURES

Figure Number	Title	Page
Figure 1.1	Project scope with 5 modules	5
Figure 2.1	Screenshot of the Physics Lab	11
Figure 2.2	Screenshot of the Physics Lab	11
Figure 2.3	Screenshot of the Physics Lab	12
Figure 2.4	Screenshot of the Physics Lab	12
Figure 2.5	Screenshot of the Physics Lab	13
Figure 2.6	Screenshot of the Physics Lab	13
Figure 2.7	Screenshot of the PhET Simulation	14
Figure 2.8	Screenshot of the PhET Simulation	15
Figure 2.9	Screenshot of the PhET Simulation	16
Figure 2.10	Screenshot of the PhET Simulation	16
Figure 2.11	Screenshot of the PhET Simulation	16
Figure 2.12	Screenshot of the Physics Studio	18
Figure 2.13	Screenshot of the Physics Studio	18
Figure 2.14	Screenshot of the Physics Studio	19
Figure 2.15	Screenshot of the Physics Studio	19
Figure 2.16	Screenshot of the Physics Studio	19
Figure 2.17	Screenshot of the Physics App	20
Figure 2.18	Screenshot of the Physics App	21
Figure 2.19	Screenshot of the Physics Machine	22
Figure 2.20	Screenshot of the Physics Machine	22
Figure 2.21	Screenshot of the Physics Machine	23
Figure 2.22	Screenshot of the Physics Machine	23
Figure 2.23	Pie chart of gender of the respondents	27
Figure 2.24	Pie chart of "How will you rate yourself in understanding the content of the Physics?"	28
Figure 2.25	Bar chart of "For Form 4 Physics Syllabus, which chapter you think is most difficult for you?"	29

Figure 2.26	Pie chart of "What are the most challenging part for physics learning?"	31
Figure 2.27	Pie chart of "Did you expose to the learning software to learn physics?"	32
Figure 2.28	Pie chart of "How often you use ICT learning software to aid in your study?"	33
Figure 2.29	Pie chart of "Did you aware about Augmented reality technology?"	35
Figure 2.30	Pie chart of "Did you use any Augmented reality aided components in your daily life?"	36
Figure 2.31	Bar chart of "If augmented reality elements are included to support the learning of Physics contents especially for visualization, do you think it is necessary?"	37
Figure 2.32	Bar chart of "In lecture module, the content will be separate each topic into concept, calculation format, example in reality will enhance user understanding and have better learning outcome."	38
Figure 2.33	Pie chart of "In lecture module, provide more 2D diagram or animation about the topics will enhance user understanding and have better learning outcome. Do you agree?"	39
Figure 2.34	Pie chart of "Tutorial module should have different types of question including objective, calculation, multiple choice question."	40
Figure 2.35	Pie chart of "Tutorial module should design based on what expected to be learnt in lecture module, experiment module and AR module. Do you agree?"	41
Figure 2.36	Pie chart of "If user answer wrong in tutorial module, system will show some explanation why the answer provided is wrong and let the user try again or given some hint based on the question."	42
Figure 2.37	Pie chart of "Do you want to have more interactive elements in virtual experiment?"	43

Figure 2.38	Pie chart of "In experiment module, user can adjust parameters and show different results based on user input to manipulate variable that can increase effectiveness of learning.".	44
Figure 2.39	Pie chart of "In experiment module, it should provide lab manual for reading to have a better understanding about the virtual experiment. Do you agree?"	45
Figure 2.40	Pie chart of "User need to answer all the questions within the given time as a training for real exam. Do you agree?"	46
Figure 2.41	Pie chart of "Past year questions applied in quiz module will be useful. Do you agree?"	47
Figure 2.42	Bar chart of "In AR module, the model should include "drag and rotate" features to have better interactivity. Do you agree?"	48
Figure 2.43	Bar chart of "In AR module, manipulated variables should be shown to the user and allow adjustment to get different outputs for better interactivity. Do you agree?"	49
Figure 3.1	Addie Model	53
Figure 3.2	System Flow Diagram	56
Figure 3.3	Storyboarding Design of welcoming page	57
Figure 3.4	Storyboarding of main menu	58
Figure 3.5	Storyboarding of lecture module	59
Figure 3.6	Storyboarding of lecture module topics	60
Figure 3.7	Storyboarding of tutorial module	61
Figure 3.8	Storyboarding of tutorial topics module topics	62
Figure 3.9	Storyboarding of experiment module	63
Figure 3.10	Storyboarding of experiment module topics	64
Figure 3.11	Storyboarding of quiz module topics	65
Figure 3.12	Storyboarding of quiz module question	66
Figure 3.13	Gantt chart for Project I	67
Figure 3.14	Gantt chart for Project II	67
Figure 4.1	Screenshot of how create Text UI element in Unity	68
Figure 4.2	Screenshot of setting properties of Text UI element in Unity	69
Figure 4.3	Screenshot of 1001 fonts website	69

Figure 4.4	Screenshot of assets font file	70
Figure 4.5	Screenshot of change font format and colour in Unity	70
Figure 4.6	Screenshot of edit font colour in Unity	70
Figure 4.7	Screenshot of how to use React tool in Unity	70
Figure 4.8	Screenshot of how to use React tool in Unity	71
Figure 4.9	Screenshot of how to add image source in Button UI element	72
Figure 4.10	Screenshot of On Click function in button UI element	72
Figure 4.11	Screenshot of Transition in button UI element	73
Figure 4.12	Screenshot of Animator in button UI element	73
Figure 4.13	Screenshot of how to add Animation recoding in button UI element	73
Figure 4.14	Screenshot of how to edit Scale in button UI element	74
Figure 4.15	Screenshot of assets audio file	74
Figure 4.16	Screenshot of how to create Audio element in Unity	75
Figure 4.17	Screenshot of how to setup properties of Audio element in Unity	75
Figure 4.18	Screenshot of assets video file	76
Figure 4.19	Screenshot of mp4 file details to get frame size of the video source	77
Figure 4.20	Screenshot of how to create a Render Texture element in Unity	77
Figure 4.21	Screenshot of setting properties of Render Texture in Unity	78
Figure 4.22	Screenshot of create and setup a Video Player in Unity	78
Figure 4.23	Screenshot of how to create a new scene in Unity	79
Figure 4.24	Screenshot of UI element should be included in the Splash screen	79
Figure 4.25	Screenshot of how to add ChangeScene game object and C# script component	80
Figure 4.26	Screenshot of how to apply ChangeScene game object in start button	80
Figure 4.27	Screenshot of how to add ExitProgram game object and C# script component	80
Figure 4.28	Screenshot of how to add turn on/off music button object in Unity	81
Figure 4.29	Screenshot of how to setup SoundManager game object in Unity	81
Figure 4.30	Screenshot of how to setting audio element in Unity	82

Figure 4.31	Screenshot of UI element in Main Menu Module	82
Figure 4.32	Screenshot of setup condition of button in Main Menu Module	83
Figure 4.33	Screenshot of UI element in Quiz Module	84
Figure 4.34	Screenshot of how to create and setup QuizManager	84
Figure 4.35	Screenshot of ItemSlot C# Script	85
Figure 4.36	Screenshot of DragDrop C# Script	86
Figure 4.37	Screenshot of how to apply C# script in to target UI element	86
Figure 4.38	Screenshot of objective question in Tutorial Module	87
Figure 4.39	Screenshot of correct option question in Tutorial Module	87
Figure 4.40	Screenshot of how to setting option button in Quiz Module	88
Figure 4.41	Screenshot of how to Setup Vuforia SDK plugin for Unity	89
Figure 4.42	Screenshot of how to get license key in Vuforia developer portal	89
Figure 4.43	Screenshot of how to create database and add image marker in Vuforia developer portal	90
Figure 4.44	Screenshot of how to import Vuforia plug-in and database into Unity	90
Figure 4.45	Screenshot of how to add AR camera component and apply license key	91
Figure 4.46	Screenshot of how to image target and AR object in Unity	91
Figure 4.47	Screenshot of how to add panel and UI element in AR module scene	92
Figure 4.48	Screenshot of how to apply C# Script component in AR object	92
Figure 5.1	Pie chart of Gender of the respondent	95
Figure 5.2	Pie chart of "How will you rate yourself in understanding the content of the Physics?"	96
Figure 5.3	Bar chart of "I think that I would like to use this system frequently."	97
Figure 5.4	Bar chart of "I found the system unnecessarily complex."	97
Figure 5.5	Bar chart of "I thought the system was easy to use."	98
Figure 5.6	Bar chart of "I think that I would need the support of a technical person to be able to use this system."	99

Figure 5.7	Bar chart of "I found the various functions in this system were well integrated."	99
Figure 5.8	Bar chart of "I thought there was too much inconsistency in this system."	100
Figure 5.9	Bar chart of "I would imagine that most people would learn to use this system very quickly."	101
Figure 5.10	Bar chart of "I found the system very cumbersome to use."	101
Figure 5.11	Bar chart of "I felt very confident using the system."	102
Figure 5.12	Bar chart of "I needed to learn a lot things before I could get going with this system."	102
Figure 5.13	System Usability Scale (SUS) score diagram	103
Figure 5.14	Pie chart of "With the help of multimedia elements (text, graphic, audio, video and animation) Can improve interactivity, so the user can learn more efficiently with better understanding"	104
Figure 5.15	Pie chart of "Virtual Physics experiment module can save a lot of time and effort in understanding, especially supporting visualization."	105
Figure 5.16	Pie chart of gender of "Augmented Reality (AR) technology used in this app will help in visualization for Physics learning."	106
Figure 5.17	Pie chart of "The depth of coverage for the topic content matched was appropriate and my expectation at the level of study. Adequate coverage of course syllabus in breadth and depth by provide adequate, useful study material"	107
Figure 5.18	Pie chart of "Quiz, tutorials and Lecture modules were adequate (content presentation)."	108
Figure 5.19	Pie chart of "In overall, the whole app is competent and effective in the delivery of Physics concepts using AR."	109
Figure 5.20	Pie chart of "The interactivity features in the apps can engage students in creative thinking, problem-solving and independent learning."	110

Figure 5.21	Pie chart of "Some learning videos related to lecture topics put in application will help user understanding much better in the lecture module."	111
Figure 5.22	Pie chart of "Different way of doing tutorial like drag and drop features, true or false will improve user understanding in different type of question in tutorial module"	112
Figure 5.23	Pie chart of "The calculation and analysis of the output dataset with the conclusion save user time in Experiment module."	113
Figure 5.24	Pie chart of "The Augmented Reality (AR) marker content are detailed and useful for user read to enhance understanding."	114
Figure 6.1	Poster of the project title	137

LIST OF TABLES

Table Number	Title	Page
Table 2.1	Comparison in interface designs for different application	24
Table 2.2	Comparison in media element for different application.	24
Table 2.3	Reason of Forces and Pressure Chapter is most difficult chapter for respondent	30
Table 2.4	Reason of Light Chapter is most difficult chapter for respondents	30
Table 2.5	Reason of Forces and Motion Chapter is most difficult chapter for respondents	30
Table 2.6	Reason of learning software help in understanding Physics content	32
Table 2.7	Respondent expect to see in learning application	34
Table 3.1	Software requirement for each multimedia element	52
Table 3.2	Hardware requirement for each multimedia element	52
Table 3.3	Description and flow diagram for welcoming page storyboarding	57
Table 3.4	Description and flow diagram for main menu storyboarding	58
Table 3.5	Description and flow diagram for lecture module storyboarding	59
Table 5.1	Suggestion for improvement of app features in the near future from respondent	

CHAPTER 1 Introduction

1.1 Introduction

In industrial revolution 4.0 [1] , some new era of modernization in education have been focus such as Internet of Things (IoT), cloud computing, augmented realities (AR) and artificial intelligence (AI). The IR 4.0 bring a lot of impact to our daily life, one of it is in Physics education. Physics education is an important area that emphasis on the Science stream because it evolves in many areas in specialized field of study. It is common to can see the trend now Augmented realities (AR) become quite important technology that use in education similarity physics studies also adopt AR in to their learning. AR come in to support physics education recently in industrial revolution 4.0 [2] because it provides a learning environment give learners opportunity to naturally interact with the material and motivate student to learn more deeply in Physics. This project focus on AR learning application for Physics education. AR technology has a significant positive effect on strengthening student self-efficacy, promoting higher-level conceptions and decreasing lower-level conceptions. The proposed title is Interactive Augmented Reality Aided Learning Application for Physics Education. This is a development-based project type, area of study about multimedia software development. This project aims to develop an interactive multimedia learning application with AR module to support Physics learning. The main target user for this project will be the secondary school student taking Physics subject.

1.2 Background

In Malaysia secondary education system, students are assigned to different class according their result when they reach upper secondary, for the student having good academic result in Science and Mathematics, will be assign to science stream class. One of the core subjects for those Form 4 and Form 5 science stream student are physics. The syllabus includes forces and motion, forces and pressure, heat, light, wave, electricity, electromagnetism, electronics and radioactivity. The teaching method is student will attend physical class in school, teacher use PowerPoint slides, whiteboard, references book as main teaching material and student also will having practical class to use lab apparatus perform physics experiment.

There are some reasons why Physics subject being consider as a challenging subject, according [3], most of the student having high motivation in learning physics, however Physics are considered as a challenging subject, student face a lot of trouble in understanding although they put in much effort to learn. Furthermore, some analysis shows that most students consider their Physics learning activities in school are less interesting and quite boring. As we known, Physics is an important subject should be pass and understanding well in order for student study engineering course in University. Even so, some further analysis shows that majority of students tend to avoid Physics related course at tertiary education level [4]. These can be explained by Physics education system in Malaysia not mature and less effective in retaining student's motivation.

In the past century, education is based on paper, verbal, book only as the evolve of computer technology, computers are used actively in education to improve the quality and learning outcomes [5]. In the term of multimedia, teachers can use graphics aids, audio and video through computer to prepare lesson plans. In physics education, there a lot of interactive application, Power Point slides, video being create to let people learn Physics easily.

1.3 Problem Statements

Students faced some difficulties in visualizing the Physics concept.

Physics is a challenging subject, not many students can pass this subject or get a good grade. Most of the physics theories having abstraction potential ideas like static charges moving or gravity forces. Most of the student may not clear how the real thing work when they first time learn Physics because it needs spam time to digest and understanding those theories. Even physics teacher faces difficult which is often difficult for students to visualize the physics [6]. Student facing a lot of conceptual difficulties in physics, e-animated, interactive, and game-like environments in which students learn through exploration can help student or teacher get much efficient in learning teaching experience [3].

Most of the learning application available did not follow professional interface design.

If software has a bad interface design will lead to difficult to use and lead user into mistakes, or if it frustrates user's efforts to accomplish user will dislike it, regardless of the computational power it exhibits or the functionality it offers, due to it model a user's perception of the software, so the interface has to be design well [7]. In e-learning, various disciplines are involved, one of a main concern shall be focus on psychological issues of user interface design [8]. The application available now did not have a professional interface design like colour usage, clarity of the content. A good interface should follow human computer interaction rule and let user use it comfortable and user friendly.

Lack of Augmented reality aided components found in physics learning application.

AR aided can be help student to understand, analyse or solve the problem scenarios, however, lack of resources or instructional technologies in accessing information within AR aided [9]. AR has become a popular topic in educational research in the last decade, but nowadays we cannot find an application with AR aided in physics learning. AR has good potential educational ability especially in science domain [10].

1.4 Objectives

To study the usage of augmented reality technologies in aided the Physics learning.

Augmented reality is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. Physics is a changeling subject, it involves many logics, abstraction theories understanding and complex calculation. With the help of interactive augmented reality aided, we can present the theories or idea behind it, so student can visualize the image behind the theories and enhance their understanding.AR can be a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects, so let's included physics element inside, user can have better understanding learning physics theories or ideas.

To develops an AR based learning software for Physics education.

Some of the theory it may having potential ides, it is abstraction of physics theory ,most of the student may not clear how the real thing work. For examples, the static charges moving or gravity forces. Instead of imagine or draw on whiteboard to present the ideas, the digital gadget can have an application show how the theories and ideas are work in behind, student can have better understanding though virtual experiment or interactive game. The details of calculation can be involving in application. Student may also face difficulties in memorise theory or calculation format, in learning application we can easily trace back that information, so we can focus of understanding instead or memorization.

To evaluate the effectiveness the AR based software can support the learning of Physics ideas and theories.

When student studying physics, most of the time they are facing a thick references book and calculator. They may face problem in understanding and calculation question. Nowadays everyone spends a lot of time in digital gadget, so why don't we move the learning platform to digital gadget though application. Student or teacher can be the user, to enhance the learning teaching experience. Some ideas and theories can be present in 2D and 3D interactive virtual experiment, student can do some self-learning and observe the ideas behind.

1.5 Scope

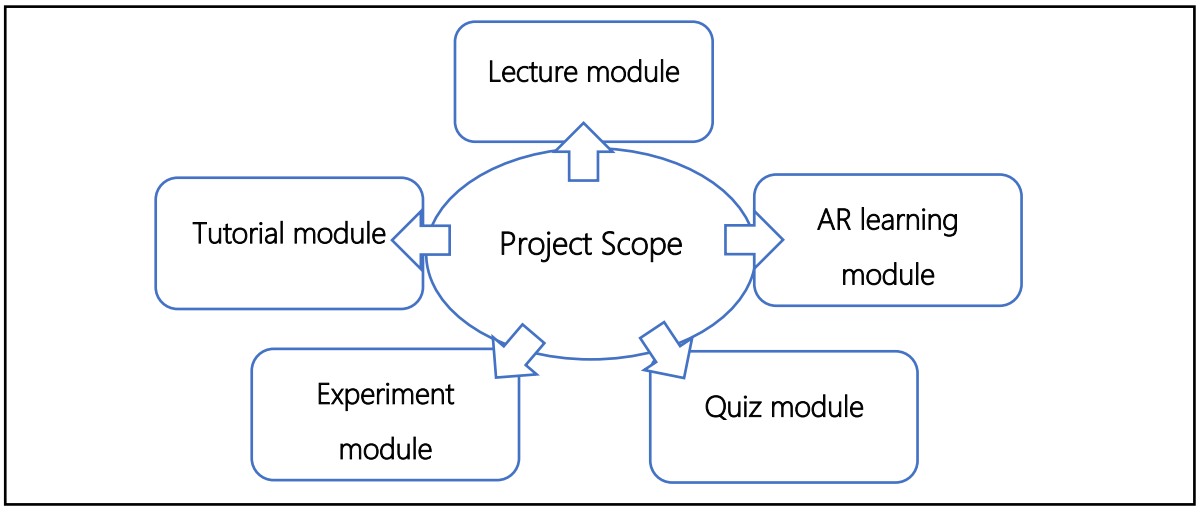


Figure 1.1 Project scope with 5 modules

1.5.1 Lecture module

The lecture module is a module let the user to having self-learning in particular physics topic, about some basic knowledge of a topics and also improve user's understanding of the basic concept. Inside this module, developer will include three section which is concept, calculation format, example in reality. Each of the section has 3-5 learning outcomes and all of them will included media element including text, graphic, audio, video and animation. With the use of multimedia element can improve the interactivity, so the user can have learned more efficient with better understanding. As a result, user can have a multimedia application which provides a simple learning environment to the users.

1.5.2 Tutorial module

The tutorial module is a module to help the user improve their understanding and digest what they learn in lecture module. The practical module will include different types of question to let user answer like objective, calculation, multiple choice question etc. If user choose the wrong answer, the application will show some explanation why the answer provided is wrong and let the user try again or given some hint based on the question, so user can base on their mistake think and try again the questions given. If user answer correctly, the application also will show the related description what the theories or ide work behind based on lecture module or the working step for the calculation question to help user have better understanding to digest the topics learnt.

1.5.3 Experiment module

The experiment simulation module is a module that allow user to do the virtual experiment in the software. In physics learning, there are a lot typical experiment propose by great physicist in past few centuries to prove their ideas or theories is workable. This module provides different experiment based different formula or equation, and show the potential idea behind. This will useful when student having interactive virtual by themselves, by input different value and observe the result shown so student can have better understanding learning physics theories or ideas.

1.5.4 AR learning module

The augmented reality learning module will perform on some suitable physics topics, to present the ideas or theories behind and increase the interactivity. The AR based learning module can utilize the natural environment and enhances the experience by adding virtual content to set a connection between the virtual and real world. As a result, it will provide a gamut of benefits from simple text-based instructions to complex step-by-step information. The 3D presentation will enhance the learning teaching experience as user can more easily visualise the physics theories or ideas behind.

1.5.5 Quiz module

The quiz module will provide a short test on all physics topics cover in the lecture module. The developer will set different set of question, user can try to answer all question within the time given. When the timer is end, it will stop user answering the question can calculate how many questions they answer correct. The quiz module is to test user understanding based on what they learn in lecture module and AR learning module so the user can know which part they still no clear can revise back the topics they did wrong.

1.6 Contribution and Significance

- Learning application

In the new technology era, learning method not only restricted to book and paper, many learning materials are moving to digital gadget. The project tries to bring E-learning environment for student, develop a software for learning process realization in the virtual space.

- Good interface design

There are many available learning applications in the market, however not majority of them having a good interface design. The project try to focus in human computer interaction, study focusing on the design of system, interaction between the users and the computer and develop a quality software with good interface design to let user can use the application in comfortable environment.

- Augmented Reality in education

Augmented Reality gradually apply in education and have been proven can improve study effectiveness. The project tries to bring AR technology into physics education to let the learning method grow in multi dimension and bring motivation to student study physics and improve their study performance. The types of AR being use in this project is Marker-less Augmented Reality. Marker-less augmented reality is one of the most widely implemented applications in the industry. Marker-less Augmented Reality is used to denote an AR application that does not need specify user environment to overlay 3D content into a scene and hold it to a fixed point in space. So, user not need require any extra equipment to use the application.

1.7 Target Audience

In the project the main target audience will be the form 4 secondary students who currently taking Physics subject. Those students could face problem in learning physics, mostly about understanding the ideas or theory behind and calculation question. The project would like to develop a learning application to help those students solve these questions they faced when learning physics. The AR technology will be applied to present some Physics theory in order to enhance the learning teaching experience. The system will provide different module, student can do some self-learning after school to help them having an effective learning progress. One of the modules will be AR module, the author will pick some challenging topics to present those Physics ideas to student, student can do interactive virtual experiment. AR supporting in physics learning are not so popular in Malaysia, so the author would like to develop in order to help student have better learning experience in Physics. With the help of interactive augmented reality aided, we can present the theories or idea behind it, so student can visualize the image behind the theories and enhance their understanding.

CHAPTER 2 LITERATURE REVIEW

2.1 AR definition

Augmented reality is an interactive experience and modification of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, addition of sound, visual elements, or other sensory stimuli [11]. There are three different types of AR available which are Marker-based, Markerless and Location based. The types being used decided by what content should be display on the live camera view within the user's view, how user interact with the digital world [12]. Marker-based AR present by anchored to real world, relies on identification of markers or user-defined images to function. It required user to pointing the camera to the marker images, then the picture or animation will be recognised and present the digital world on the marker. Markerless AR is the contents can be placed freely in all parts of physical environment, this allows user to try different combinations of objects, styles and location. It allows real-life scale placement of the virtual augmented objects [13]. Location-based AR is the AR contents are anchored to a specific location which the devices can recognise using GPS, compass sensor and accelerometer while predicting where the user is focusing as a trigger to pair dynamic location with points of interest in order to provide relevant data or information.

2.2 AR issues

2.2.1 Benefits

AR can increase the perceived value of products and brands by increases engagement and interaction. So, it can provide a great and richer user experience. The AR technology apply on the device which is mobile and personal, which can hugely accessible to a rapidly growing smartphone market because no specific media needs to be purchased, alternative to other media platform [14]. AR technology is slowly growing in the market and become popular, well implemented AR activity conveys innovation and responsiveness.

2.2.2 Limitations

There are also some limitations on AR technology, first, it may be quite expensive to implemented and develop AR technology-based projects and to maintain it, it will be costly

to develop AR enabled devices. Furthermore, AR technology is lack of privacy concern due to the scope, scale, and sensitivity of the information collect from the user. Besides, extreme engagement with AR technology will bring to major healthcare issues and mental health issues.

2.3 Applications of AR

AR technology has been applied on several fields to help industry increase the work performance. In automotive, AR in-car dash boards to provide drivers with a range of technical and travel information, act as virtual instructor for maintenance. In foreign country They using AR app to let their consumers take in an X-ray view of their promoted car. In retail site, some company activating virtual product demos using AR enabled packaging which help them reduce their returns rate. In tourism, AR technology use in augmented exhibition content for premium museum or gallery visitors and virtual tour guides for specific city tours. It also using geo-targeting AR to locate nearest attractions, viewpoint and restaurant [15].

2.4 Usage of AR in Physics

For Augmented Reality in Physics education, people have tried motion understanding using an augmented air table, information such as the objects velocity, angular velocity and kinetic energy can be overlayed over the objects in real-time to give direct understanding of physics motion laws [16]. Some developer create module that let students are enabled to actively build their own experiments and study them. A variety of tools are provided to analyse forces, mass, paths and other properties of objects before, during and after experiments. Innovative teaching content is presented that exploits the strengths of the 3D virtual environment.

2.5 Comparisons of similar AR applications

2.5.1 Physics Lab

Physics Lab is a mobile application let user learn science in physics by demonstrate virtual experiments [17]. The application also can be a good platform for teachers demonstrate physics experiments in class, and students also can explore inside beyond classrooms.

Interface designs

For interface design, the interface uses the colour appropriately, white colour background (label A) simple and clean (label B). It also follows the simplicity concept, label everything nicely(label C) and have reasonable font size and colour(label D). For the navigation panel part, which is consistently available at the upper right-hand side of the application (Label E).

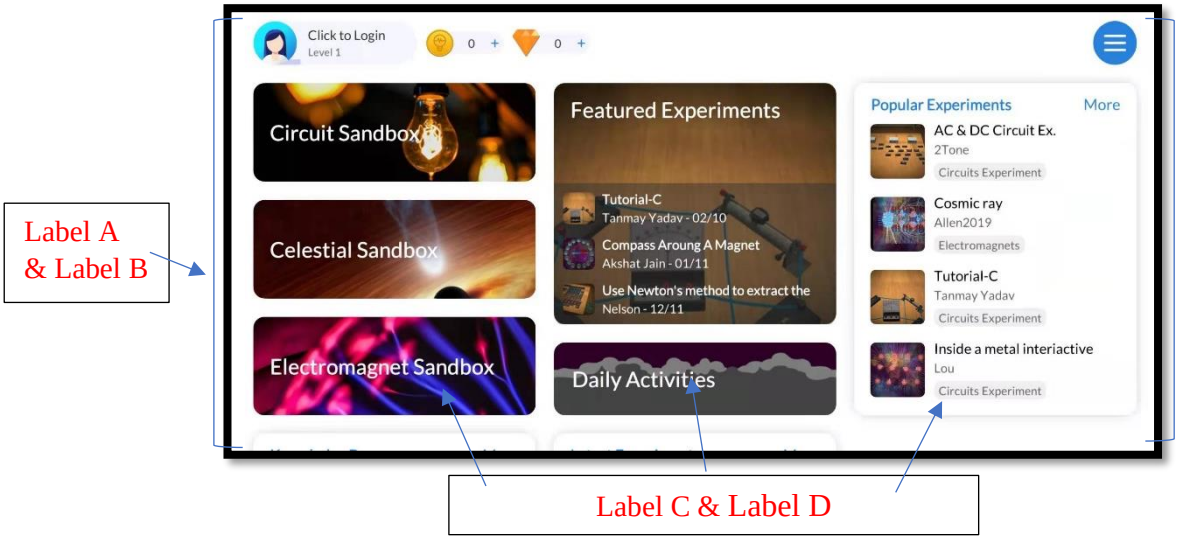


Figure 2.1 Screenshot of the Physics Lab

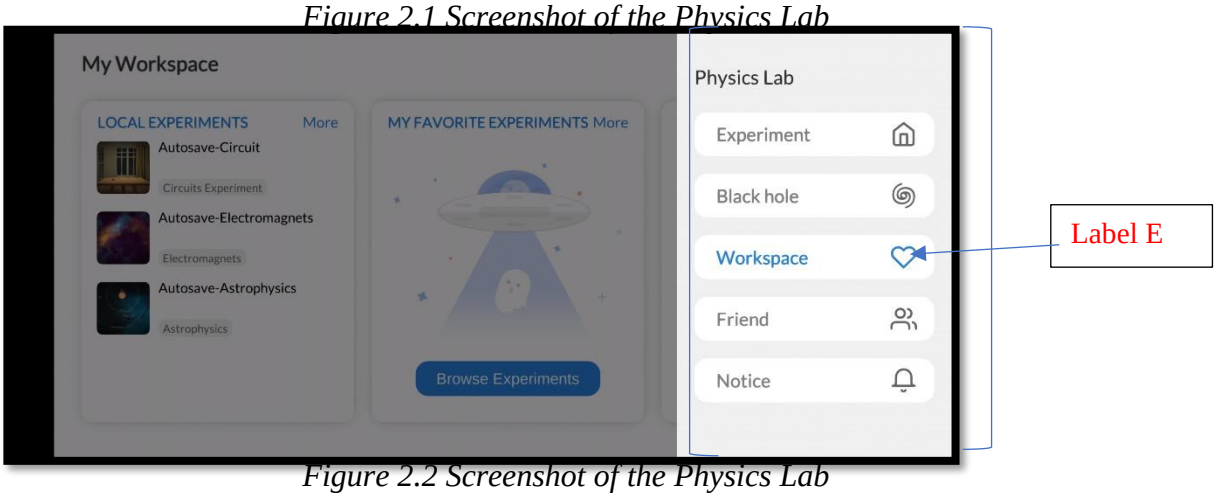


Figure 2.2 Screenshot of the Physics Lab

Strength

Physics Lab has 3 features included Circuit sandbox, Celestial Sandbox, Electromagnet Sandbox. In Circuit Sandbox, user can play with various circuit components, build own 3D electric circuits, and see how they work in real-time. The features included 55 circuit components. Celestial Sandbox allow user can load solar system, observe each planet's revolution speed, orbit. User can input negative charge, positive charge, magnet bar, observe how the electrostatic attraction between them and their magnetic field changes, moving direction. It also provides gyroscope function, so user can have difference view in difference angle. For media element, nice graphics in display those electric circuit and electrostatic charge. When user input many components won't cause any performance issue. Animation in charge moving and planet move at orbit is clear and smooth. Physics Lab is a free application available at Play Store. Multiple users can share idea when they build some experiments to public, add title and some description, others can run the demonstration and left a comment to have further discussion on the experiments.

Circuit Sandbox

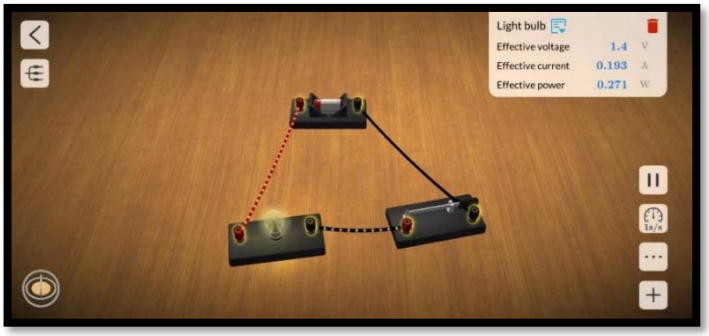


Figure 2.3 Screenshot of the Physics Lab

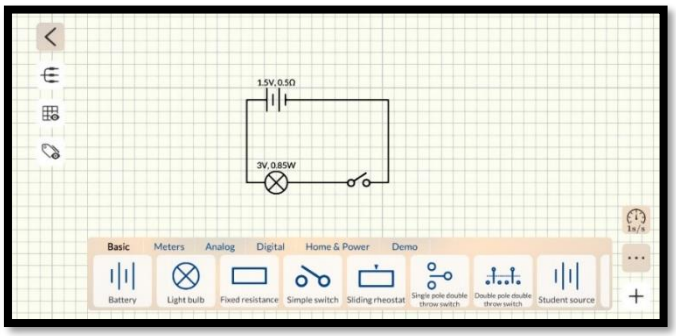


Figure 2.4 Screenshot of the Physics Lab

Celestial Sandbox

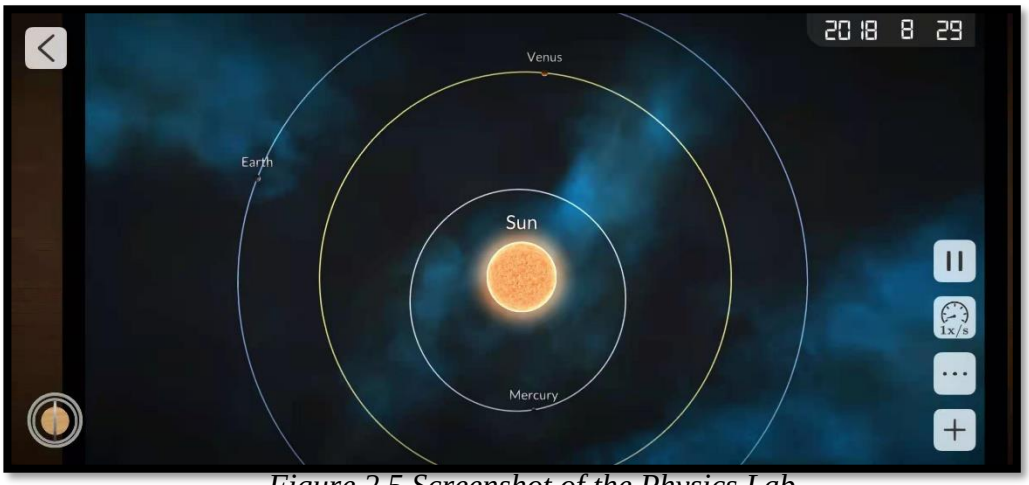


Figure 2.5 Screenshot of the Physics Lab

Electromagnet Sandbox

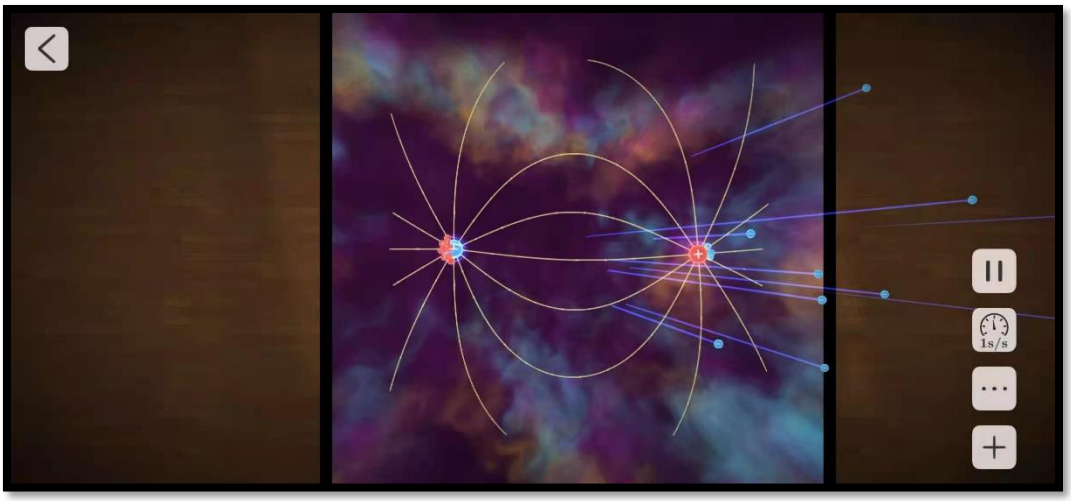


Figure 2.6 Screenshot of the Physics Lab

Weakness

However, each time load into the application takes long time, a great interface should more productive through good design and shortcuts. The theme font used is all same in whole application, user may feel monotonous maybe can use different to highlight some point. Drawback is the compass in Electromagnet Sandbox is too small, user cannot see clear the pointer direction heading. Another drawback is the lightbulb is on or off, doesn't have much difference in view, the brightness of lightbulb should be increase when it is on. Physics Lab does not have any sound when user do any action and does not have background music. Most of the basic features are free but some advance gadget or circuit component required user purchase to unlock the features to use them.

2.5.2 PhET Simulations

PhET Simulations is a mobile application develop by experts at the University of Colorado Boulder [18]. This application engages in science and mathematics, interactive aided presentation in different topic. Students and teacher are target users in learning or demonstration purpose, so the student can visualise the idea and theory behind in the Science.

Interface Design

PhET Simulations did a very good job in interface design, (label A)clear and beautiful layout user able to find what they want easily and each topic are separate with categories(label B). In clarity of content, it provides some description about the module before start the virtual experiment(label C).

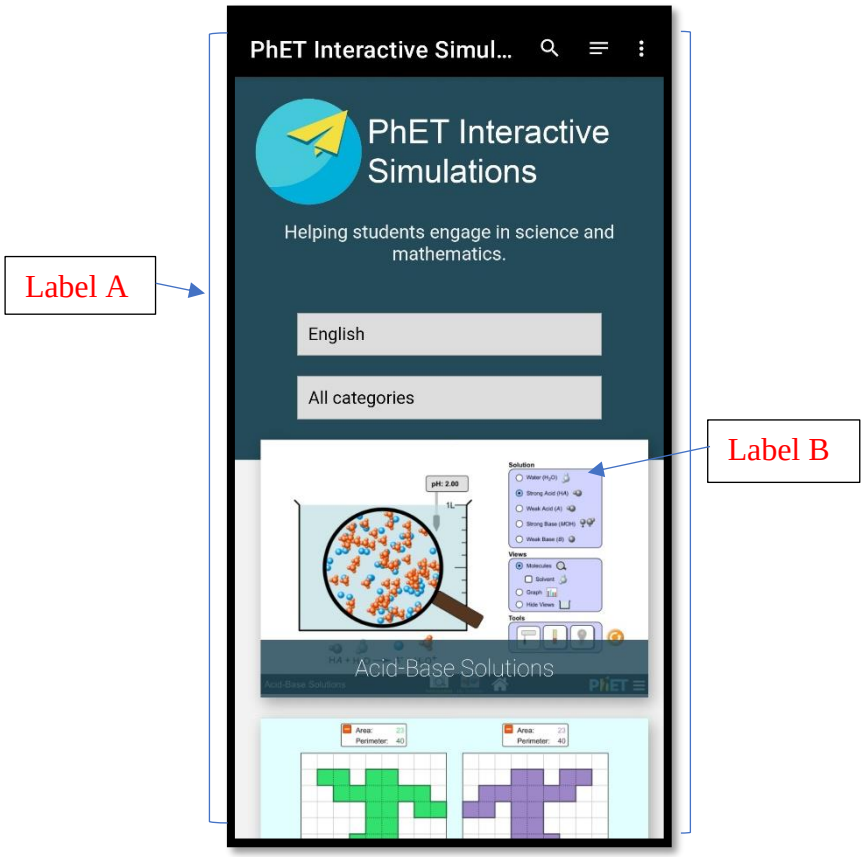


Figure 2.7 Screenshot of the PhET Simulation

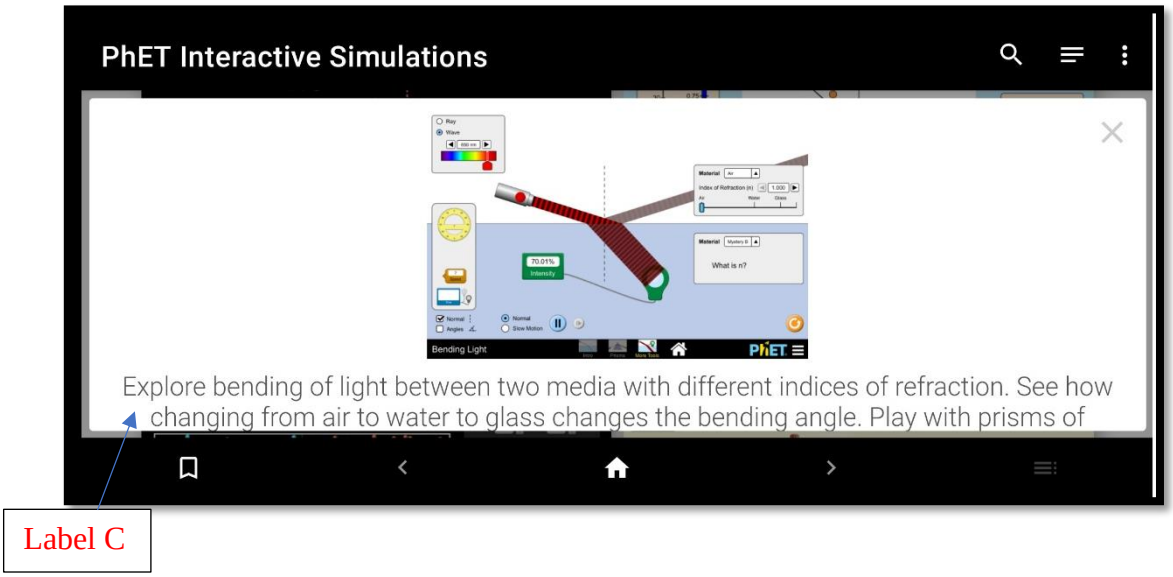


Figure 2.8 Screenshot of the PhET Simulation

Strength

The learning model included 3 majors in many topics, for example, Mathematics e.g., Arithmetic, Area Model Algebra, Build a Fraction, Chemistry e.g., Acid-Base solution, Atomic Interactions, Isotopes and Atomic Mass Physics e.g., Balloons and Static Electricity, Charges and Fields, Blackbody Spectrum etc. For media element, reasonable font for some term. Good graphics in every topic or interactive games, good performance. The application has some correct and wrong notification sound in some interactive game. Excellence animation in displays some theory in physics and chemistry. Single user application in learning different topics in science and mathematics. It develops by University Colorado Builder, RM3.99 sold in Play Store.

Balloon and Static Electricity

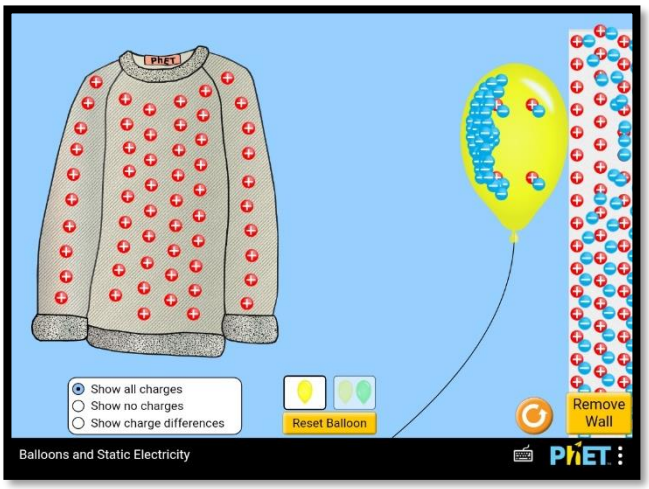


Figure 2.9 Screenshot of the PhET Simulation

Charge and Fields

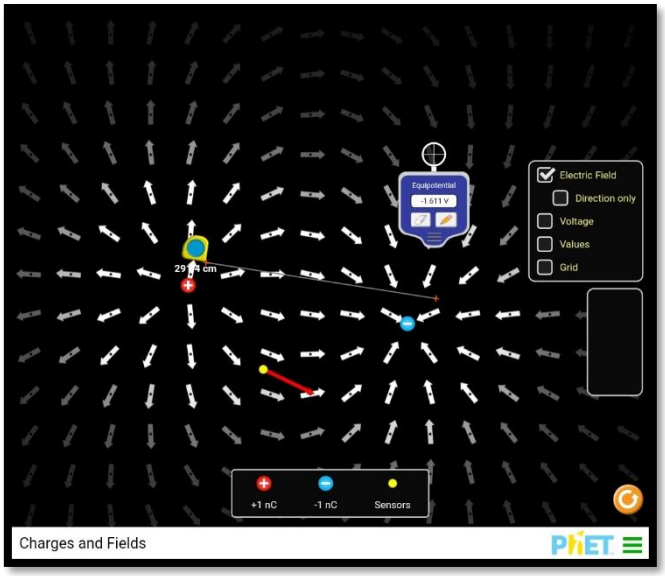


Figure 2.10 Screenshot of the PhET Simulation

Blackbody Spectrum

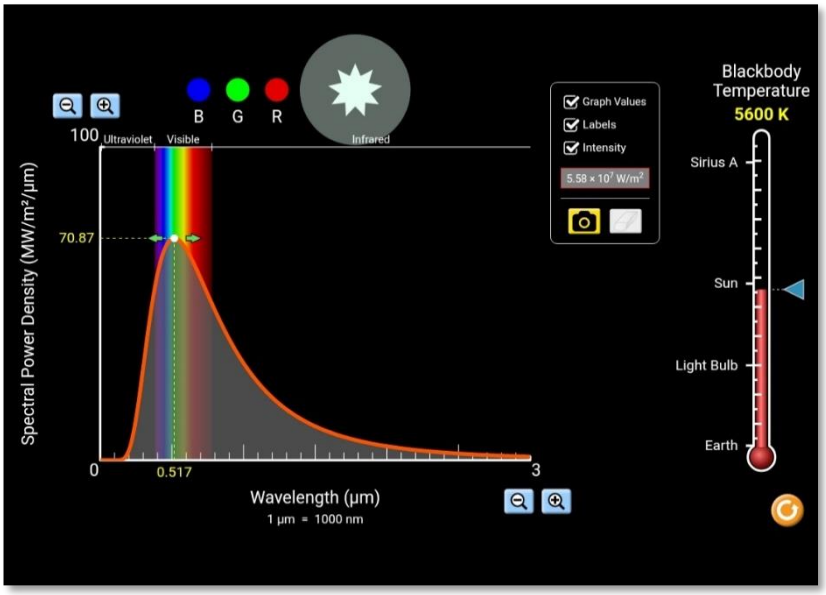


Figure 2.11 Screenshot of the PhET Simulation

Weakness

There are few weaknesses in PhET Simulations, due to the display layout is fixed cannot be zoom in & out, the font size is very small. The theme font used is all same in whole application, user may feel monotonous maybe can use different to highlight some point. The application did not have any background music.

2.5.3 Physics Studio

This is a mobile application let user learn Physics with virtual experiments. Physics Studio is a virtual lab to learn general physics [19]. It is a fun app to learn school science through games on touchscreen device.

Interface Design

Physics Studio done a very good job in interface design, clean, attractive, simple(label A). Reasonable theme font, bold, underline, colour for some important term(Label B).

Strength

Physics Studio let user learning Physics in different topic through virtual experiment and presentation: Mechanics, Electricity, Waves and Optics, Energy, States of matter, Electromagnetism, Atomic Structure etc. The application provides further explanation for every theory, let user can easily absorb physics knowledge. Good graphics in every topic or interactive games and virtual experiment, good performance The application have some correct and wrong notification sound in quiz. Notification sound when user interactive with the virtual experiment. Excellence animation in displays some theory in every physics theory and graphical presentation. Free mobile application available in Play Store, In-app purchase for some privileges. Single user for student does self-learning in various physics topic.

Weakness

In media element of text, Physics Studio display all text in very small font size, users are difficult to see the content well, especially in some calculation part suggest use bigger font to let user mind clear to understand the content. For audio part, it is suggested to provide some audio like background music or interactive sound with the virtual experiment gadget.

Mechanics

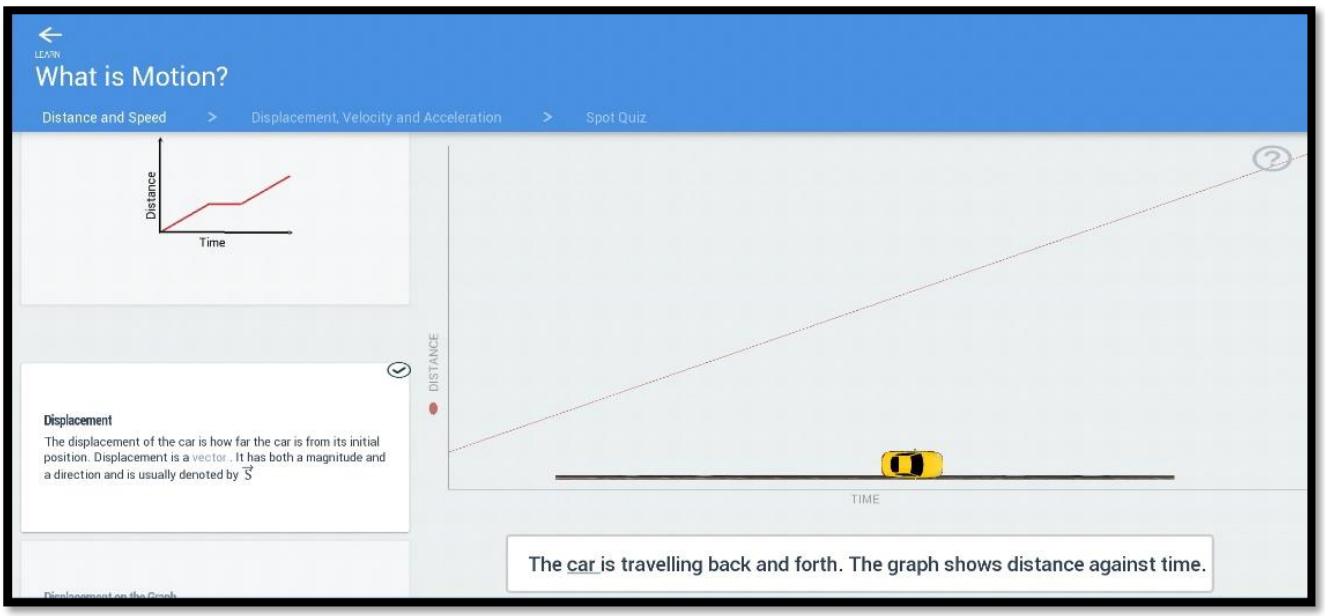


Figure 2.12 Screenshot of the Physics Studio

Electricity

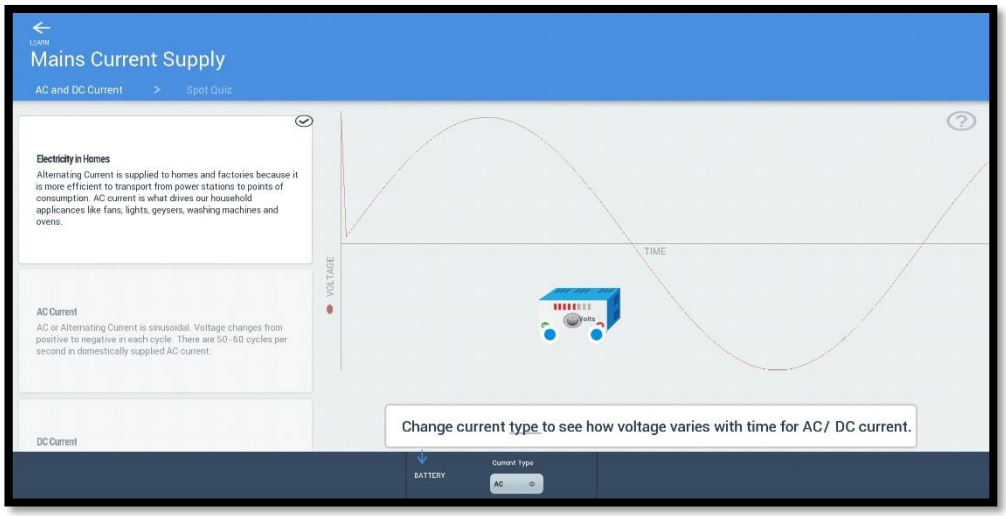


Figure 2.13 Screenshot of the Physics Studio

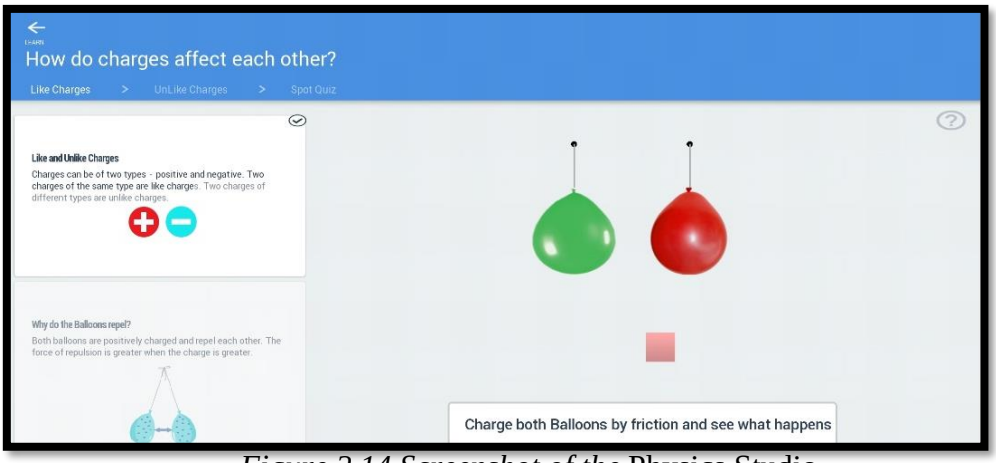


Figure 2.14 Screenshot of the Physics Studio

Interface

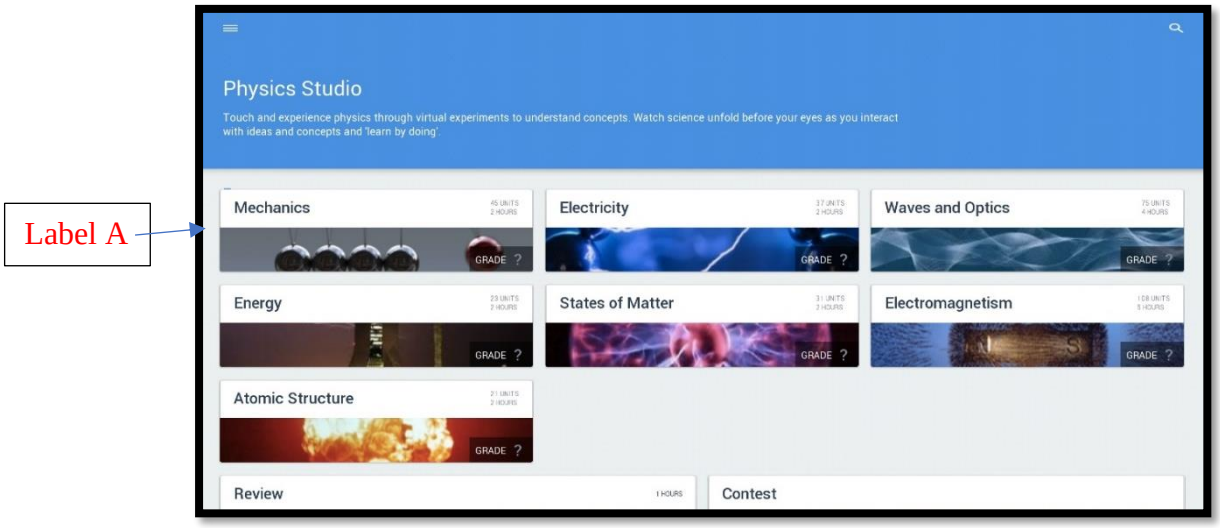


Figure 2.15 Screenshot of the Physics Studio

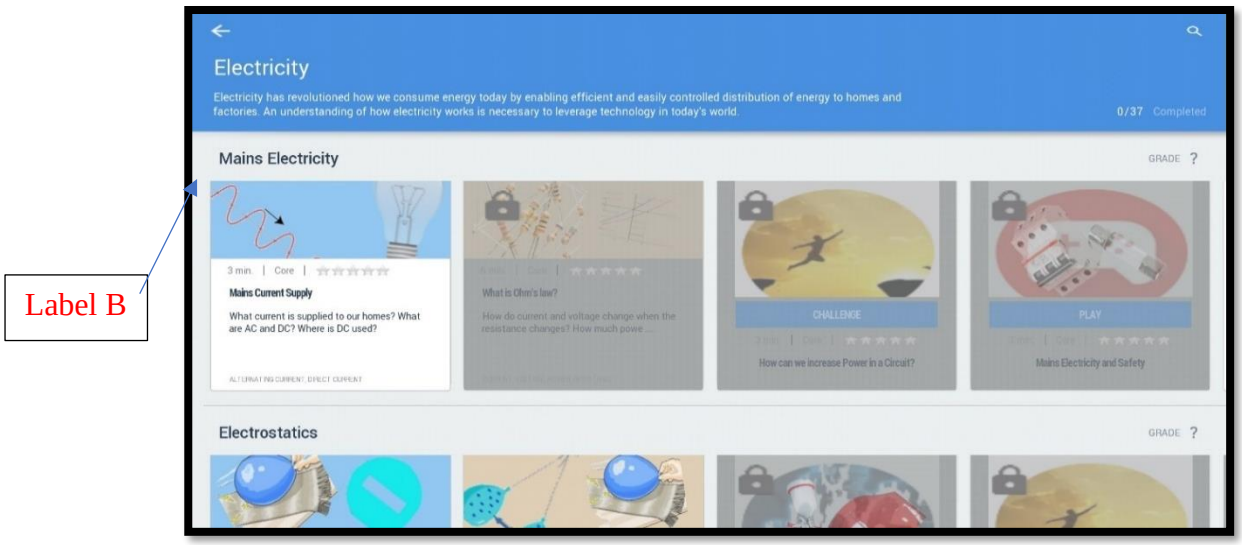


Figure 2.16 Screenshot of the Physics Studio

2.5.4 Physics App

Physics App is a mobile application let students learn physics easily and intuitively with practical simulations in virtual physics lab [20]. It works like a school lab simulation app and make the theories more practical.

Interface Design

Physics App's interface design, mostly usage of blue colour let it look tidy and consistent (Label A). Navigation panel is clear with mention what subtopic included in each topic. High interactivity as each virtual presentation of experiment has many variables can modify and see the result.

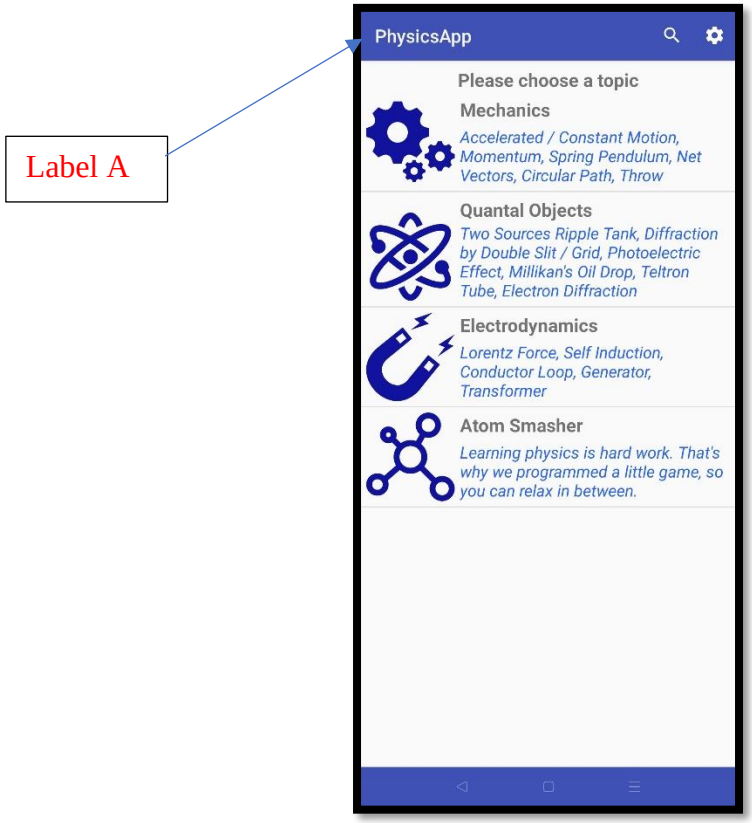


Figure 2.17 Screenshot of the Physics App

Strength

Physics App let user learning Physics in three major physics topics: Mechanics, Quantal Object, Electrodynamics. Mechanics included experiment in topic motion, momentum, spring pendulum etc. Quantal Object included experiment in electron diffraction two source ripple tank etc. Electrodynamics included experiment in topic Lorentz force, self-induction,

conductor loop etc. For media element, well structed text in colour and font and size. Poor graphic use as the application only flat and 2D component be used. Animation in virtual experiment is clear and precise along with some calculation. Free mobile application available in Play Store, In-app purchase for some privileges. Single user for student does self-learning in various physics topic.

Mechanics-Momentum

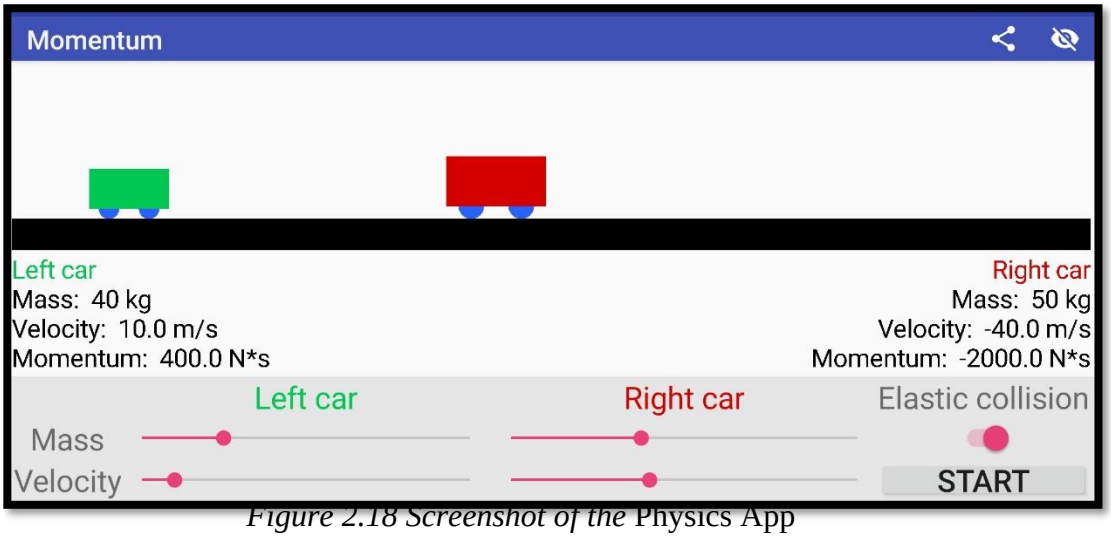


Figure 2.18 Screenshot of the Physics App

Weakness

However, Physics App's user interface only included blue colour let user feel bored(label A), a learning application suggested to be more colourful. Poor graphical presentation as every presentation is 2D and very simple, suggest 3D presentation as it is always look more well presented. The application did not have any background music or interactivity sound but have some interacted vibration. Free application in play-store but when using the features will pop out annoying advertisement frequently.

2.5.5 The Physics Machine: Physics Classroom and Tools

The Physics Machine is a mobile application developed in conjunction with physics professors and teachers [21]. The application has physics theories ranging from detailed explanations, practice problems, video, tutorials, forums, tools, review sheet, and calculators.

Interface Design

Physics Machine's interface design have beautiful layout sperate with unit for each topic from basic to hard(label A). Good clarity of content as provide some description when user click in(label B).

Strength

Physics machine let user learning Physics in many topics e.g., Kinematics, Work and Forces, Power, Momentum etc. It also designs different calculator for student easy related to the formula use or doing exercise. For media elements, text used different font, size, colour are reasonable and beautiful. It provides some video by using YouTube plug-in to explain some of the theories. Free mobile application available in Play Store. Single user for student does self-learning in various physics topic.

Interface

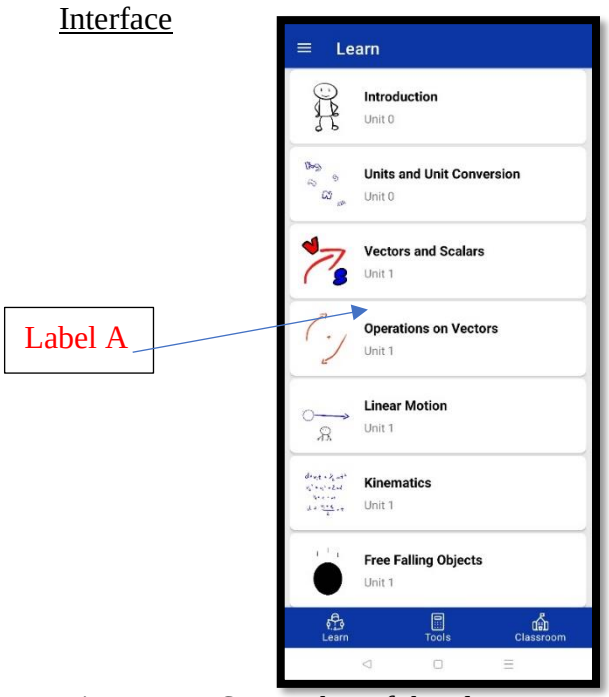


Figure 2.19 Screenshot of the Physics *Machine*

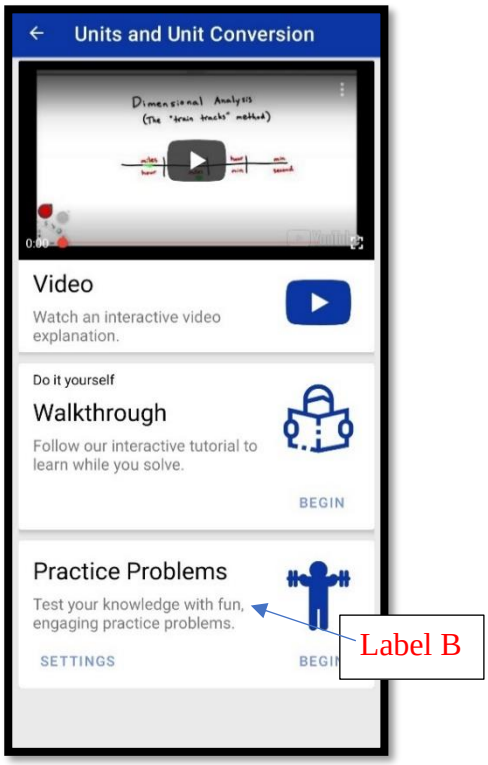


Figure 2.20 Screenshot of the Physics *Machine*

Interactive Tutorial

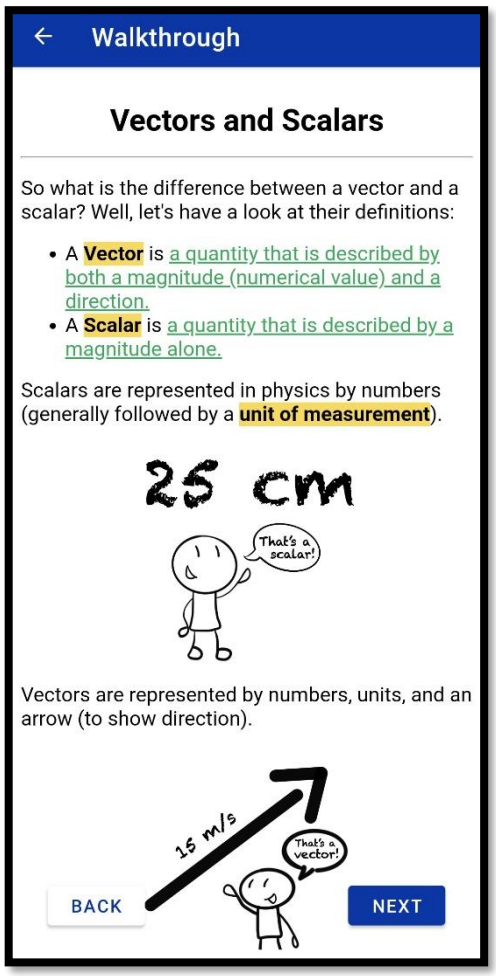


Figure 2.21 Screenshot of the Physics Machine

Practice Problems

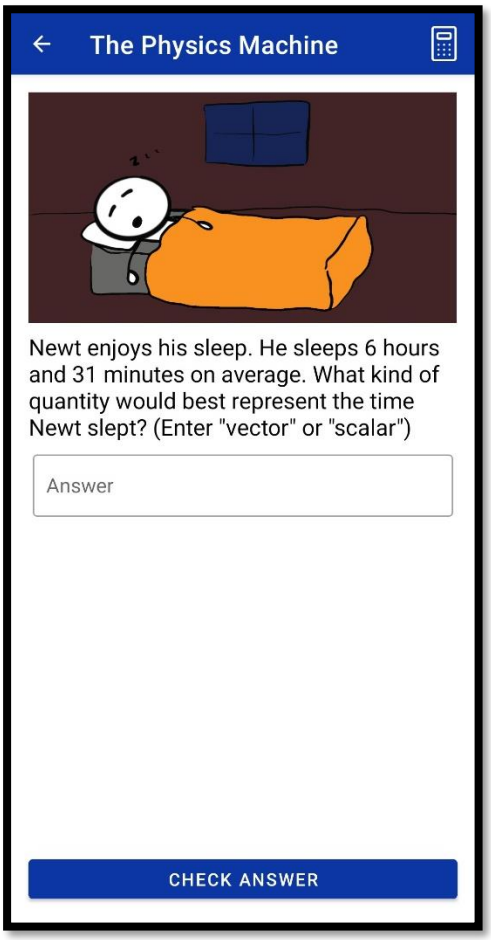


Figure 2.22 Screenshot of the Physics Machine

Weakness

Physics Machine did not have any animation of virtual experiment, all ideas and theories are present in hand drawing image only, it is suggested to have 3D presentation or interactive element example like virtual experiment lab. The application does not have any audio, it is suggested to provide some audio like background music or interactive sound.

2.6 Summary of the Similar Applications (Comparison Tables)

Table 2.1: Comparison in interface designs for different application.

Interface Components / Application	Usage of colour	Consistency Navigation Panel	Clarity of Contents	Interactivity	Simplicity
Physics Lab (*Turtle 2018*)	3	3	3	3	3
PhET Simulations (*University of Colorado Boulder 2020*)	4	4	3	3	3
Physics Studio (*Maza Learn 2013*)	3	2	4	5	4
Physics App (*A_K 2018*)	1	2	2	2	4
The Physics Machine (*Tsuri LLC 2020*)	5	2	4	1	2

1-Worst , 2-Poor , 3-Average , 4-Good , 5-Excellence

Table 2.2: Comparison in media element for different application.

Media Element / Application	Text	Graphics	Audio	Video	Animation		AR
					2D	3D	
Physics Lab (*Turtle 2018*)	2	4	1	-	-	2	-
PhET Simulations (*University of Colorado Boulder 2020*)	2	5	2	-	-	4	-
Physics Studio (*Maza Learn 2013*)	3	5	1	-	-	4	-
Physics App (*A_K 2018*)	4	1	1	-	4	-	-
The Physics Machine (*Tsuri LLC 2020*)	5	2	1	4	-	-	-

1-Worst , 2-Poor , 3-Average , 4-Good , 5-Excellence

2.7 Resolved Solution

The author cannot find any physics learning application having AR module, so the author would like to introduce AR module inside the learning application to help student having better understanding and learning experience. Most of the learning application available did not do well in interface design. the author would like to focus in good interface design about usage of colour, simplicity and interactivity. For media element, text could be improved by using different font, colour and highlight important terms, a learning application should attach more video inside to let student direct view some learning video in application.

2.8 User-centred Design

The learning approach will be used for this project will be user centred design approach. User-centred design(UCD) can be known as an iterative design process throughout the whole development life cycle we focus on gain a deep understanding for target user who will be using the product, know their needs in each phase of the design process [22].

There are four phases in UCD approach according to The Interaction Design Foundation [23], first is understand context of use. The developers will identify and understanding of user needs by use different methods and tools such as surveys, questionnaire, interview etc. Second is specify user requirements, the developers will try to identify each main function and specify the user requirement using some method such as user story. After identify specify requirement from user, third is create design solutions, developers come out potential solution, building from a rough concept to a complete design. The last phase is evaluation, the outcomes will be tested and evaluate from user, check the design performance, satisfaction of requirement need. Then make further improvement and iteration to previous phase until system satisfies is reached.

In this project UCD approach is used because the author brings the users into every stage in design process, it is useful to find out which part works well and which part does not and why. The target user is for student only, so the system should be meet student's expectation and requirements by using this approach the project can achieve that. Furthermore, this approach will design for the target user with specify requirement in order to reduce the project risk, the author stay close with user can improve the quality of the system in design, privacy and ethical. The author can know each user difference perspective and lead the project to right direction.

2.9 Users Requirements Gathering

2.9.1 Survey Questionnaire

In this research study, the author is going to collect user requirements from the target user which are the secondary school form 4 student who currently taking Physics subject. According to [24] user requirement is defined as a document usually used in software engineering that specifies what the user expects the software to be able to do. User requirements are functional requirements. They deal with functionality that is visible and important to users that a system has to deliver to satisfy the business objectives that the system is designed to fulfil. User requirement is important in software development because the user can confidence in what is the project scope and how the system can benefit them. The development team can know their ideas matches and fulfil the target user requirement or not. Furthermore, user requirement enables the development team to fix the scope of the project early on and ensures that the development team able to proceed to the next phase in the given time. There are few methods of collect user requirement from the target user such as through interviews sessions, Joint Application Development (JAD), survey questionnaires, document analysis and observation.

The author is going to collect user requirement through survey questionnaire. There are total twenty-three questions which separated into four parts in the survey questionnaire, which are Demographic Information, General Question about Learning Difficulties, General Knowledge on Computing and Exposure to AR, Specific Question on Expectation of the Software. The sample questionnaire can be referring to Appendix A.

2.9.2 Data collection and analysis

Part A: Demographic Design

1. Gender

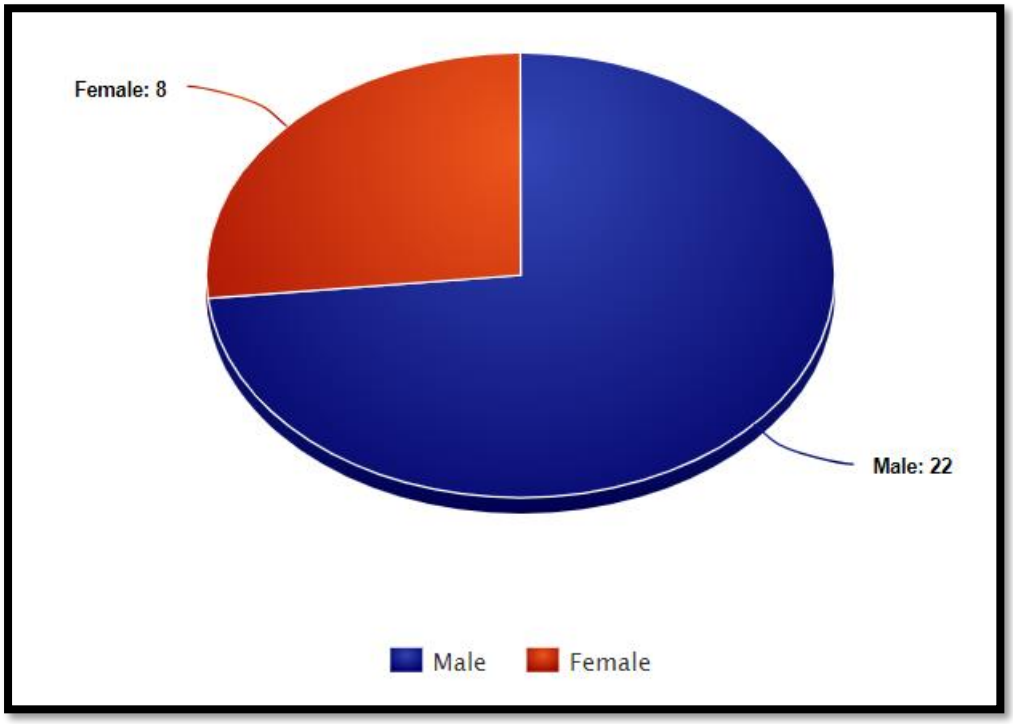


Figure 2.23 Pie chart of gender of the respondents

As refer to Figure 2.23, there are 30 samples which are secondary school Form 4 student currently taking Physics subject took part in this survey question. 22 of them is male, 8 of them is female.

2. How will you rate yourself in understanding the content of the Physics?

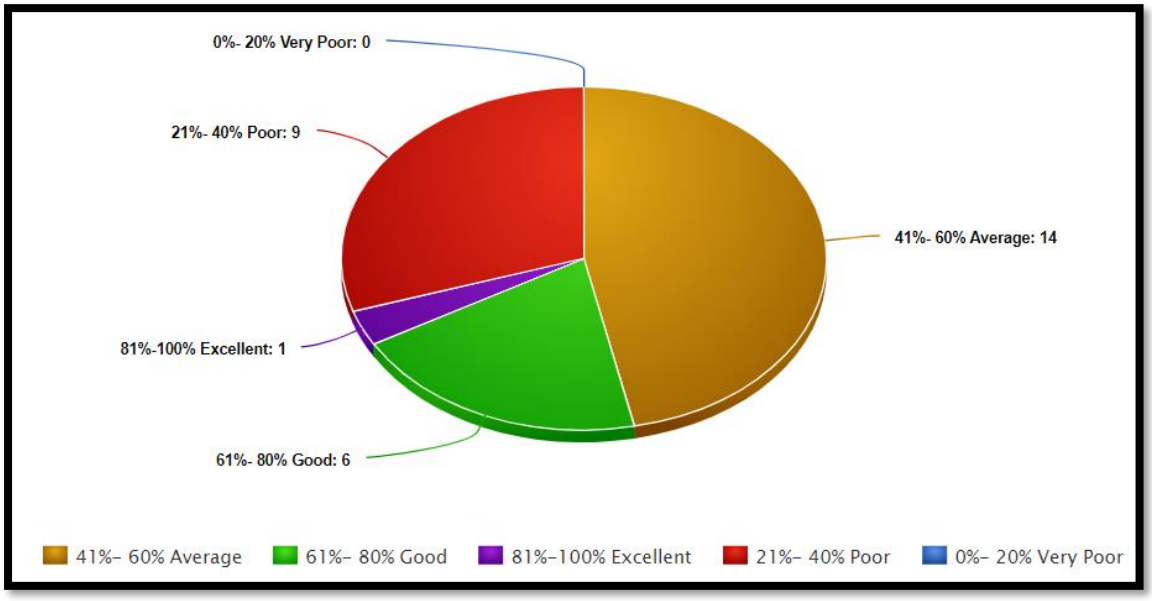


Figure 2.24 Pie char of "How will you rate yourself in understanding the content of the Physics?"

This pie chart in Figure 2.24 shown about respondent themselves in understanding the content of the Physics subject syllabus. 14 respondents rate themselves about 40% - 60% average in understanding the content of the Physics, 9 respondents rate themselves poor in understanding the content of the Physics, 6 respondents good in understanding the content of the Physics, only one respondent rate himself/herself excellent in understanding the content of the Physics. The result shown that majority of the respondent not confidence rate themselves master and understanding the content of the Physics syllabus and majority is in average and poor. This shown that Physics is a challenging subject and no every student can master it well.

Part B: General Questions (Learning difficulties)

1. For Form 4 Physics Syllabus, which chapter you think is most difficult for you?

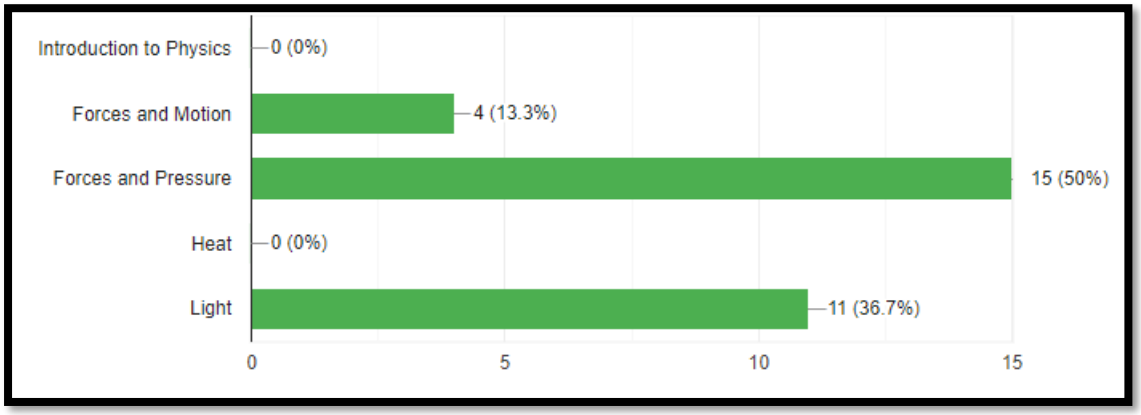


Figure 2.25 Bar chart of "For Form 4 Physics Syllabus, which chapter you think is most difficult for you?"

The bar chart in figure 2.25 shown that half of the respondent think Forces and Pressure chapter is the most difficult chapter in the From 4 Physics Syllabus. The second highest chapter is Light, and least is Forces and Motion only 4 respondents think this chapter is most difficult. Introduction to Physics and Heat chapter no any respondent thinks there are difficult chapter, this shown that these two chapters contents are quite easy understand. Forces and Pressure and Light chapter could be difficult for majority due to several reason will be analysed in next question.

2. Among the chapters you select from Q1, can you provide some reasons why you think it is the most difficult chapter?

Table 2.3: Reason of Forces and Pressure Chapter is most difficult chapter for respondent

When solve the problem of forces and pressure need to consider many conditions which affect the result	Many calculations formula
Can't understand the equation, don't know when to use	Too many formula
Concepts and calculation have different condition affect the result lead to trap, student easy answer wrong in exam	Formula and equation is hard to understand
Equation applies in different situation , not sure which should be apply according to question	Equation is hard need spam much time understand how to apply
Less different situation examples	Mathematical equation is hard to understand
Not sure how to use the formula	Very time consuming in understand concepts
Exam question will relate to real situation which less teach	Many formulas and mathematical equation
Mathematical equation part is hard	

Table 2.4: Reason of Light Chapter is most difficult chapter for respondents

There are so many type images formed by convex and concave which need time to understand it.	because light have many formula
This is because light is abstract and more of the teacher did not focus on that chapter	The lenses concept is very hard and need spam many times to understand
Teacher spend less time teach the last chapter	This chapter have many formula
Concepts in this chapter is too hard to understand	The concepts are too abstract
Difficult to understand	Hard to understand formula, many symbol
Not able to visualize its concepts	

Table 2.5: Reason of Forces and Motion Chapter is most difficult chapter for respondents

Because it depends on situation	Question relates real situation
Not sure how the concepts relate to real situation	Less example and understanding

This question is answer based on respondent answer for last question which chapter is most difficult and provide some reasons. For the respondent think Forces and Pressure is the most difficult chapter, several response claim that this chapter content a lot of formula, mathematical

equation which they are not master well, they do not know when to apply the correct formula according to different situation. Some response also claim that the exam question come out from this question normally contain many conditions let student overlook and lead to mistake. For the light chapter, majority of them claim that the content is abstract and they not able to visualise the concepts and lead to concepts in this chapter is too hard to understand. Two respondent claims that the lenses abut convex and concave part is very hard need spam many times to understand the concepts. For the forces and motion chapter, they think the content and concepts is depends on real situation and less example given lead to less understanding.

3. What are the most challenging part for physics learning?

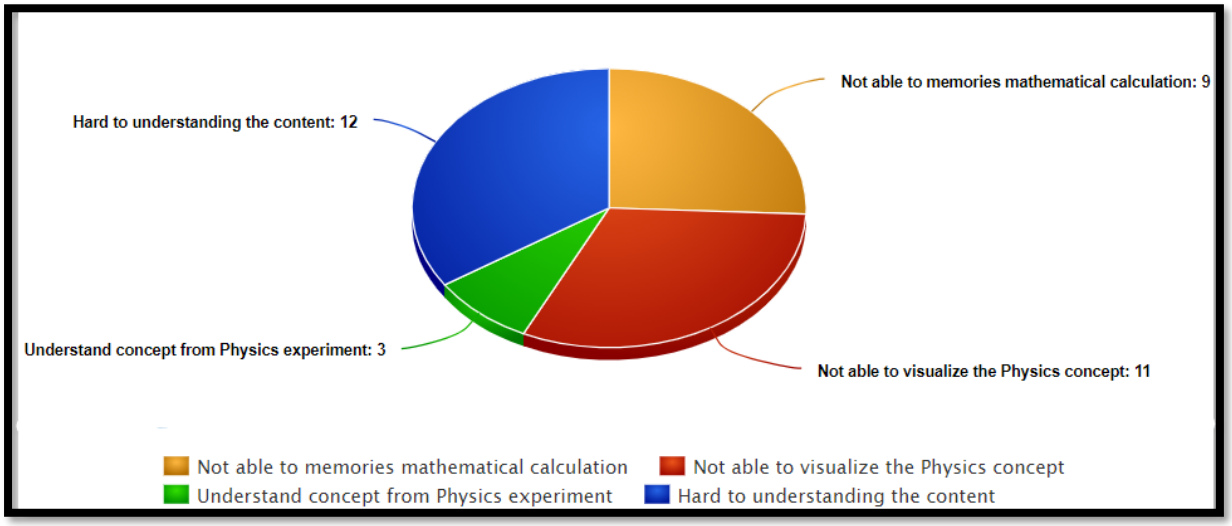


Figure 2.26 Pie chart of "What are the most challenging part for physics learning?"

The pie chart in figure 2.26 shown the response of what are the most challenging part for physics learning based on their experience. Majority of the response about 12 and 11 responses claims that the Physics concepts and content is hard to understand and not able to visualise those concepts. These could be the main reason lead to Physics learning to be challenging, most of the student face same problem they may not clear how the real thing works because cannot visualize the concepts in their mind. 9 responses say they no able to memories the mathematical calculation and 3 responses cannot understand concepts try to show from the Physics experiment. Mathematical equation is important in answering most of the question and understand how it works but it may be hard due to a lot of mathematical symbols being used and very complicated.

Part C: General Knowledge on Computing and exposure AR

1. Did you expose to the learning software to learn physics?

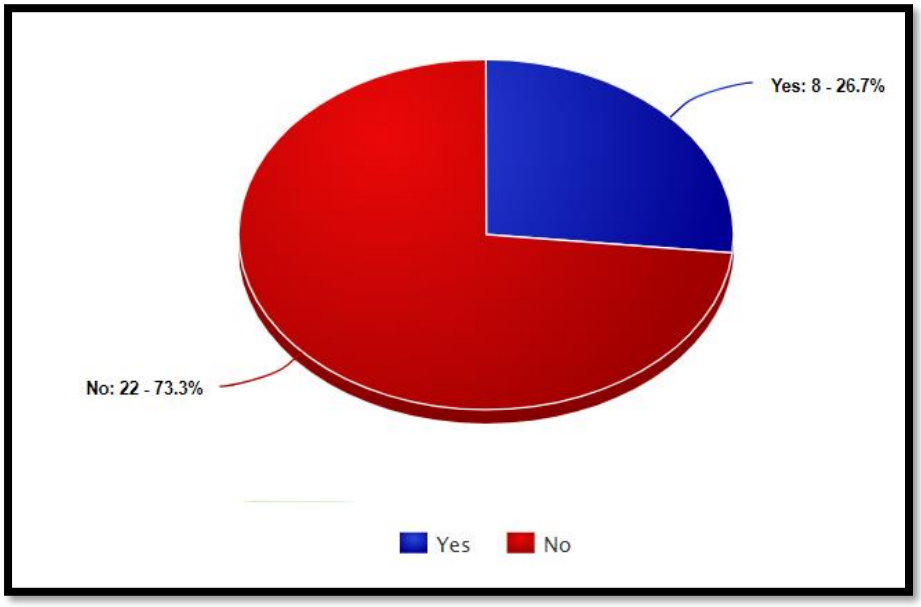


Figure 2.27 Pie chart of "Did you expose to the learning software to learn physics?"

The pie chart shown in Figure 2.27 is the result of the question "Did you expose to the learning software to learn physics?". This question ask that did the respondents use and expose to any learning software to aid them in learning Physics. Majority of the response, about 22 response 73.3% they did not have any experience in using any learning software to learn Physics. There are only 8 response 28.7% have expose to the learning software to learn physics. From the result shown that the Physics learning application is less popular and being used for students.

2. Did the software help you much in understanding Physics content? Please provide reason.

Table 2.6: Reason of learning software help in understanding Physics content

Because they can show the experiment and also straight to the point	Yes, because it can help me to visualize the concept of physics.
The content is easier understand	Visualize the concept of physics
The material is more straight to the point	Help me visualize the concepts
Content is easier to understand	I can more understand and visualize concepts

There are only 8 respondents expose to the learning software to learn physics. These are their reason why they think it help them much in understanding Physics content. Majority of the response claim that the content in the learning application normally is more straight

to the point so they can easier understand and digest the content. They also mention they can easily visualise the concept but did not mention through what method.

3. How often you use ICT learning software to aid in your study?

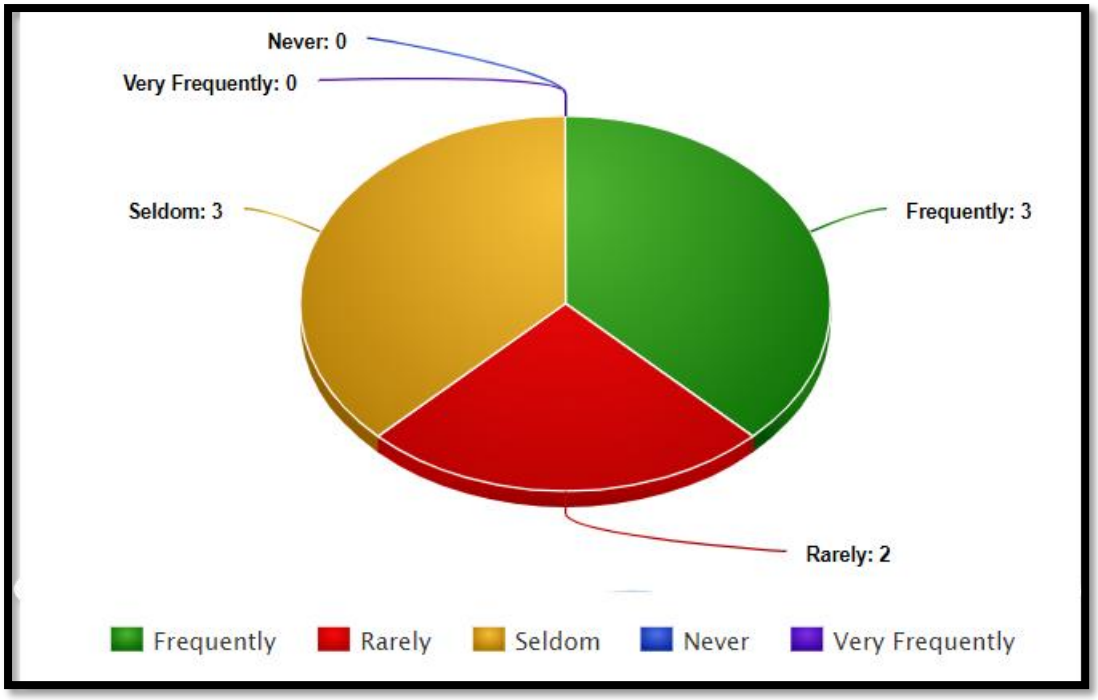


Figure 2.28 Pie chart of "How often you use ICT learning software to aid in your study?"

The pie chart in Figure 2.28 shown that among the 8 respondent 3 of them use learning application frequently, 3 of them seldom use, 2 of them rarely use. They may only use the learning application for study certain content or topic and the application being use provide better content let them easier understand and aid in their Physics learning.

4. If you have chances to expose to a new learning application, what did you expect to see in the software?

Table 2.7: Respondent expect to see in learning application

3D visualizes motion video	Animation let user easy understand
Short and easy understand teaching video	Can put shorter lecture video
Animation is added	Explain more in formula part
Formula part can explain in details	Good quality lecture video
Include interesting history or fact	More hard question and explain in details
Provide concepts for different scenario so the user has a fully understanding about that topic	Video and animation
Can include animation	Content more interesting and useful
Animation and video with explanation	Can involves more video in the application
Can put some interesting fact	Explain hard higher thinking order question
Explain on formula	Good explanation video
Include good teaching video	Include short video with explanation

For the respondent did not expose to learning application before, most of them suggest that lecture video should be included in the module can help them much in understanding the content. Some respondent also suggests that animation video with some explanation can help much in digest the concepts in the particular topics. Furthermore, some respondent also claim that some the content should be filter, should more interestingly relate to real example or put some fact or history.

5. Did you aware about Augmented reality technology?

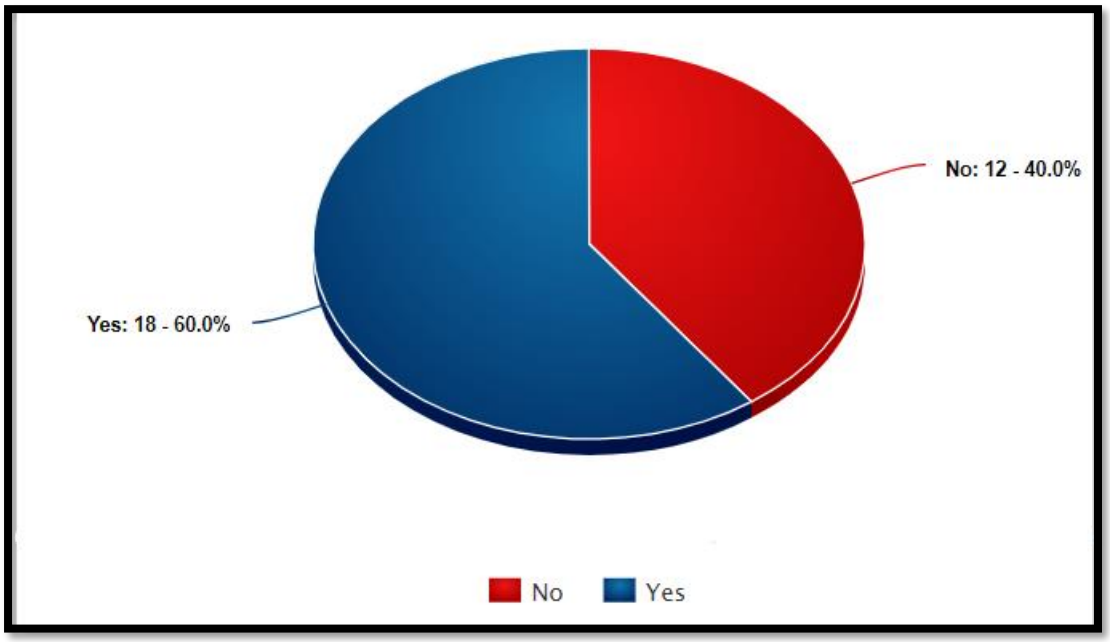


Figure 2.29 Pie chart of "Did you aware about Augmented reality technology?"

The pie chart in figure 2.29 shown the percentage of respondent aware of reality technology. Majority of the respondent 60% aware of the AR technology. 40% of 12 respondent did not aware of the AR technology. The first AR technology appeared in 2008, and minority of foreign country apply AR techniques to aid their business. AR technology is slowly glowing in the world and no so popular in our country yet.

\

6. Did you use any Augmented reality aided components in your daily life?

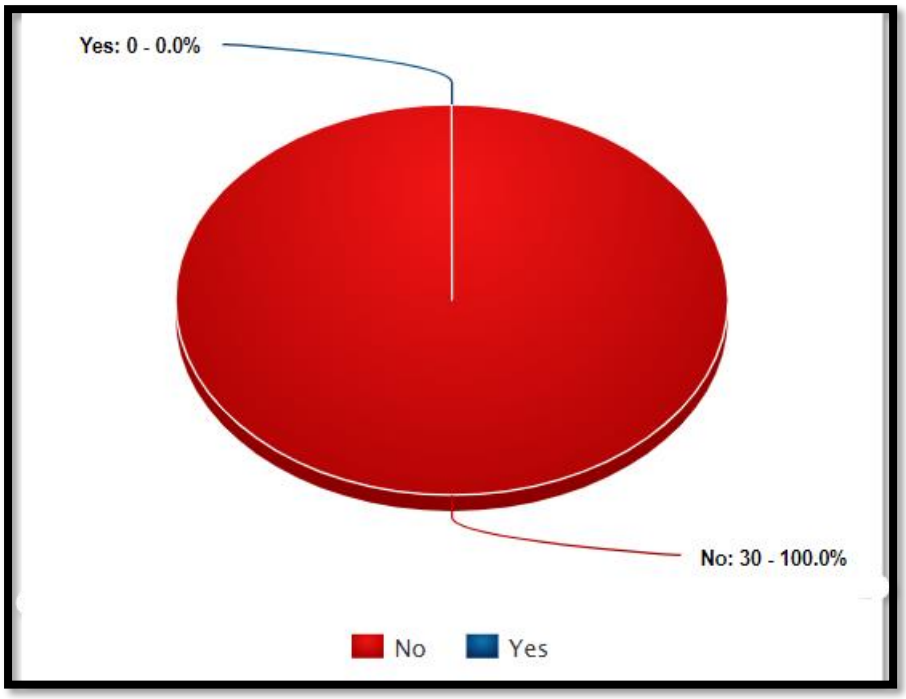


Figure 2.30 Pie chart of "Did you use any Augmented reality aided components in your daily life?"

The pie chart in Figure 2.30 shown that all the respondents did not use AR aid components in their daily life, as mention at above, AR technology is not popular in our country and it have not implemented on aid in our daily life.

7. What is the AR application you use before? Please list down.

Zero respondent use any Augmented reality aided components in your daily life, no result for this question.

8. If augmented reality elements are included to support the learning of Physics contents especially for visualization, do you think it is necessary?

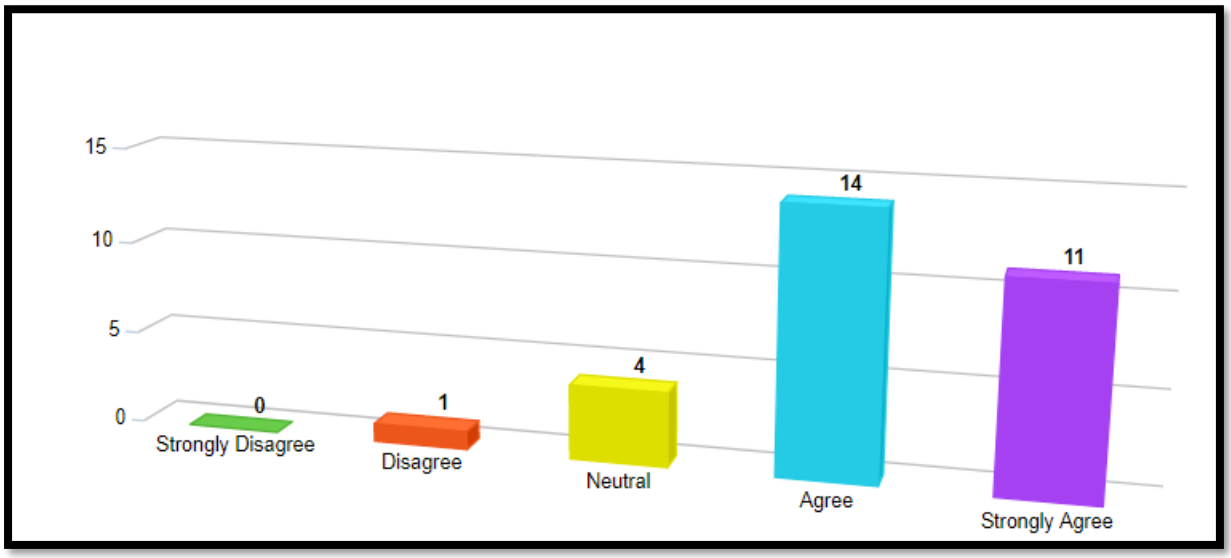


Figure 2.31 Bar chart of "If augmented reality elements are included to support the learning of Physics contents especially for visualization, do you think it is necessary?

The bar chart in Figure 2.31 show respondent thinks it that necessary to let augmented reality elements are included to support the learning of Physics contents especially for visualization. 11 respondents strongly agree this statement and 14 respondents agree, 4 respondents think neutral, and only one respondent disagree. Based on the result majority of them support with author statement when AR element included can support and aided in Physics learning especially for visualization.

D)Specific Questions (expectation of the software)

Lecture Module

1.In lecture module, the content will be separate each topic into concept, calculation format, example in reality will enhance user understanding and have better learning outcome. Do you agree?

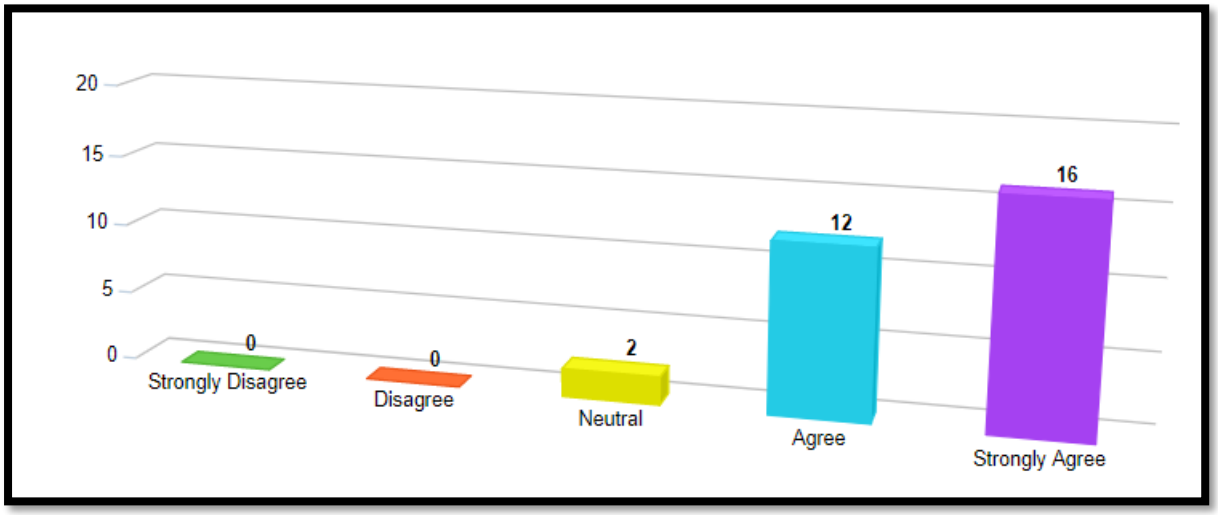


Figure 2.32 Bar chart of "In lecture module, the content will be separate each topic into concept, calculation format, example in reality will enhance user understanding and have better learning outcome. Do you agree?"

The bar chart in Figure 2.32 shows that the degree of agree based on the lecture module idea from author, the content will be separate each topic into concept, calculation format, example in reality will enhance user understanding and have better learning outcome. 16 respondents strongly agree with this statement and 12 respondents agree, 2 respondents stay neutral.

2.In lecture module, provide more 2D diagram or animation about the topics will enhance user understanding and have better learning outcome.
Do you agree?

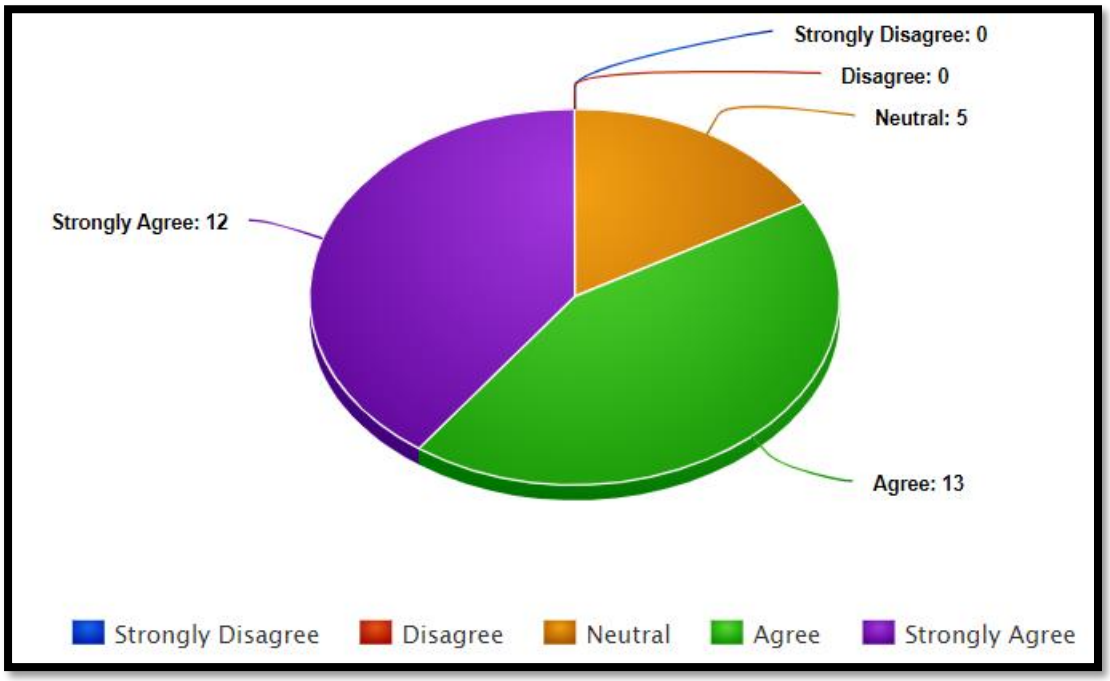


Figure 2.33 Pie chart of "In lecture module, provide more 2D diagram or animation about the topics will enhance user understanding and have better learning outcome. Do you agree?"

The bar chart in figure 2.33 shows the degree of agree based on the lecture module idea from author, provide more 2D diagram or animation about the topics will enhance user understanding and have better learning outcome. 16 respondents strongly agree with this statement and 12 respondents agree, 2 respondents stay neutral.

Tutorial Module

1.Tutorial module should have different types of question including objective, calculation, multiple choice question.
Do you agree?

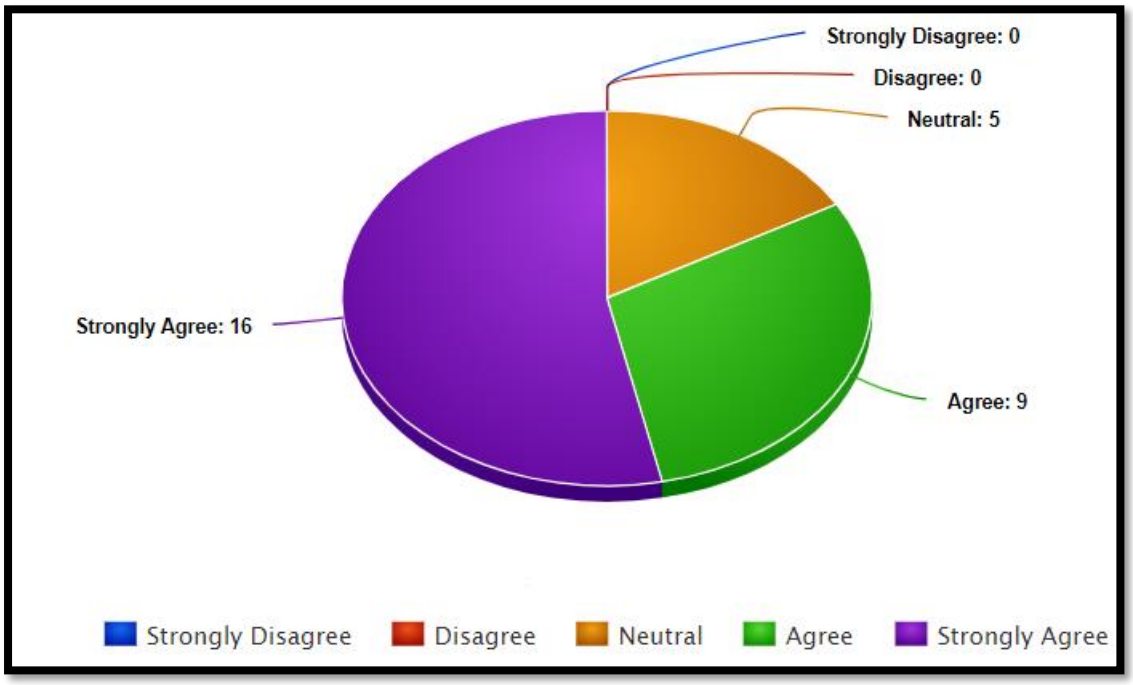


Figure 2.34 Pie chart of "Tutorial module should have different types of question including objective, calculation, multiple choice question. Do you agree?"

The pie chart in Figure 2.34 shows the degree of agree based on tutorial module idea should have different types of question including objective, calculation, multiple choice question. 16 respondents strongly agree with author's idea and 9 respondents agree, 5 respondents stay neutral. As we know Physics subject examination has different type of question, the student should familiar with each question so they can answer well in exam.

2.Tutorial module should design based on what expected to be learnt in lecture module, experiment module and AR module.
Do you agree?

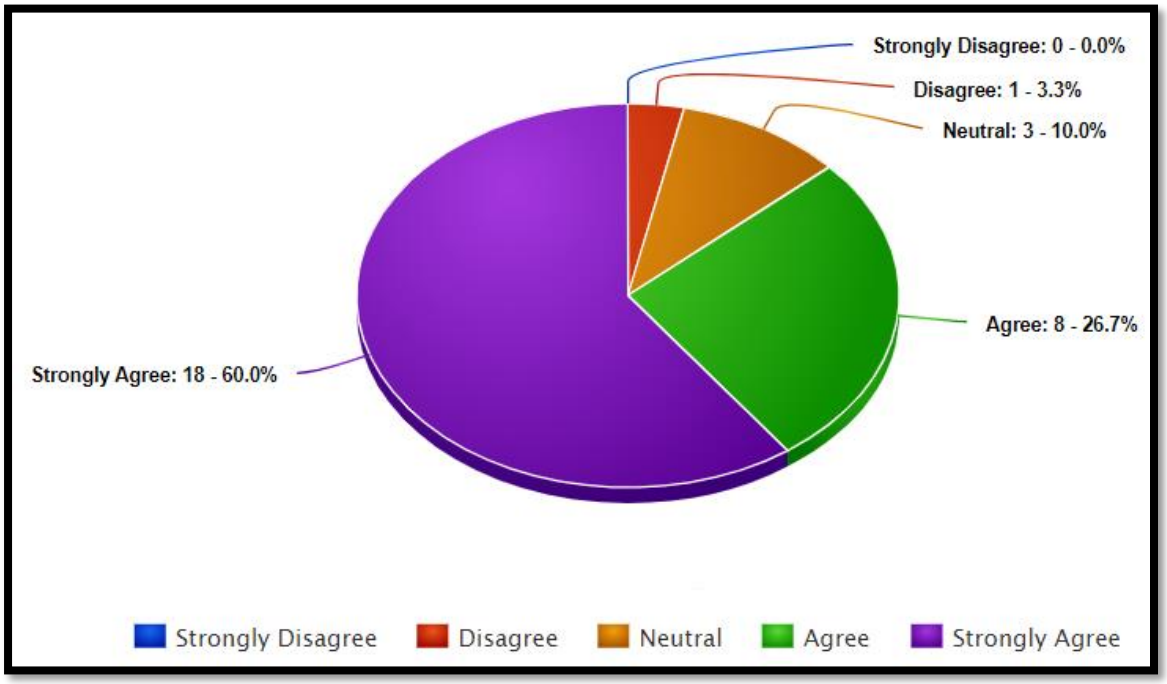


Figure 2.35 Pie chart of "Tutorial module should design based on what expected to be learnt in lecture module, experiment module and AR module. Do you agree?"

The pie chart in Figure 2.35 shows the degree of agree based on design based on what expected to be learnt in lecture module, experiment module and AR module. 18 respondents strongly agree with author's idea and 8 respondents agree, 3 respondents stay neutral and only one respondent disagree with this statement. Due to time constraint, author focus all module on one topic only. The topics selected is based the user requirement which chapter is the most difficult chapter.

3.If user answer wrong in tutorial module, system will show some explanation why the answer provided is wrong and let the user try again or given some hint based on the question.
Do you agree?

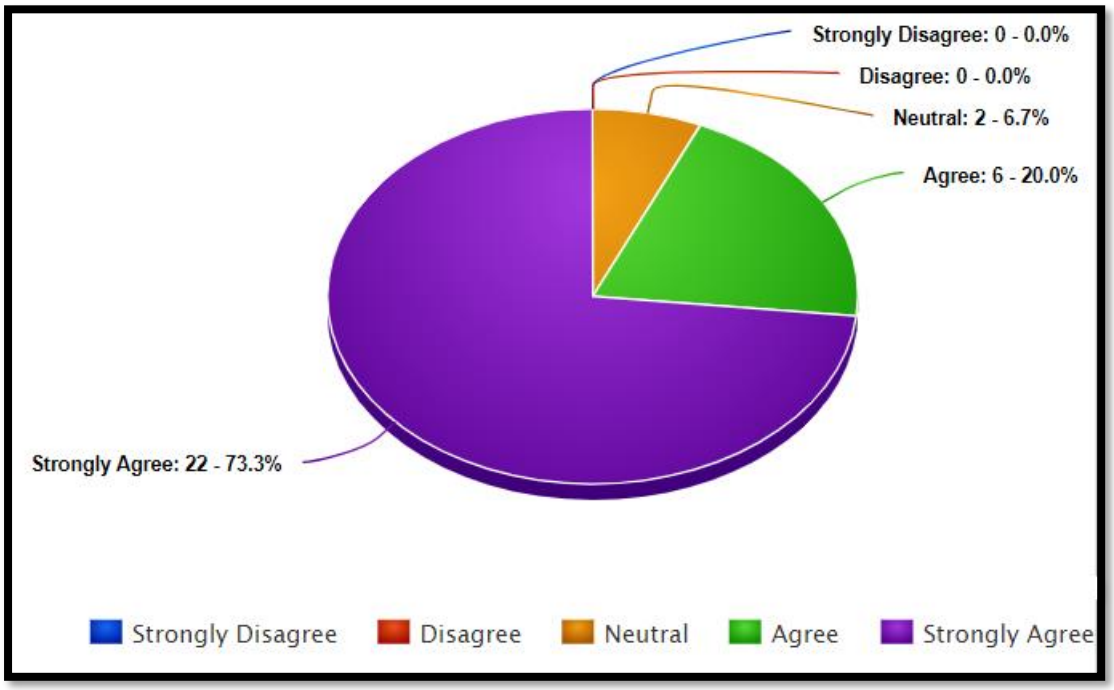


Figure 2.36 Pie chart of "If user answer wrong in tutorial module, system will show some explanation why the answer provided is wrong and let the user try again or given some hint based on the question. Do you agree?"

The pie chart in Figure 2.36 shows the degree of agree based on design based on if user answer wrong in tutorial module, system will show some explanation why the answer provided is wrong and let the user try again or given some hint based on the question. 22 respondents (73.3%) strongly agree with author's idea and 9 respondents agree (20%), only 2 respondents stay neutral (6.7%). The tutorial module can let student well digest what they learnt from lecture. Student can apply they understanding and do the question, if they misunderstanding the concepts, the explanation is important to let them know what mistake they done and can increase the efficiency of study process.

Experiment module

1. Do you want to have more interactive elements in virtual experiment?

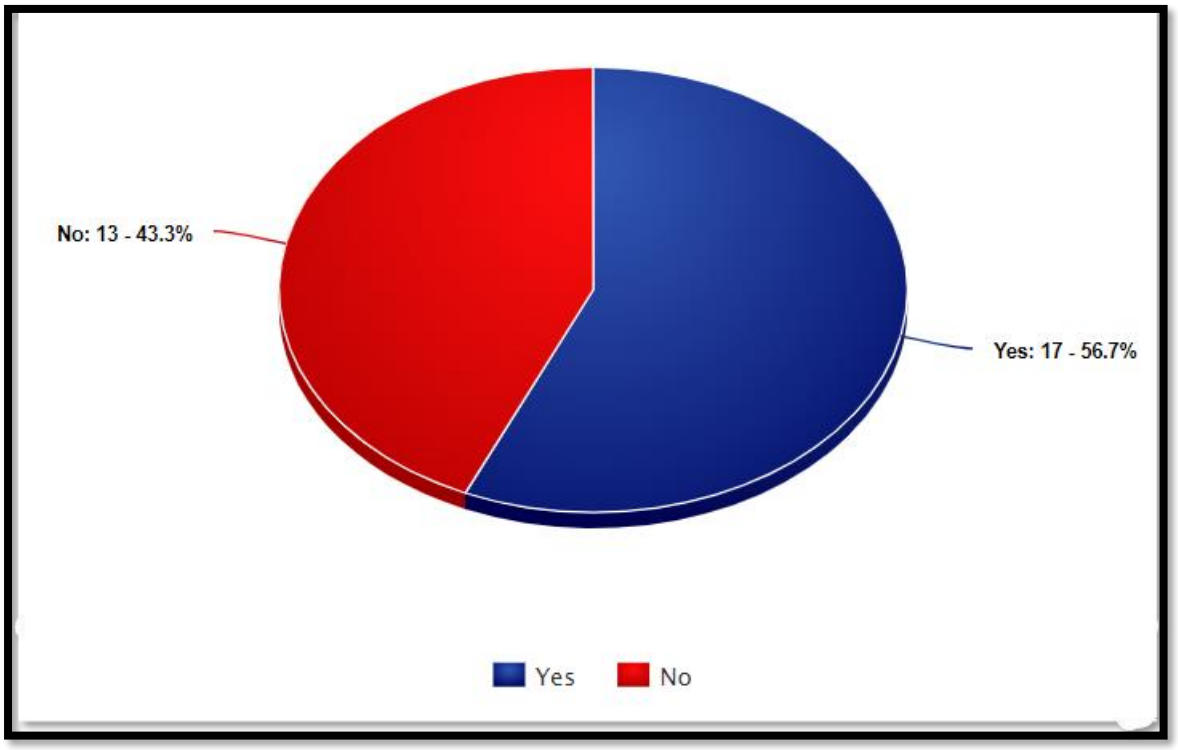


Figure 2.37 Pie chart of "Do you want to have more interactive elements in virtual experiment?"

The pie chart in Figure 2.37 shows that whether the respondent want more interactive in the experiment module. 17 respondents want more interactive element in the experiment module (56.7%) and 13 respondents don't want so much interactive element in the experiment module (43.3%). In virtual experiment, so save a of budget and time to perform, the main purpose is the student can understand the content try to bring out from the experiment, more interactive element the user can feel like they are doing things and more understand the setup and content.

2. In experiment module, user can adjust parameters and show different results based on user input to manipulate variable that can increase effectiveness of learning.
   Do you agree?

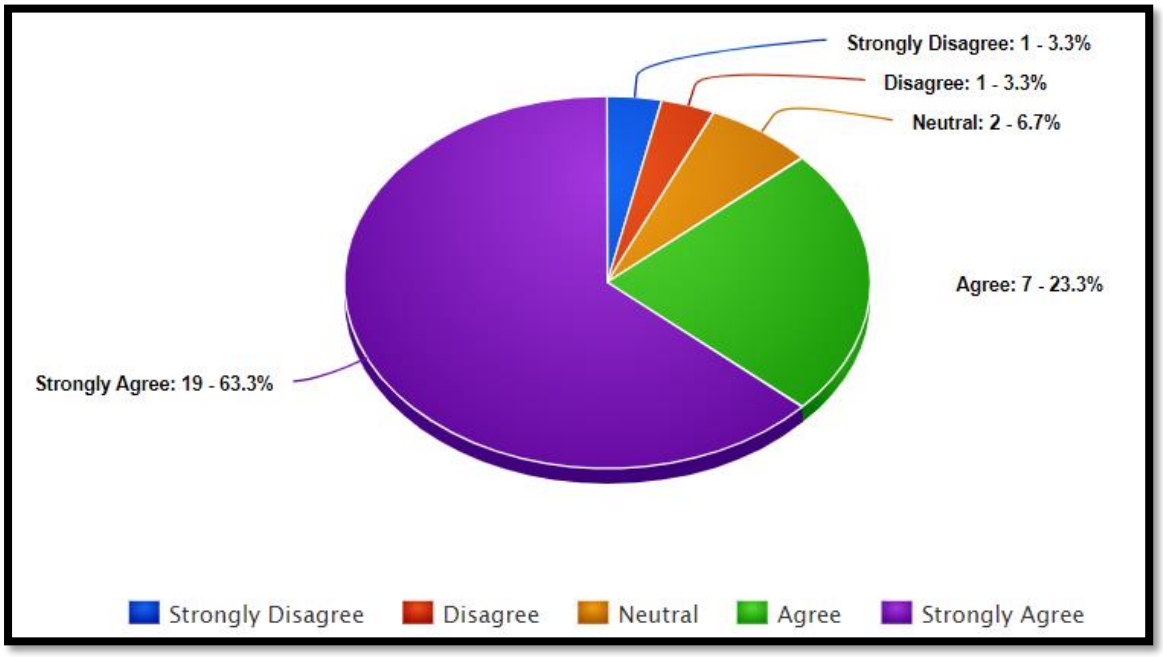


Figure 2.38 Pie chart of "In experiment module, user can adjust parameters and show different results based on user input to manipulate variable that can increase effectiveness of learning. Do you agree?"

The pie chart in Figure 2.38 shows whether the degree of agree based on author idea about the experiment module, user can adjust parameters and show different results based on user input to manipulate variable that can increase effectiveness of learning. 19 respondents strongly agree (63.3%) ,7 of the respondents agree (43.3%), 2 respondents neutral, one respondent disagree (3.3%) and one respondent strongly disagree (3.3%). For science experiment, the manipulated variables is important to show different result and let people have better understanding how the theory and concepts work.

3. In experiment module, it should provide lab manual for reading to have a better understanding about the virtual experiment.
   Do you agree?

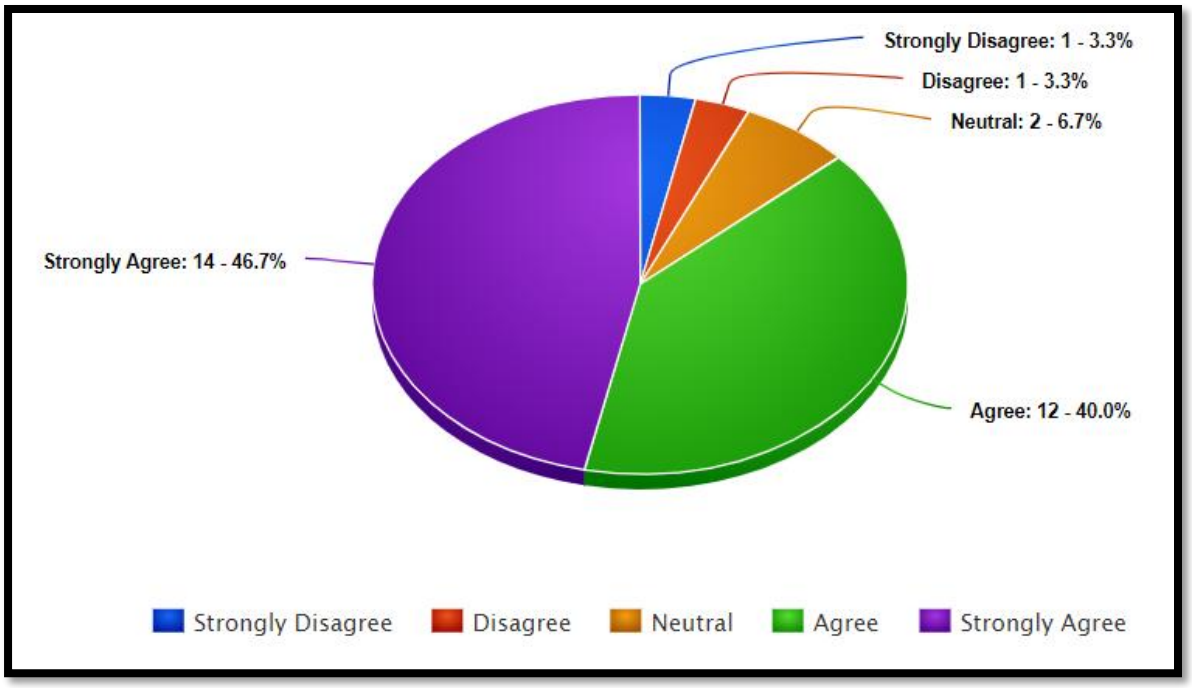


Figure 2.39 Pie chart of "In experiment module, it should provide lab manual for reading to have a better understanding about the virtual experiment. Do you agree?"

The pie chart in Figure 2.39 shows whether the degree of agree based on author idea about the experiment module, it should provide lab manual for reading to have a better understanding about the virtual experiment. 14 respondents strongly agree (46.7%), 12 of the respondents agree (40.0%), 2 respondents neutral (6.7%), one respondent disagree (3.3%) and one respondent strongly disagree (3.3%). For science experiment, the lab manual is important when we perform experiment to refer, it shows the problem statement, procedure etc.

Quiz module

1. User need to answer all the questions within the given time as a training for real exam. Do you agree?

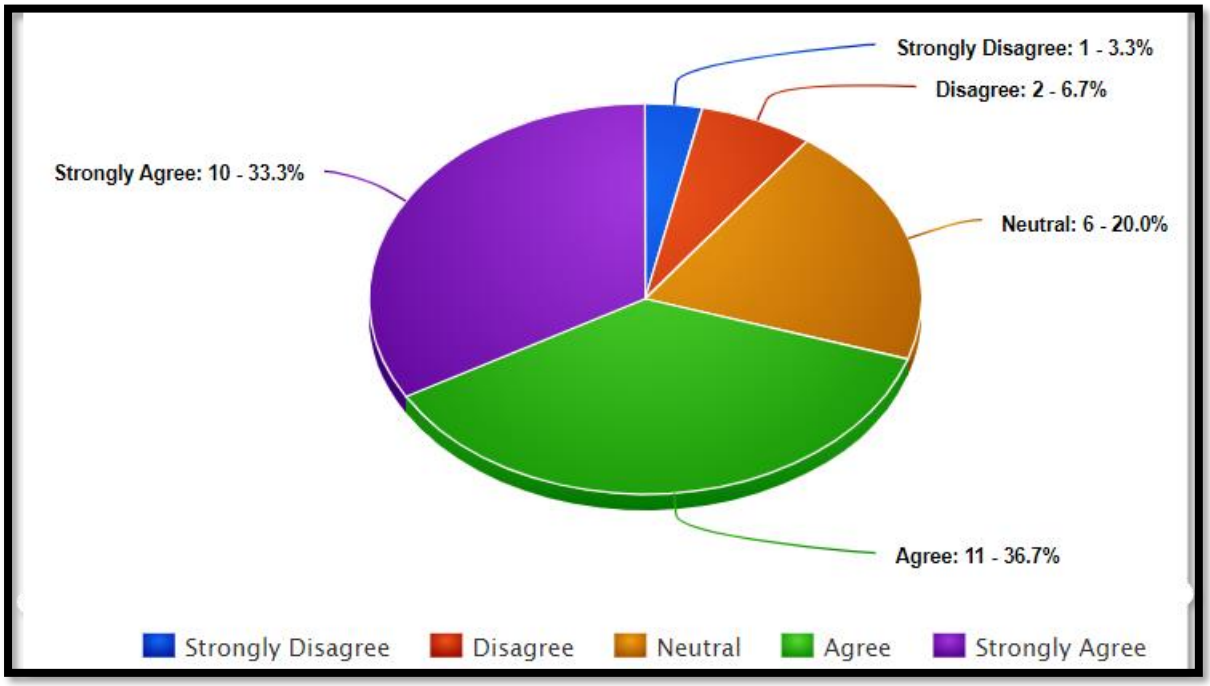


Figure 2.40 Pie chart of "User need to answer all the questions within the given time as a training for real exam. Do you agree?"

The pie chart in Figure 2.40 shows whether the degree of agree based on author idea about the quiz module, all the questions within the given time as a training for real exam. 10 respondents strongly agree with the statement (33.3%), 11 respondents agree (36.7%), 6 neutral (20.0%), 2 disagree (6.7%) and only one respondent strongly disagree (3.3%). Most of the time student facing not enough time to answer all the question in examination, because Physics subject may include many calculations problem need do it carefully. By practice in the learning application can increase speed of answer.

2. Past year questions applied in quiz module will be useful.
Do you agree?

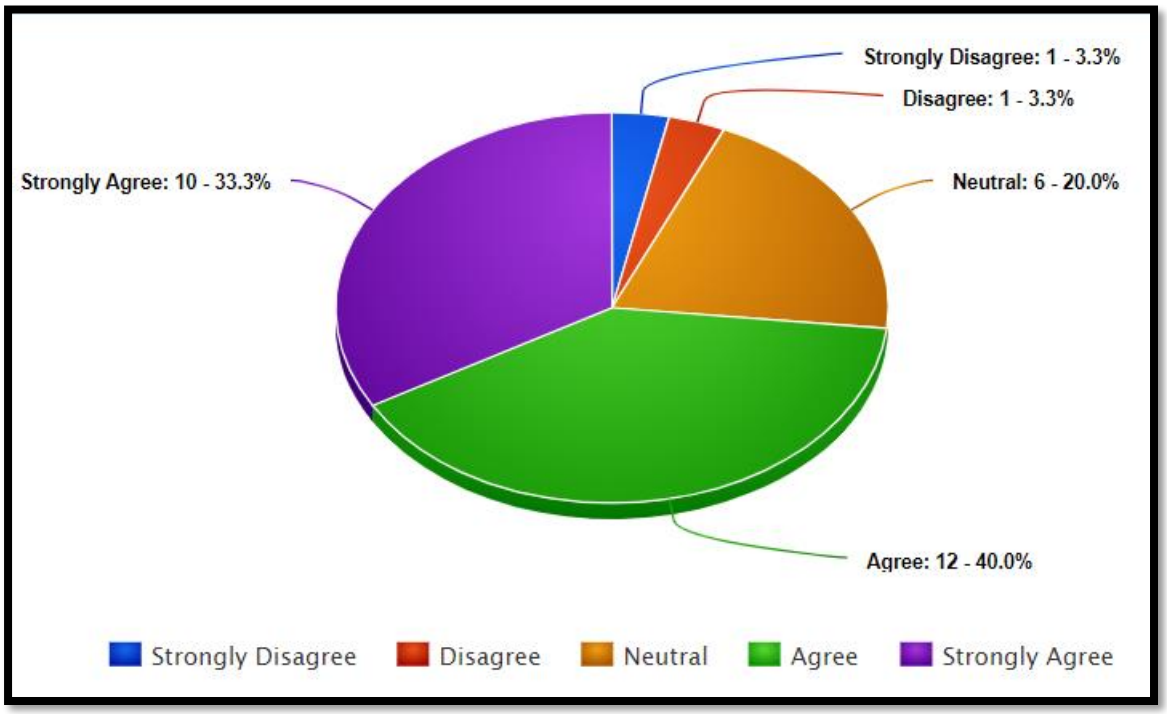


Figure 2.41 Pie chart of "Past year questions applied in quiz module will be useful. Do you agree?"

The pie chart in Figure 2.41 shows that whether the degree of agree based on author idea about the quiz module, the questions applied in the quiz module should take from past year paper set. 10 respondents strongly agree with the statement (33.3%), 12 respondents agree (40.0%), 6 neutral (20.0%), 2 disagree (3.3%) and only one respondent strongly disagree (3.3%). Most of the time student will practice by doing the past year questions to enhance their understanding. The past year paper question about particular topics will be use in quiz module. The author belives it can help student much in understanding concepts.

AR learning module

1. In AR module, the model should include "drag and rotate" features to have better interactivity.
   Do you agree?

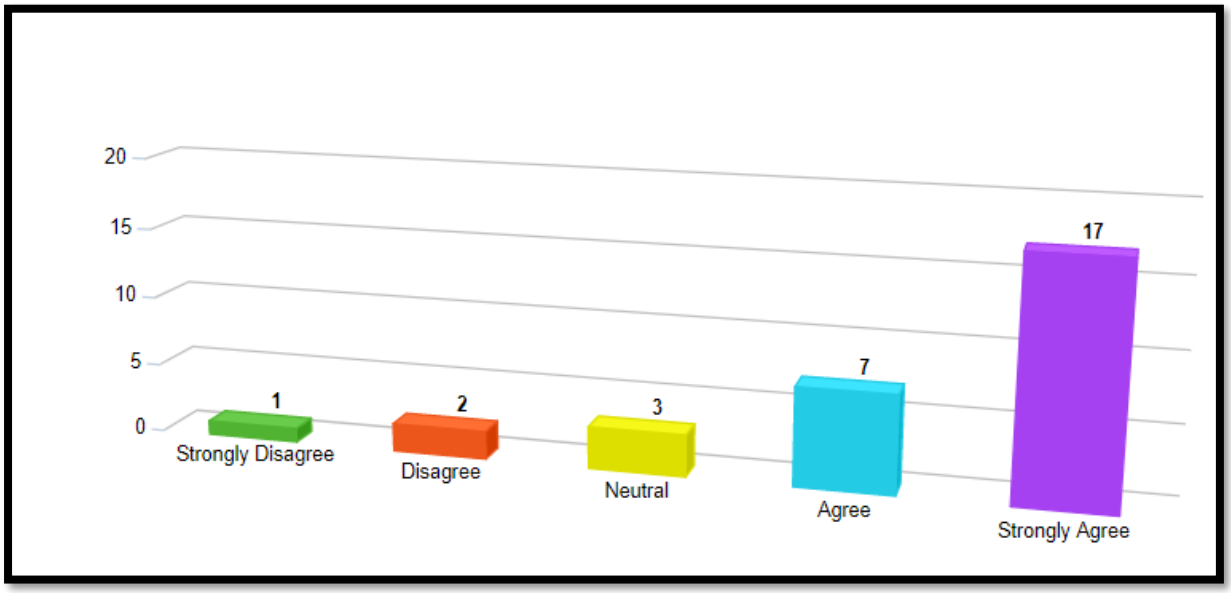


Figure 2.42 Bae chart of "In AR module, the model should include "drag and rotate" features to have better interactivity. Do you agree?"

The bar chart in Figure 2.42 shows whether the degree of agree based on author idea about the AR module, the model should include "drag and rotate" features to have better interactivity. 17 respondents strongly agree with the statement, 7 respondents agree, 3 neutral, 2 disagree and only one respondent strongly disagree (3.3%). AR module will show the virtual presentation of the particular concepts, and drag and rotate function can increase the interactivity.

2. In AR module, manipulated variables should be shown to the user and allow adjustment to get different outputs for better interactivity.
   Do you agree?

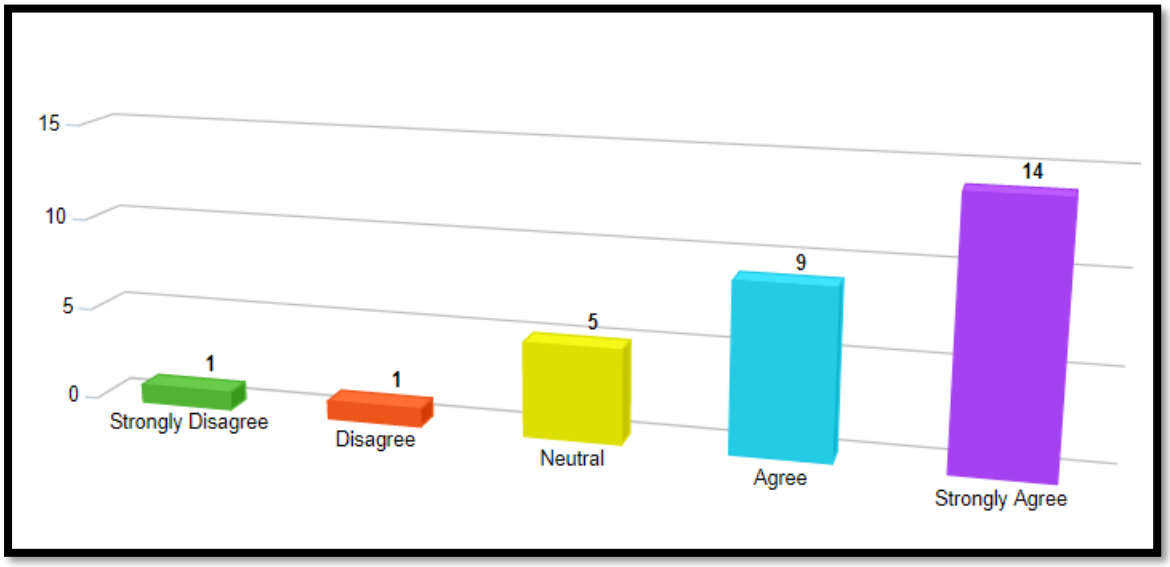


Figure 2.43 Bar chart of "In AR module, manipulated variables should be shown to the user and allow adjustment to get different outputs for better interactivity. Do you agree?"

The bar chart in Figure 2.43 shows whether the degree of agree based on author idea about the AR module, manipulated variables should be shown to the user and allow adjustment to get different outputs for better interactivity. 14 respondents strongly agree with the statement, 9 respondents agree, 5 neutral, 1 disagree and only one respondent strongly disagree (3.3%). AR module will show the virtual presentation of the particular concepts, manipulated variables should be shown to the user and allow adjustment to get different outputs for better interactivity.

Did you have any suggested improved/added component for any module ?

If yes, please stated out

No respondent gives any suggestion.

2.9.3 Discussions

Majority of the respondent rate themselves not understand well in Physics subject, we can observe that Physics is a challenging subject. The author decided to focus whole learning on one topic only which is the Form 4 syllabus last chapter, Light. This chapter is the second highest result of respondent think is difficult and normally school teacher will less focus on this chapter due to time constraint. The author hope that can increase Form 4 student understanding and answer well in exam for this chapter's content and theory. Most of them face the problems not able to memorise and understand the mathematical equation, and not able to visualize the theory or concepts try to bring out from the topics. From the result, the author found out learning application is not popular to aided student in Physics learning, the author hopes the development of this application's contribution will help much in improve the software for future usage. For the respondent who did not use learning software in Physics learning expectation to the learning software, there are three main point they hope can included in the system. First, they hope can included more video inside, the video can be short, interesting explain the concepts in simplest and easiest way. Second, animation motion video can help much in visualize the concepts of the particular topics. Third, added in some history or interesting fact and let them more why they need to learn the topics and how to apply in industry or daily life. They agree the learning application can improve their Physics subject study performance. They welcome AR technology and agree with the statement given AR element applied in the learning application can enhance the visualization. For five modules, author have proposed the idea and ask in the user requirement whether they agree with the statement stated, and the result shown all the ideas and strongly agree by the majority.

CHAPTER 3 METHODOLOGY AND SYSTEM DESIGN

3.1 Overview

This chapter the author will discuss system requirements to develop the application based on software and hardware. The author will also list the software requirement for each multimedia element. The methodology being used is ADDIE model to develop the system will be discuss in this chapter about five phases what author will be do. System flow diagram will be show and storyboard design according every module proposed. Lastly the project planning will be showed as list in the granting chart according methodology being selected by author.

3.2 System Requirements

3.2.1 Software Requirements

Authoring tool (development platform): Vuforia, Unity, Android Studio

Vuforia is an augmented reality software development kit for mobile devices that enables the creation of augmented reality applications. It uses computer vision technology to recognize and track planar images and 3D objects in real time. Vuforia have high reliability for development AR module because Vuforia Engine can support AR app development for different OS such as Android, iOS, Lumin. This project having the AR module need Vuforia to develop, the features will be use are Image Targets, Object Tracking Methods, Model Targets etc.

Unity is a cross-platform game engine developed by Unity Technologies, this authoring tool gives developers ability to create games and experiences in both 2D and 3D. This platform is quite user-friendly, provide many documentations to let user know how to use and it can integrate with Vuforia engine, adding it to a Unity project. This software is chosen because it suitable to our project to create an interactive Experiment module and AR module. The features will be use are Editor Speed & Editor UI Redesign and Virtual Texturing

Android Studio is the official integrated development environment for Google's Android operating system, designed specifically for Android development. Andriod Studio is a popular and trustworty software to develop an application. In this project, the author need put in all module together and form a system, Android Studio can help to do that, and it having friendly user interface for developers. The features will be use are Visual Layout Editor,Colour Preview, Instant App Run etc.

Table 3.1: Software requirement for each multimedia element

Multimedia Element	Software
Text	• Adobe Illustrator • Fontlab Studio • FontCreator • Fontbase
Graphic	• Adobe Illustrator • Adobe Photoshop • Adobe InDesign • Affinity Designer
Audio	• Adobe Audio • Youtube to mp3 converter • Audacity
Video	• Youtube to mp4 converter • Adobe Premiere Pro CC • Wondershare Filmore9
Animation	• 3D painter • Anime Studio • Animaker • Synfig

3.2.2 Hardware Requirements

Table 3.2: Hardware requirement for each multimedia element

Hardware	**Minimum Requirements**	**Optimum Requirements**
OS	Windows 7	Windows 10
Processor	intel core i5-4690k	intel core i7-4790k
Memory	4GB RAM	8GB RAM or above
Graphics Card	GeForceMX130	GTX 780 or RX 470 or better
DirectX	Version 9.0c.	Version 12
Storage	500GB	1TB

3.3 ADDIE model

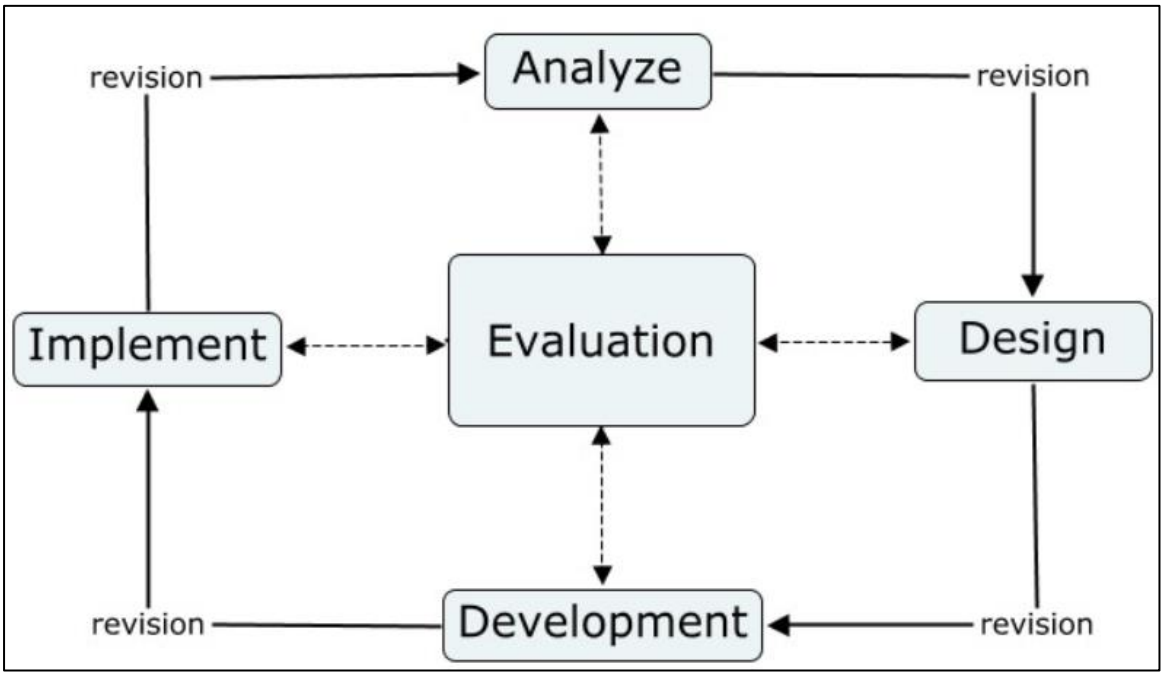


Figure 3.1 ADDIE model

3.3.1 Analysis

Analysis

The Analysis phase can be considered as the "Goal-Setting Stage." The focus of the designer in this phase is on the target audience. In the analysis phase, the instructional problems and goals are clarified, and main objectives will be established. It is also here that the program matches the level of skill and intelligence that each student/participant shows, . developers have to identified learning environment and learner's existing knowledge and skills. There were some research techniques will be used such as jobs analysis, task analysis and needs analysis, in the end the output of the analysis will include instructional goal and a list of tasks, these outputs will later be the input for the design phase.

During the analysis phase, more on documentation work, author will be conduct research to analyse the existing learning application. The author will do literature review about related information of the existing system such as functionalities, features, strengths and weakness can be found. Multimedia element which are text, audio, video, animation, graphics, and component of interface design which are usage of colour, consistency navigation panel, clarity of contents, interactivity, simplicity these features will be compared and produce comparison tables. As a result, the author able to identified problem statements and proposed solution to solve these problems. After that, the main objectives of this project and project

scope are established. The authoring, developing tools and supporting software are analysed and identified.

3.3.2 Design

The design phase will determine all goals with learning objective, perform subject matter analysis, assessment instruments to know tools to be used to gauge performance, various test for exercises and content, lesson planning and media selection. The approach in this phase should be systematic with a logical, orderly process of identification, development and evaluation of planned strategies which target the attainment of the project's goals. Systematic means a logical, orderly method of identifying, developing and evaluating a set of planned strategies targeted for attaining the project's goals. It should follow a very specific set of rules, and each element of the instructional design plan must be executed with attention to detail. Being a stickler for the details is crucial to the success of the design stage. This systematic approach makes sure that everything falls within a rational and planned strategy, or set of strategies, that has the ultimate goal of reaching the project's targets.

During the design phase, the author will sketch prototype of the user interface design to know the general idea about learning software look like. Author will do data gathering and survey from target user which are student and teacher by using questionnaire. The questionnaire will be two section, first section is 10 questions about what content of the physics learning software should focus on, second section are 10 questions about how a learning software interface should be look like. The response will be record and form a analysis report. After that, UML diagram about use cases diagram and activity flow will be produced by author and these inputs will be use and follow in development phase.

3.3.3 Development

The development phase is where the developers create and assemble the content assets that were created in the design phase. Programmers work to develop and/or integrate technologies. Testers perform debugging procedures. The project is reviewed and revised according to any feedback given.

During the development phase, the author will choose Unity as development platform, integrate with Vuforia and start coding the software. The lecture module will be developed first for the topics chosen in analysis and design phase. Second, the tutorial module will be developed based on learning scope in lecture module and follow by quiz module. Forth, the experiment module will be develop using Adobe Illustrator to design the graphic part. AR

module will be the last one to develop using Unity. The design of interface by using authoring tool and other supporting software like Adobe Illustrator, Anime Studio to choosing the colours , font and adding the attractive graphics. The interface will be design based on consistency navigation panel, clarity of the content and interactivity. Author will add in more multimedia elements such as text, animation, video, to enhance understanding of the user in learning.

3.3.4 Implementation

In the implementation phase, a procedure for training the facilitators and the learners is developed. The facilitators' training should cover the course curriculum, learning outcomes, method of delivery, and testing procedures. Preparation of the learners include training them on new tools (software or hardware), student registration.

During implementation phase, the deliverable will be produced, the software is coded, tested, installed and supported. The author will provide training how to use the software and the software will be testing by the target user and found out the weakness and improve again. The several versions of software will be produced based on their user experience.

3.3.5 Evaluation

The evaluation phase consists of two parts: formative and summative. Formative evaluation is present in each stage of the ADDIE process. Summative evaluation consists of tests designed for domain specific criterion-related referenced items and providing opportunities for feedback from the users.

During evaluation phase, the author will be performing continuous formative evolution from time to time. The author will be testing all functionalities first. At the end of project II, once the system is developed the author will distribute the system and invite the user to sit for testing, the testing criteria include interface design testing, functionalities testing, unit testing, system testing and the author will collect feedback by interview section from tester, to determine reliability and content validity, the deliverable can meet the objective or not, the feedback will be collected for further enhancement for the system. The testing part will be focus interface design include useability, clarity of content and simplicity, and another part will focus on application module functionalities. The author will produce the summarized report about receive final output regarding the project.

3.4 System Flow Diagram

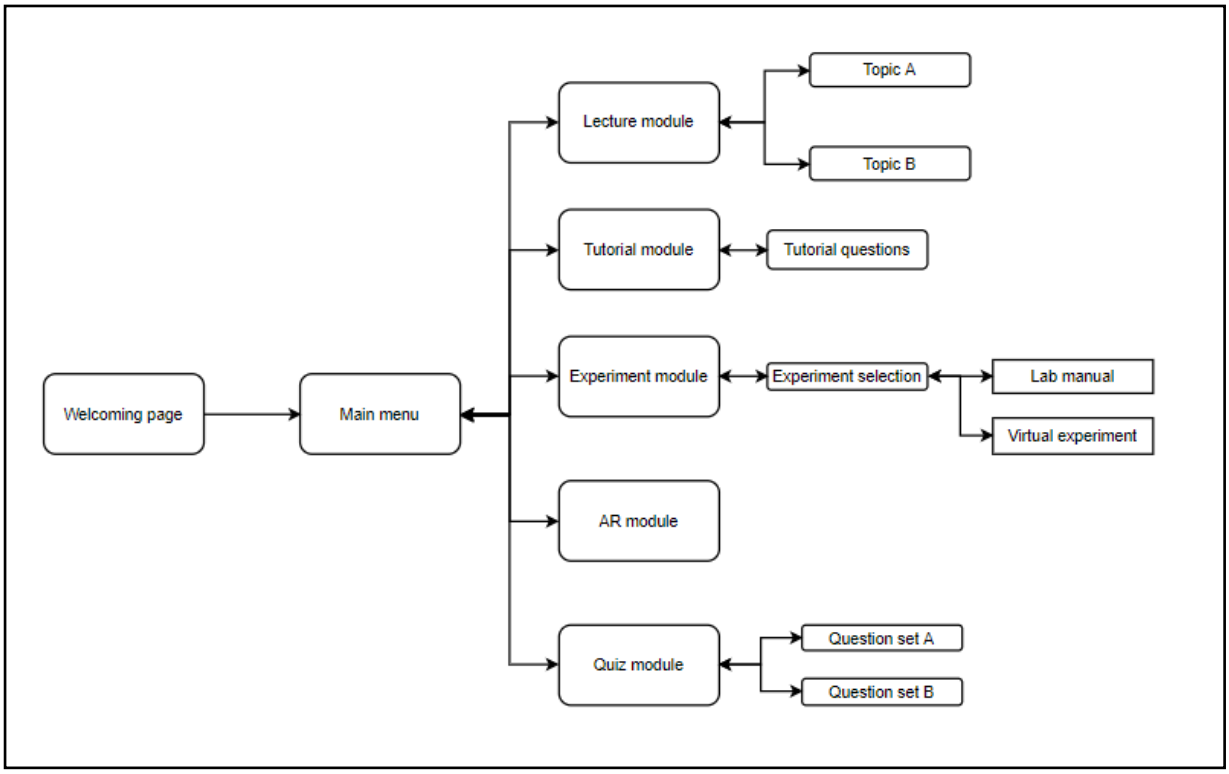


Figure 3.2 System Flow Diagram

3.5 Storyboarding Design

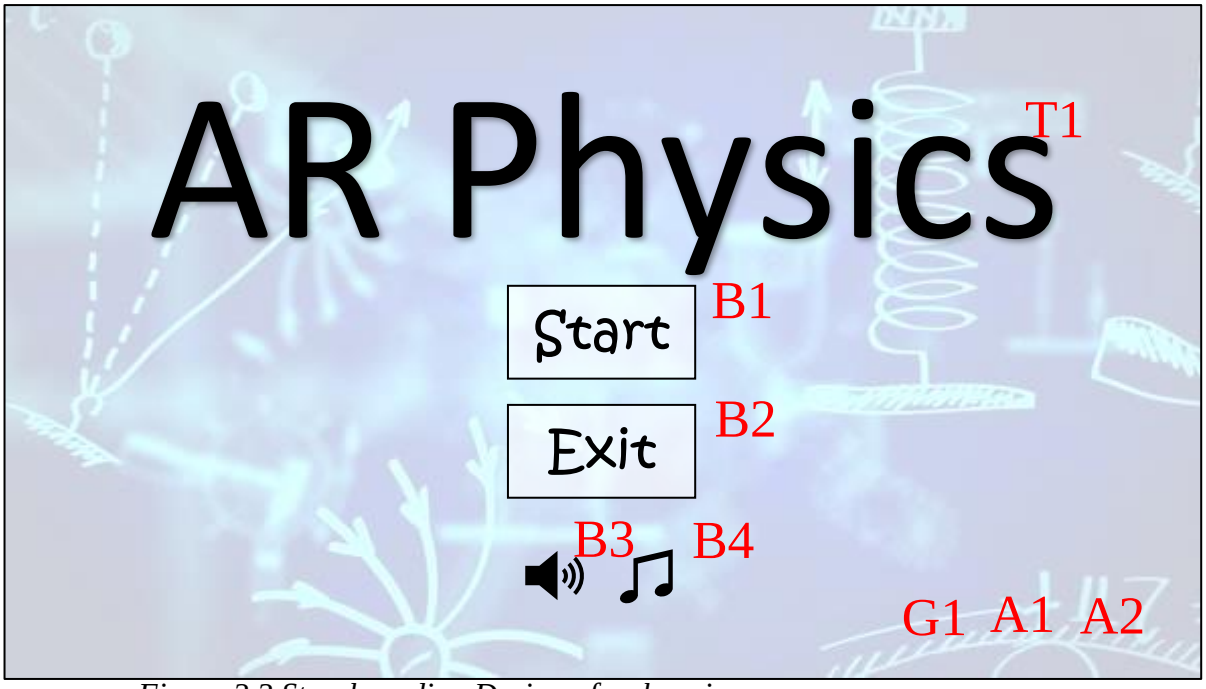
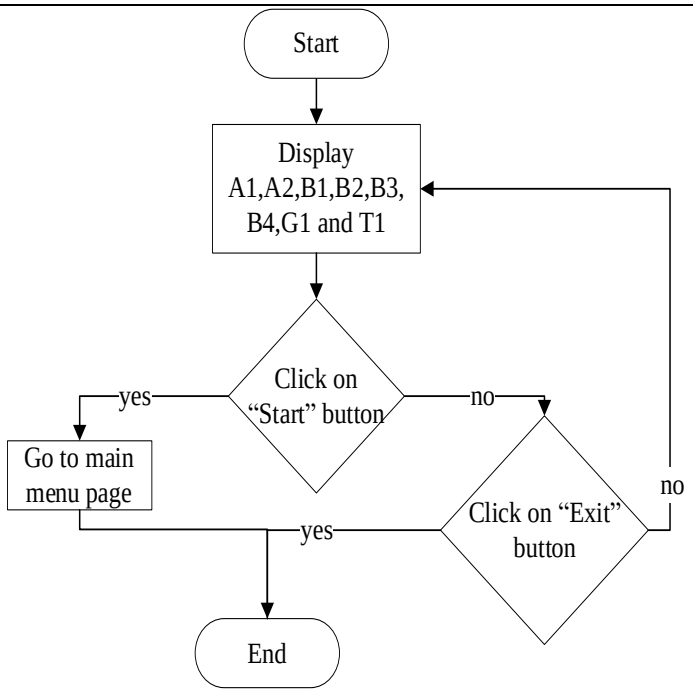


Figure 3.3 Storyboarding Design of welcoming page

Table 3.3 Description and flow diagram for welcoming page storyboarding

Descriptions	Flow Diagram
A1,A2,B1,B2,B3,B4,G1 and T1 will be shown on the Welcoming page when the application being launch. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B1 is a button element link to main menu. -B2 is a button element to terminate the application. -B3 is a button element to turn off sound. -B4 is a button element to turn off background music. -G1 is the background graphic. -T1 is the text element show name of the application.	

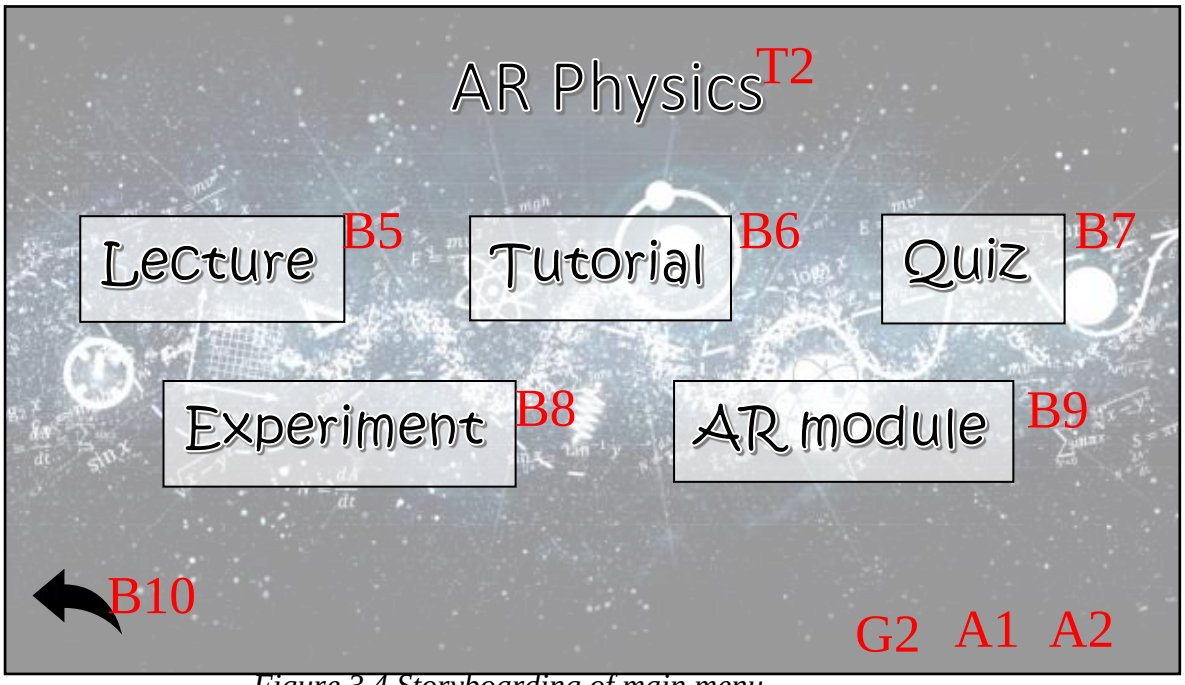
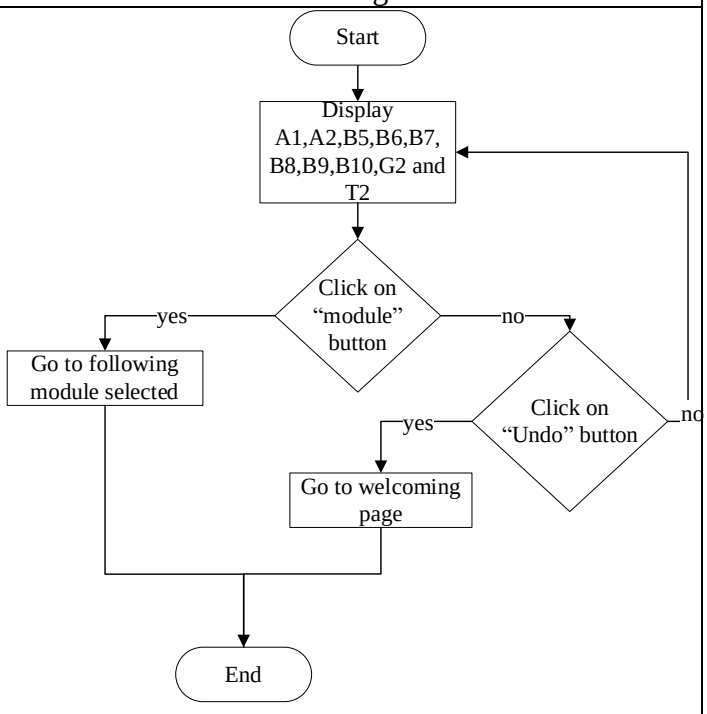


Figure 3.4 Storyboarding of main menu

Table 3.4 Description and flow diagram for main menu storyboarding

Descriptions	Flow Diagram
A1,A2,B5,B6,B7,B8,B9,B10,G2 and T2 will be shown when user come to main menu page. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B5 is a button element link to lecture module. -B6 is a button element link to tutorial module. -B7 is a button element link to quiz module. -B8 is a button element link to experiment module. -B9 is a button element link to AR module. -B10 is a button to undo to welcoming page. -G2 is the background graphic. -T1 is the text element show name of the application.	

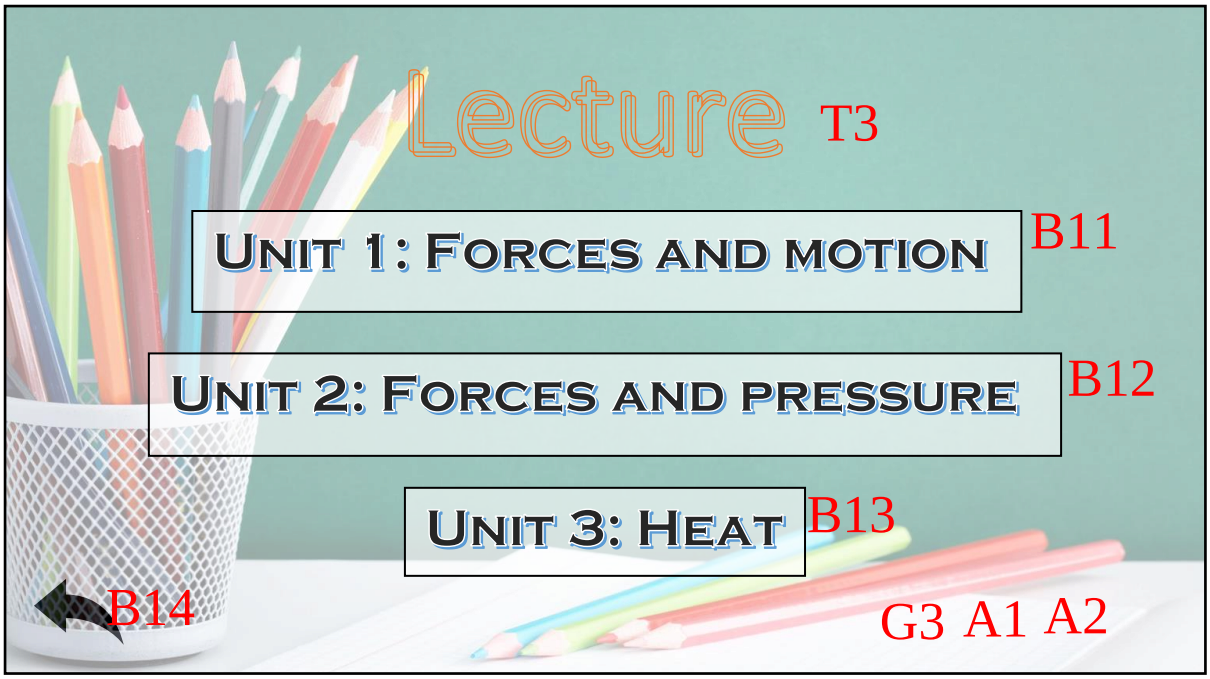
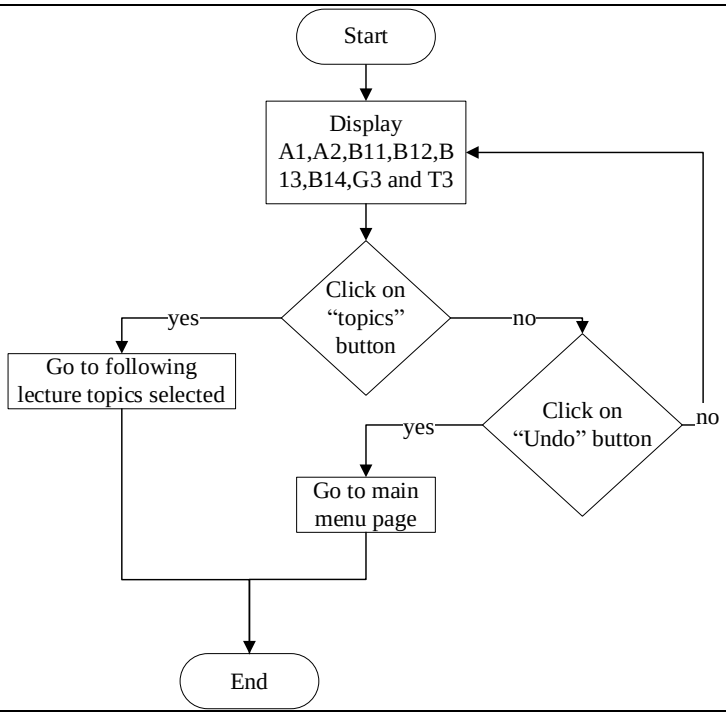


Figure 3.5 Storyboarding of lecture module

Table 3.5 Description and flow diagram for lecture module storyboarding

Descriptions	Flow Diagram
A1,A2,B11,B12,B13,B14,G3 and T3 will be shown when user come to lecture page. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B11 is a button element link to lecture module topics. -B12 is a button element link to lecture module topics. -B13 is a button element link to lecture module topics. -B14 is a button to undo to welcoming page. -G3 is the background graphic. -T3 is the text element show lecture module.	

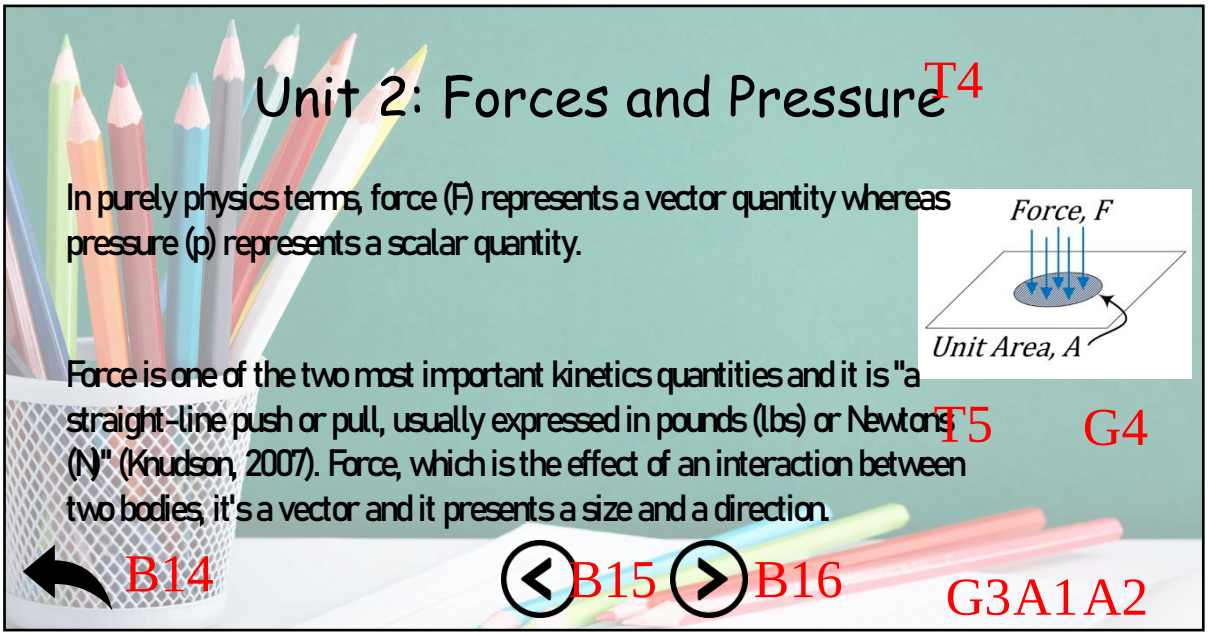
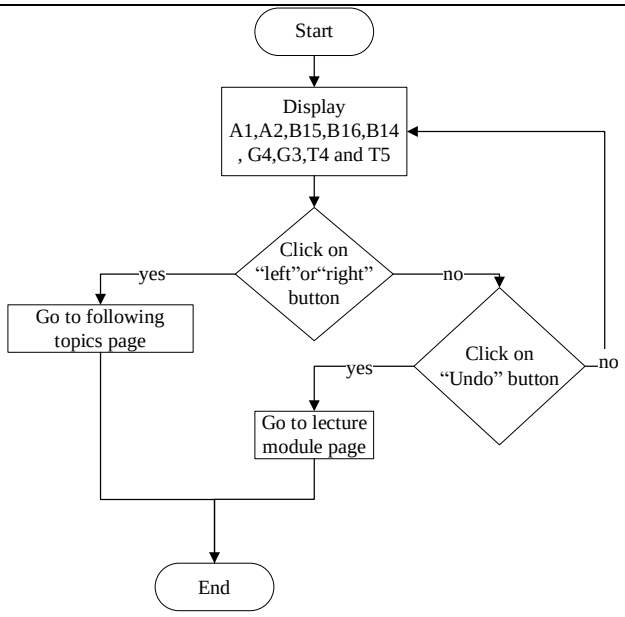


Figure 3.6 Storyboarding of lecture module topics

Table 3.6 Description and flow diagram for lecture module topics storyboarding

Descriptions	Flow Diagram
A1,A2,B15,B16,B14, G4,G3,T4 and T5 will be shown when user come to lecture topics. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B16 is a button element link to next page of the topics. -B15 is a button element link to previous page of the topics -B14 is a button to undo to welcoming page. -G3 is the background graphic. -G4 is the picture of the concept. -T4 is the text element show topics name. -T5 is the text element show content of the topics	

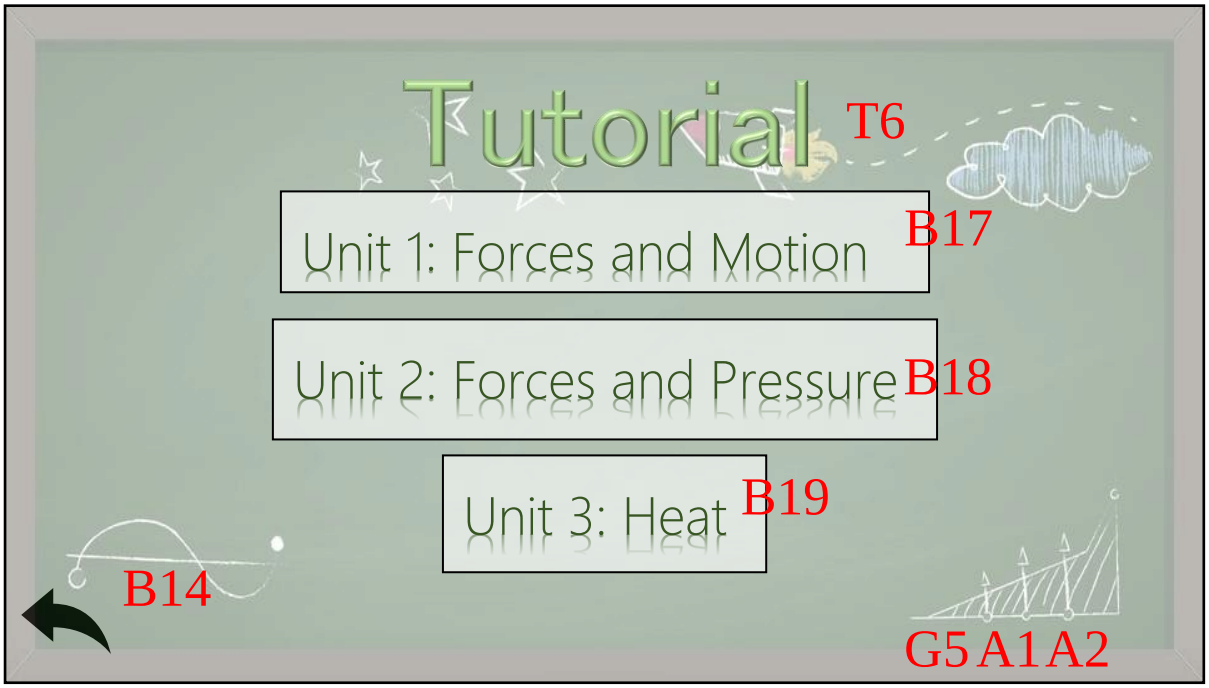
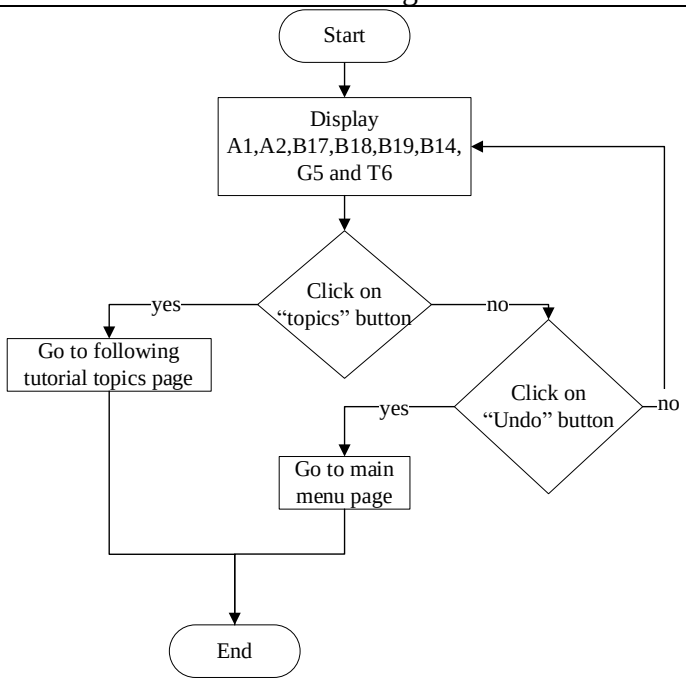


Figure 3.7 Storyboarding of tutorial module

Table 3.7 Description and flow diagram for tutorial module storyboarding

Descriptions	Flow Diagram
A1,A2,B17,B18,B19,B14,G5 and T6 will be shown when user come to tutorial module. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B17 is a button element link to tutorial module topics. -B18 is a button element link to tutorial module topics. -B19 is a button element link to tutorial module topics. -B14 is a button to undo to welcoming page. -G5 is the background graphic. -T6 is the text element show tutorial module.	

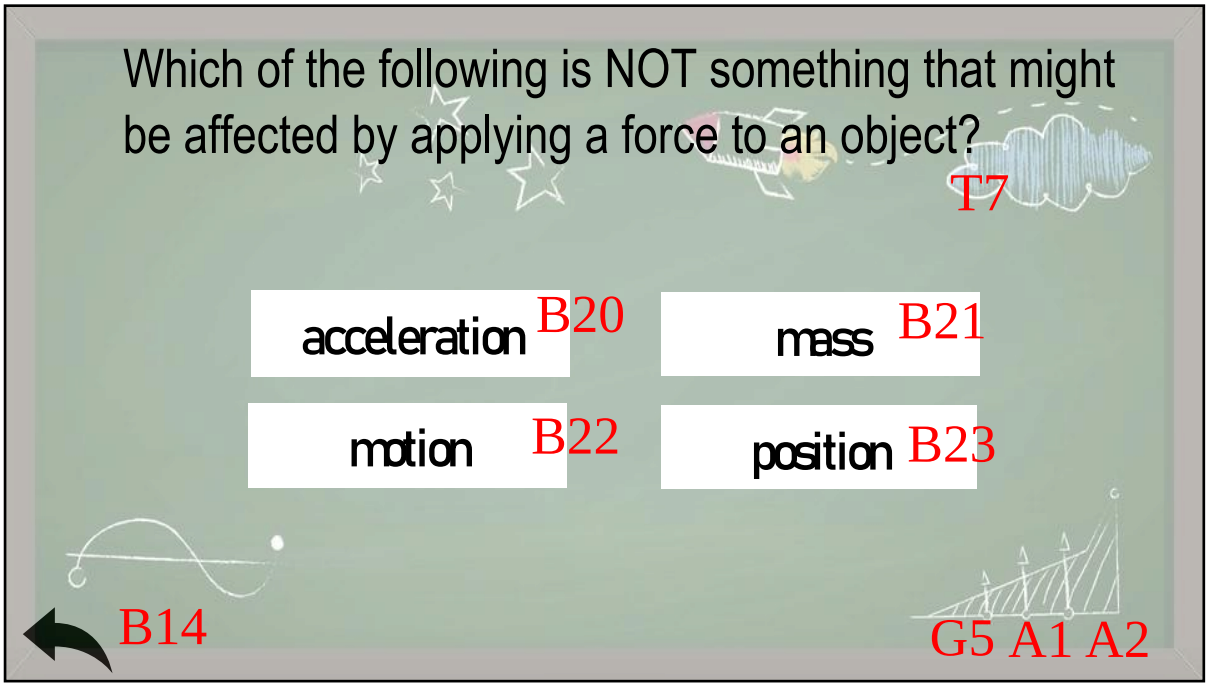
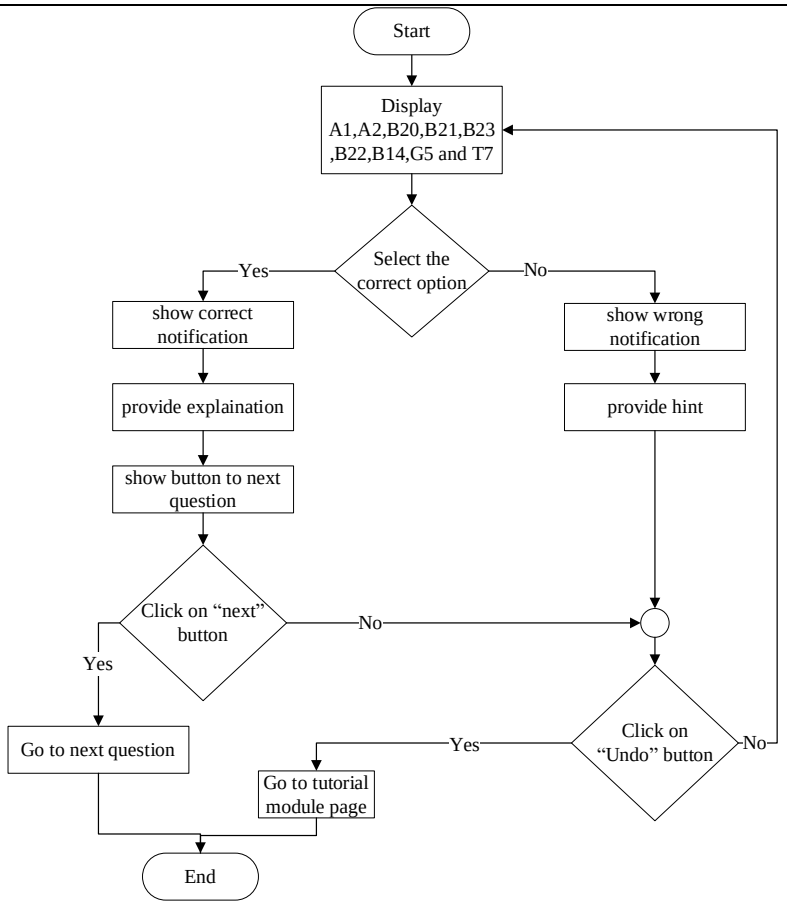


Figure 3.8 Storyboarding of tutorial topics module topics

Table 3.8 Description and flow diagram for tutorial module topics storyboarding

Description	Flow Diagram
A1,A2,B20,B21,B23,B22,B14,G5 and T7 will be shown when user come to tutorial module question. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B20 is a button element for one of the answer options. -B21 is a button element for one of the answer options. -B22 is a button element for one of the answer options. -B23 is a button element for one of the answer options. -B14 is a button to undo to welcoming page. -G5 is the background graphic. -T7 is the text element show question.	

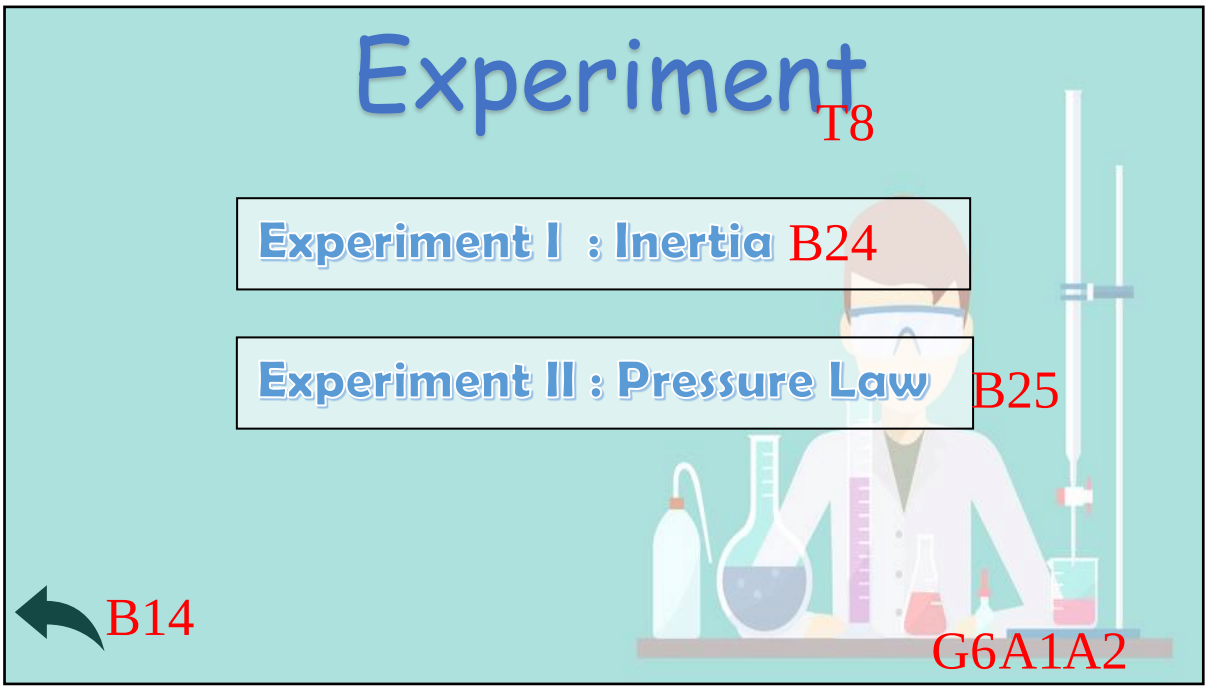
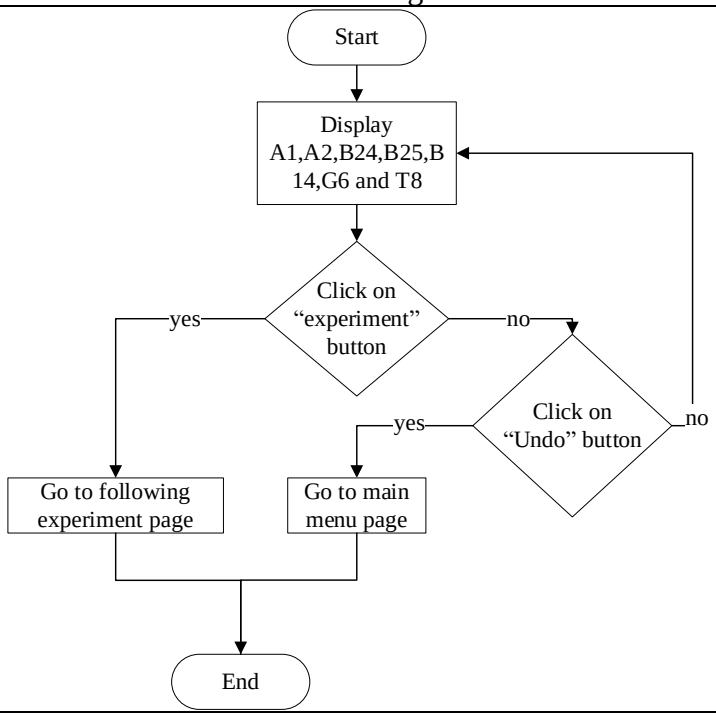


Figure 3.9 Storyboarding of experiment module

Table 3.9 Description and flow diagram for experiment module storyboarding

Description	Flow Diagram
A1,A2,B24,B25,B14,G6 and T8 will be shown when user come to experiment module. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B24 is a button element link to experiment selected. -B25 is a button element link to experiment selected. -B14 is a button to undo to welcoming page. -G6 is the background graphic. -T8 is the text element show experiment module.	

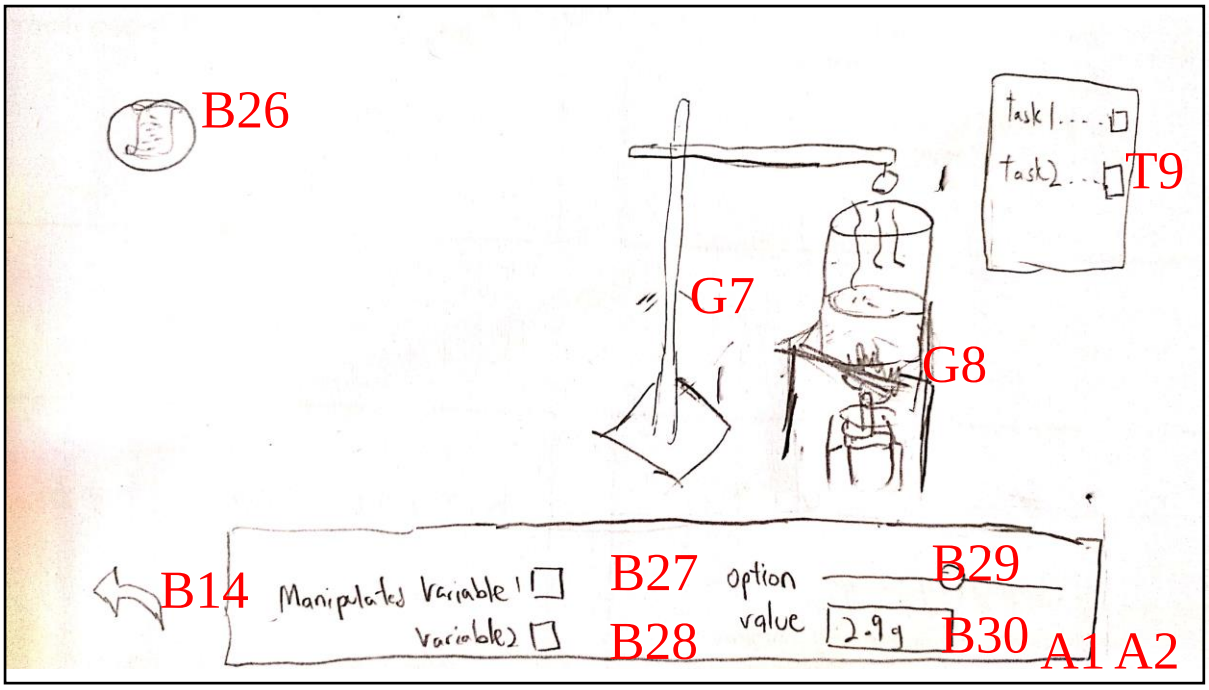


Figure 3.10 Storyboarding of experiment module topics

Table 3.10 Description and flow diagram for experiment module topics storyboarding

Descriptions
A1,A2,B14,B26,B27,B28,B29,B30,T9,G7,G8 and T9 will be shown when user come to experiment selected. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B26 is a button element to show lab manual -B27 is a button element for manipulated variable -B28 is a button element for manipulated variable -B29 is a button element for manipulated variable -B30 is a button element for manipulated variable -B14 is a button to undo to welcoming page. -G7 is the graphic element for virtual experiment. -G8 is the graphic element for virtual experiment. -T9 is the text element show experiment progress.

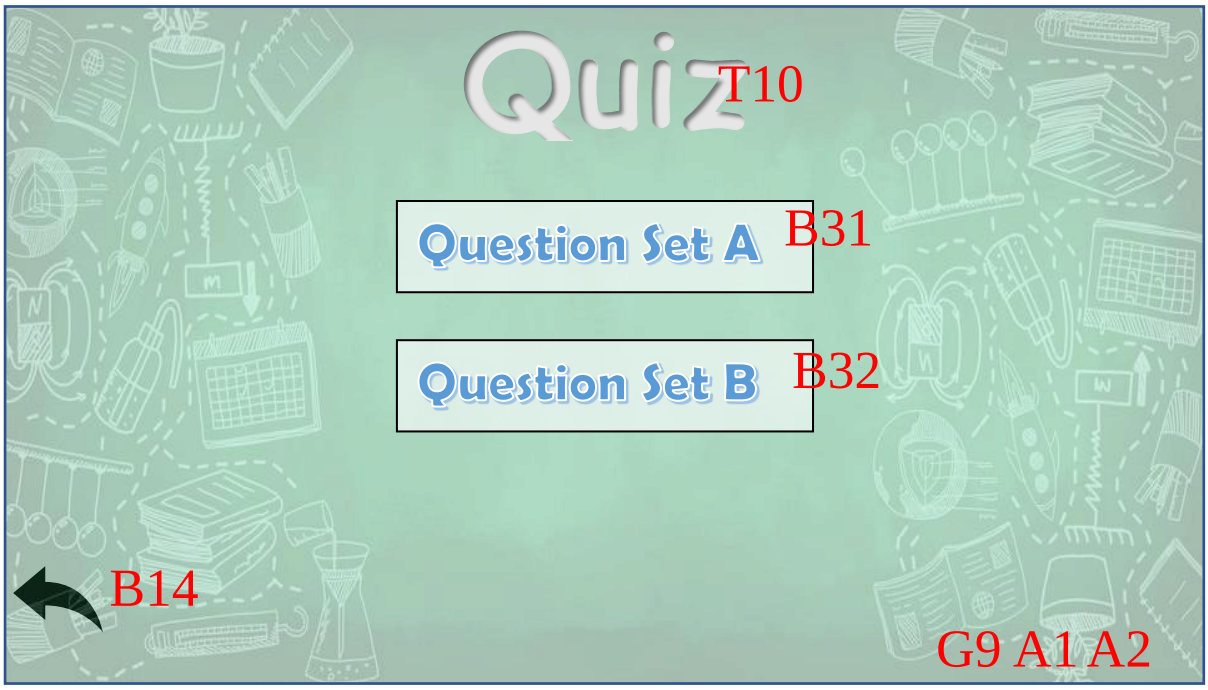
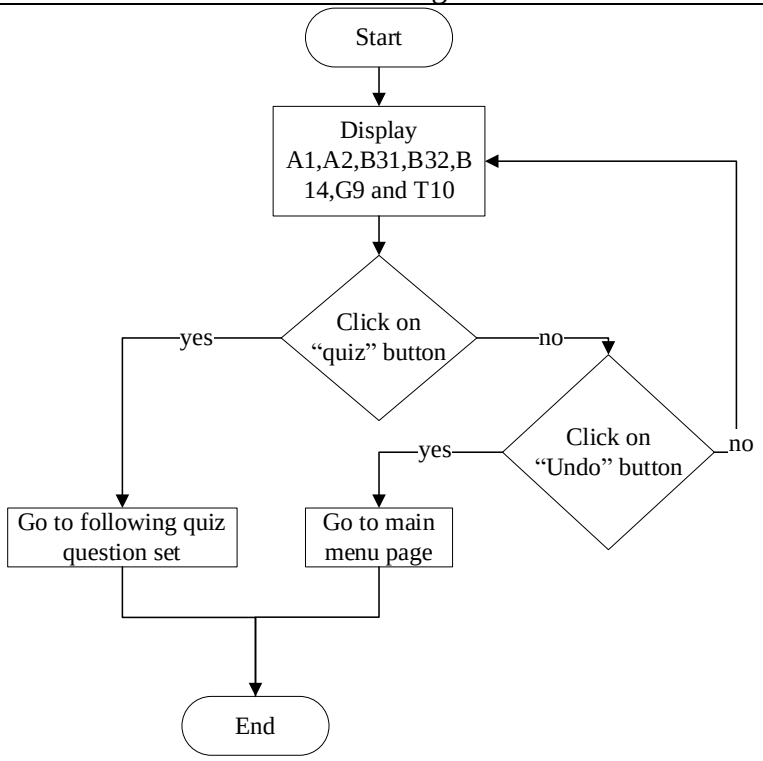


Figure 3.11 Storyboarding of quiz module topics

Table 3.11 Description and flow diagram for quiz module storyboarding

Descriptions	Flow Diagram
A1,A2,B31,B32,B14,G9 and T10 will be shown when user come to quiz module. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B31 is a button element link to question set selected. -B32 is a button element link to question set selected. -B14 is a button to undo to welcoming page. -G9 is the background graphic. -T10 is the text element show quiz module.	

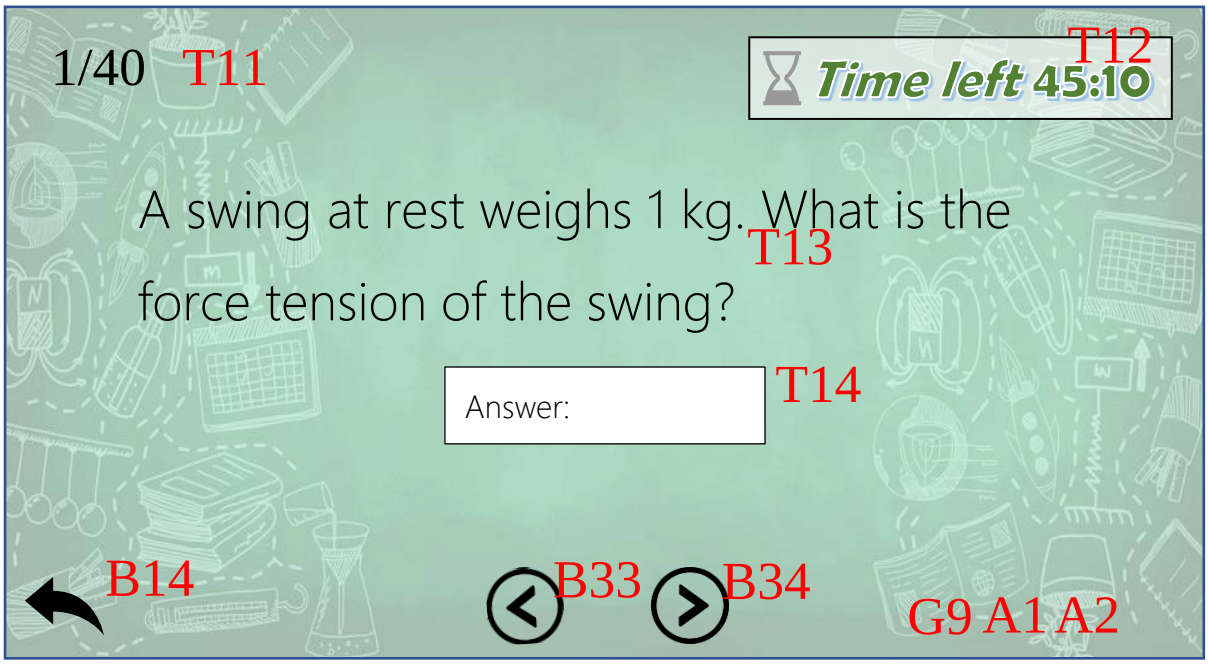
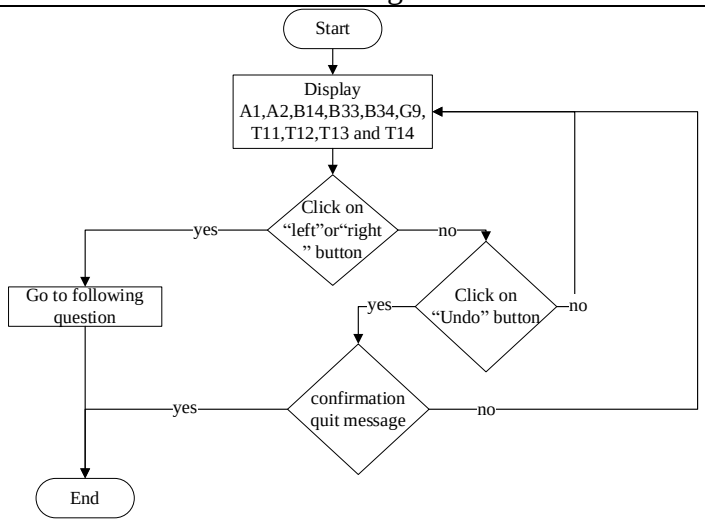


Figure 3.12 Storyboarding of quiz module question

Table 3.12 Description and flow diagram for quiz module question storyboarding

Descriptions	Flow Diagram
A1,A2,B14,B33,B34,G9,T11,T12,T13 and T14 will be shown when user come to quiz module question set. -A1 is audio element for every element user interact. -A2 is audio element for background music. -B33 is a button element link to next question. -B34 is a button element link to previous question. -B14 is a button to undo to quiz module -G9 is the background graphic. -T11 is the text element show question number -T12 is the text element show time left to answer. -T13 is the text element show quiz. -T14 is the text element let user input answer.	

3.6 Project Planning

3.6.1 Project 1

Figure 3.13 Gantt chart for Project I

3.6.2 Project 2

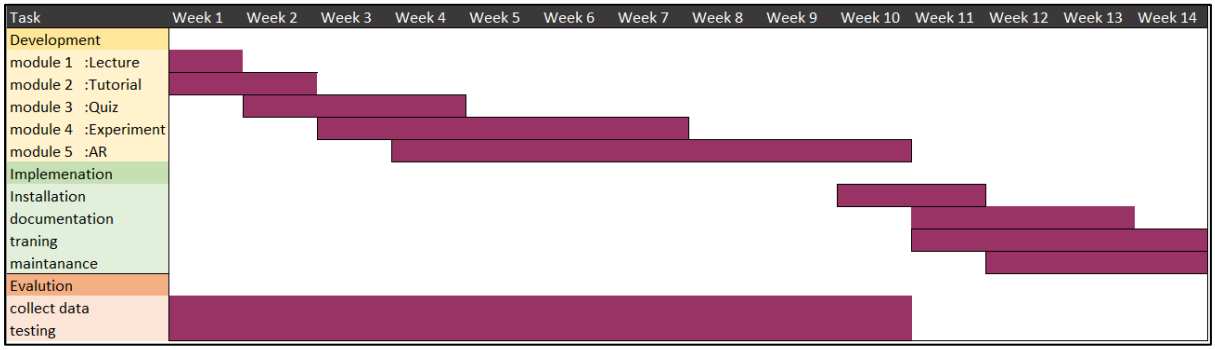


Figure 3.14 Gantt chart for Project II

CHAPTER 4 DEVELOPMENT

4.1 Overview

In this Chapter the author is going to discuss the development process of the whole system. The development process can be separated into three parts which are Pre-authoring process, authoring process and Post-authoring process. The author will state out the content creation process in Pre-authoring, the media content that is created will ultimately be used in authoring tools to create the final product such as create video, audio, graphics, animations, screenshots and text for eLearning courses content.

4.2 Development Process

4.2.1 Pre-authoring Process

4.2.1.1 Process of Creating and Editing Text

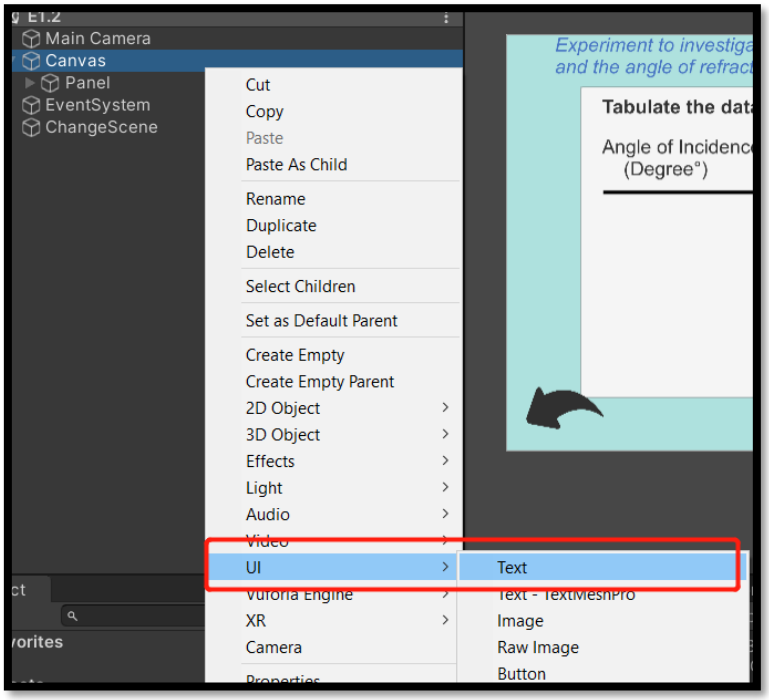


Figure of 4.1 Screenshot of how create Text UI element in Unity

Step 1: Create the UI text element as child of the Canvas.

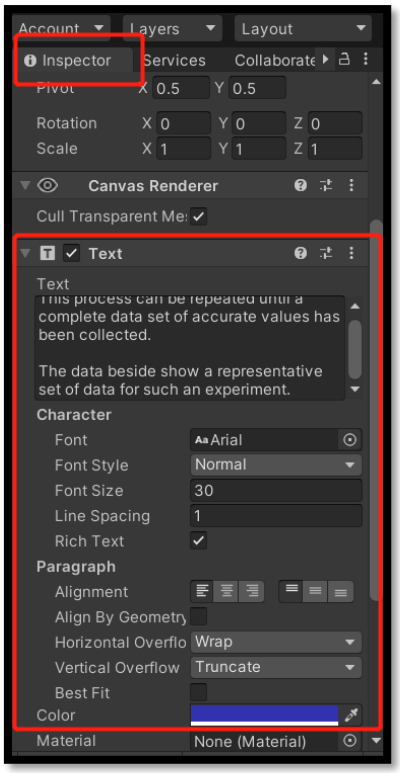


Figure of 4.2 Screenshot of setting properties of Text UI element in Unity

Step 2: Select the text element and edit the setting under Inspector tab which are Text, Character, Paragraph and Colour.

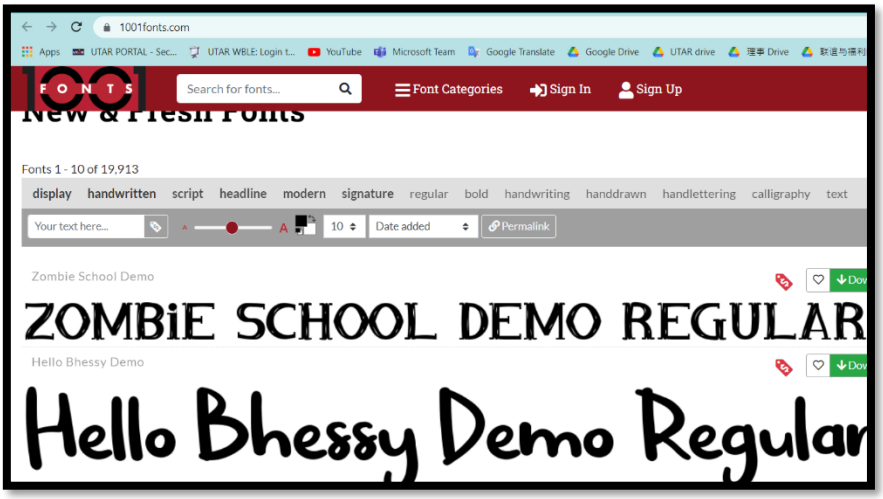


Figure of 4.3 Screenshot of 1001 fonts website

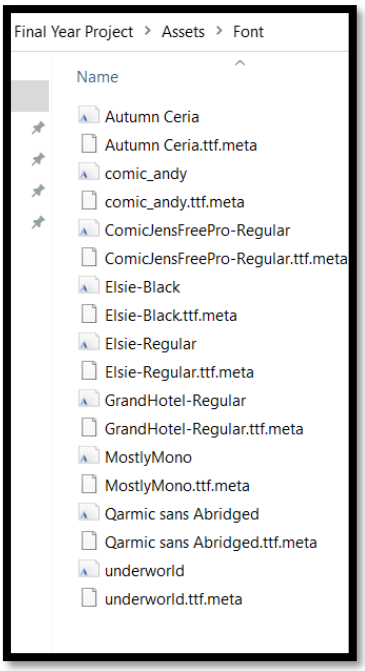


Figure of 4.4 Screenshot of assets font file

Step 3: For the Font can be get in the https://www.1001fonts.com/ website, search and download the suitable and free font can be used for your project. After you download, extract the zip file, copy the ttf file into your project assets. Create a file name Font in the Asserts to easier organize different type of material and other type of Font can be put in the same folder as well. After that, the Unity well automatic read the ttf file and create a ttf meta, then the user can be use download font by drag or press select the font you want to use.

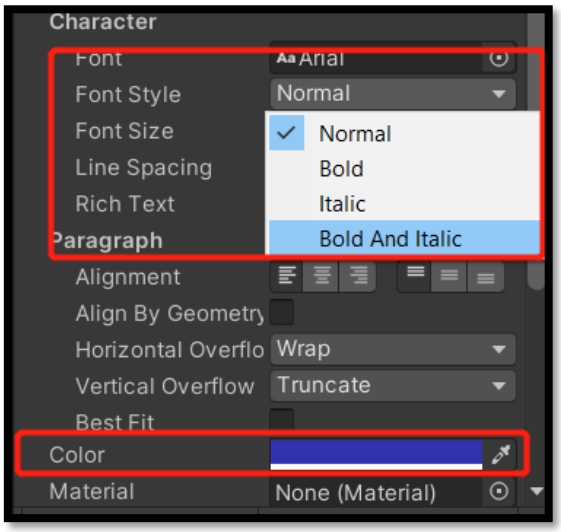


Figure of 4.5 Screenshot of change font format and colour in Unity

Figure 4.6 Screenshot of edit font colour in Unity

Step 4: Next, user can select the font style of normal, bold or italic. User can be editing the font size, line spacing and alignment based on your user interface design. For the text colour can be edit through RGB 0-255, user can either drag the slider to adjust or enter colour hex code or select colour in the screen by click the pipette icon.

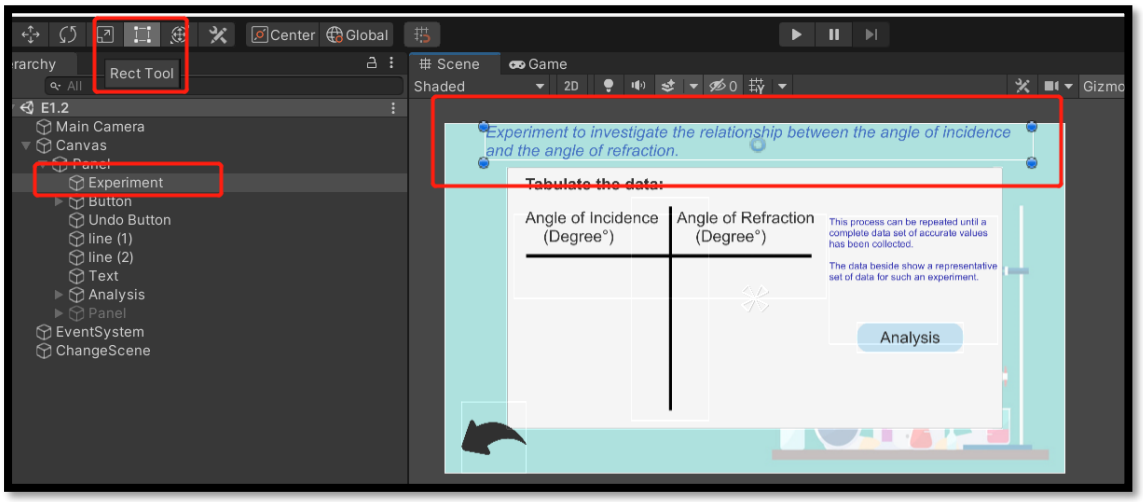


Figure of 4.7 Screenshot of how to use React tool in Unity

Step 5: Lastly, user need use React tool to scale the size and move the text position.

4.2.1.2 Process of Creating and Editing Graphics

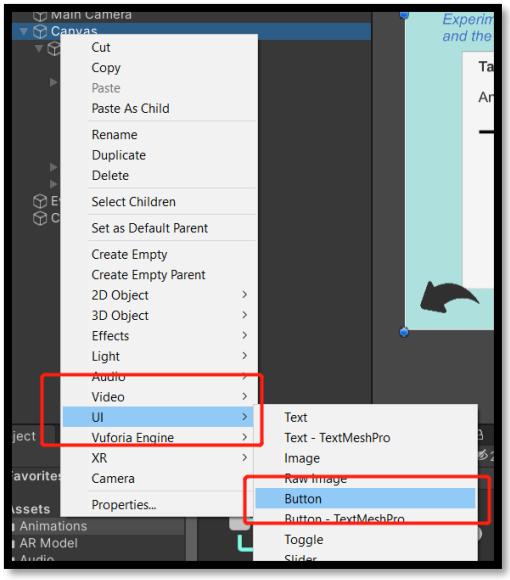


Figure of 4.8 Screenshot of how to use React tool in Unity

Step 1: Create the UI button element as child of the Canvas.

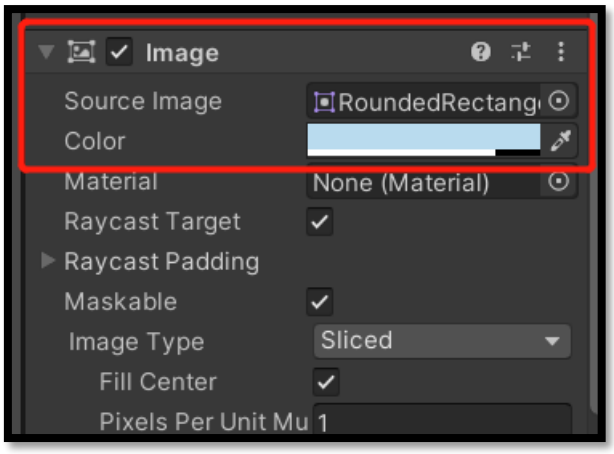


Figure of 4.9 Screenshot of how to add image source in Button UI element

Step 2: Select the button element and edit the setting under Inspector tab which are Image and Button. In the Image tab, user can change the default button image into any image you want by simply drag the image into the source image. The button image can be found online or make by yourself, and the image you found are suggested transparent.

Step 3: Next, user can adjust the colour of the button, if user want original colour of the image just setting to hexadecimal FFFFFF.

Figure of 4.10 Screenshot of On Click function in button UI element

Step 4: After that, user need to work on On Click() function, which mean the click event happen, what will happen. The Runtime Only can drag in the Game Object or any UI element then select function you want to perform in the script to key in value if required.

4.2.1.3 Process of Creating and Editing Animations

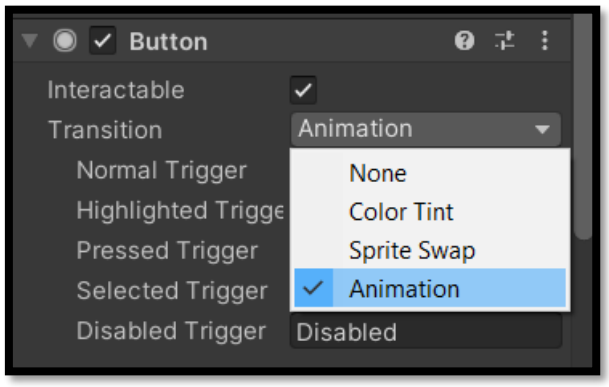


Figure of 4.11 Screenshot of Transition in button UI element

Step 1: For adding animation on button such as hover it will become bigger, first select the button change the Transition from Color Tint into Animation.

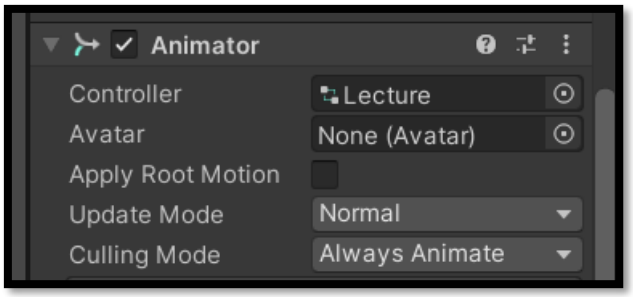


Figure of 4.12 Screenshot of Animator in button UI element

Step 2: Then press Auto generate animation, you will see a Animator Tab is added in the Inspector.

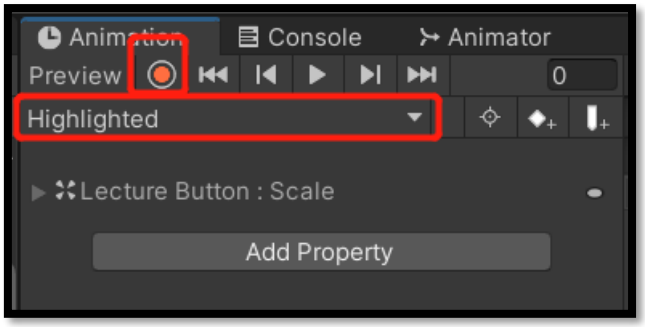


Figure of 4.13 Screenshot of how to add Animation recoding in button UI element

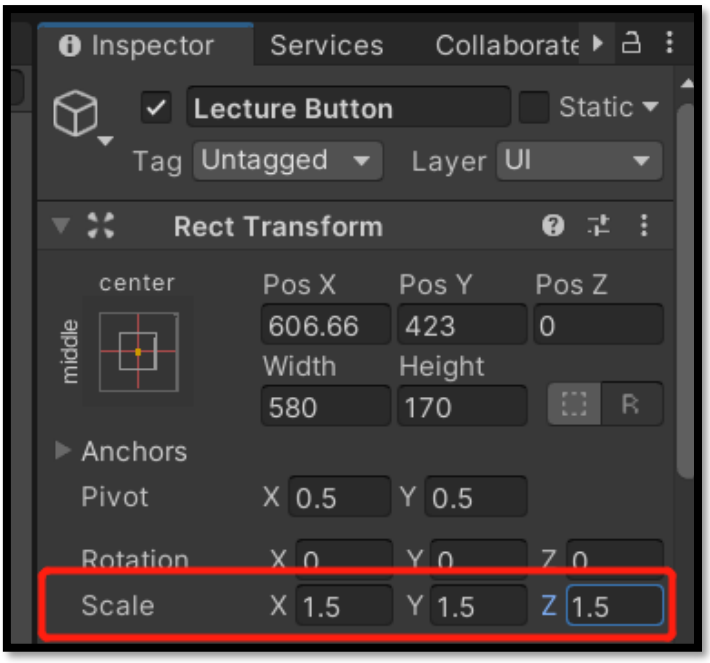


Figure of 4.14 Screenshot of how to edit Scale in button UI element

Step 3: After that go to Animation select normal and press the record red button, then select Highlighted and press record red button and change the Scale X, Y and Z into 1.5 then when user hover that particular UI element will have animation become bigger.

4.2.1.4 Process of Editing Audio

Step 1: First need gets the audio source, for the background music can find online resource and download. For the narrator can found the online generator from text transform into speech such as Voice Maker or Voice booking.

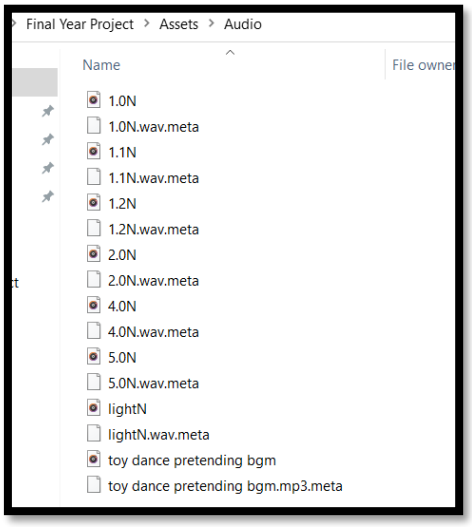


Figure of 4.15 Screenshot of assets audio file

Step 2: After get the audio source import the mp3 file into the Assert, create a file name Audio in the Asserts to easier organize different type of material and other audio file can be put in the same folder as well.

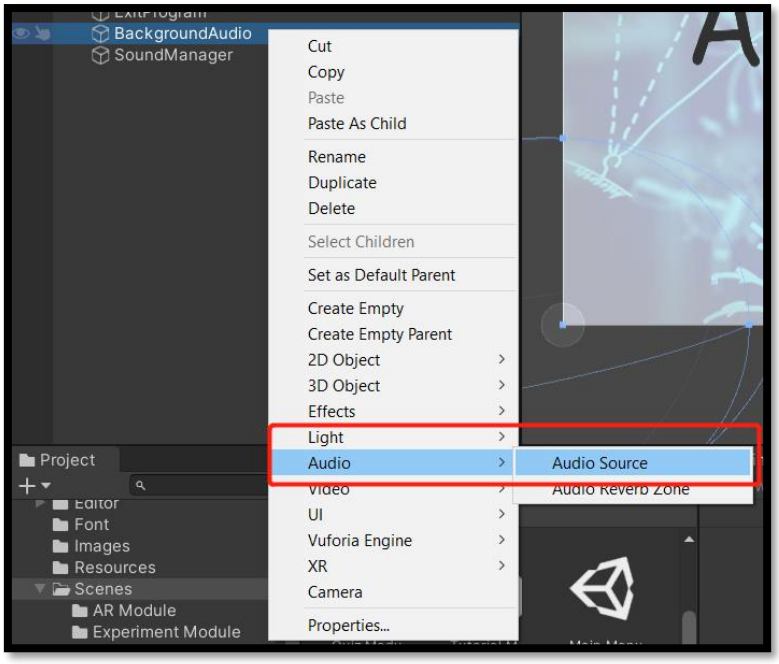


Figure of 4.16 Screenshot of how to create Audio element in Unity

Figure of 4.17 Screenshot of how to setup properties of Audio element in Unity

Step 3: Create a Audio Source element, drag or select the mp3 file into the AudioClip. There are few options can select such as loop, Play On awake etc, you can setting based on your requirement.

4.2.1.5 Process of Editing Video

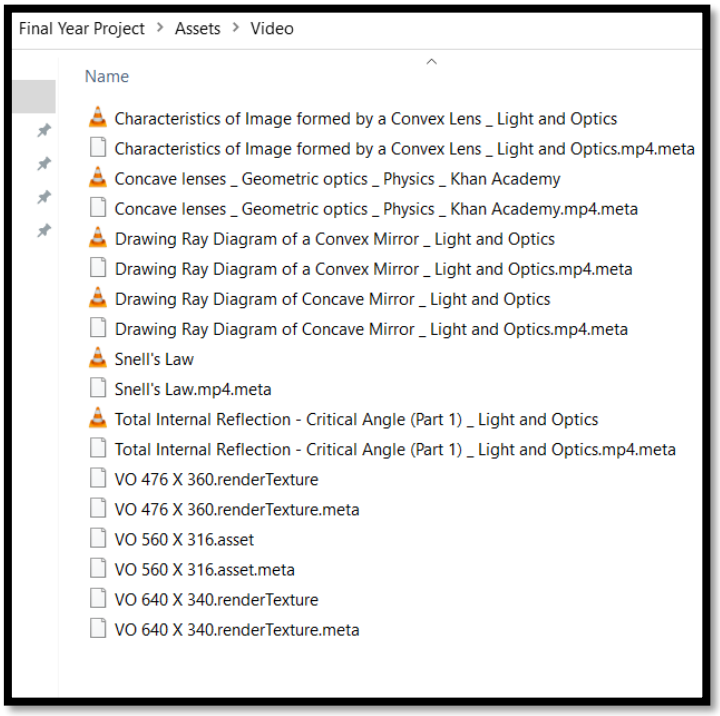


Figure of 4.18 Screenshot of assets video file

Step 1: First get the video source in mp4 format, after that import the mp4 file into the Assert, create a file name Video in the Asserts to easier organize different type of material and other video file can be put in the same folder as well.

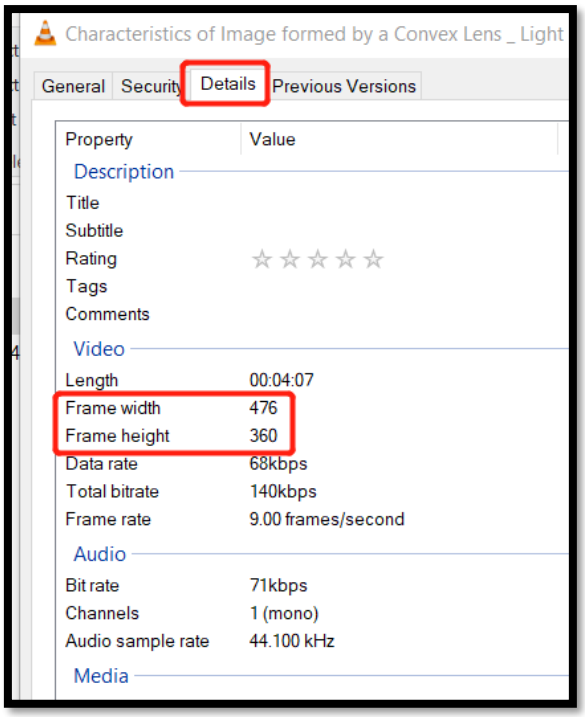


Figure of 4.19 Screenshot of mp4 file details to get frame size of the video source

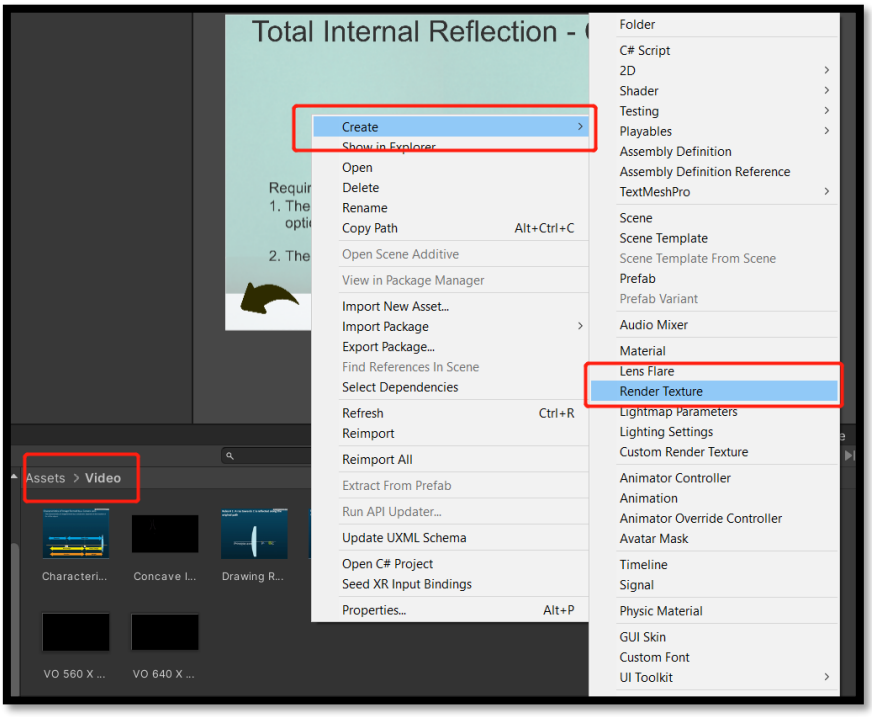


Figure of 4.20 Screenshot of how to create a Render Texture element in Unity

Figure of 4.21 Screenshot of setting properties of Render Texture in Unity

Step 2: After that, create a new Render Texture in video folder, go to the video source, right click go to properties, then Details, check the video frame width and height then edit the value in the Render Texture Size.

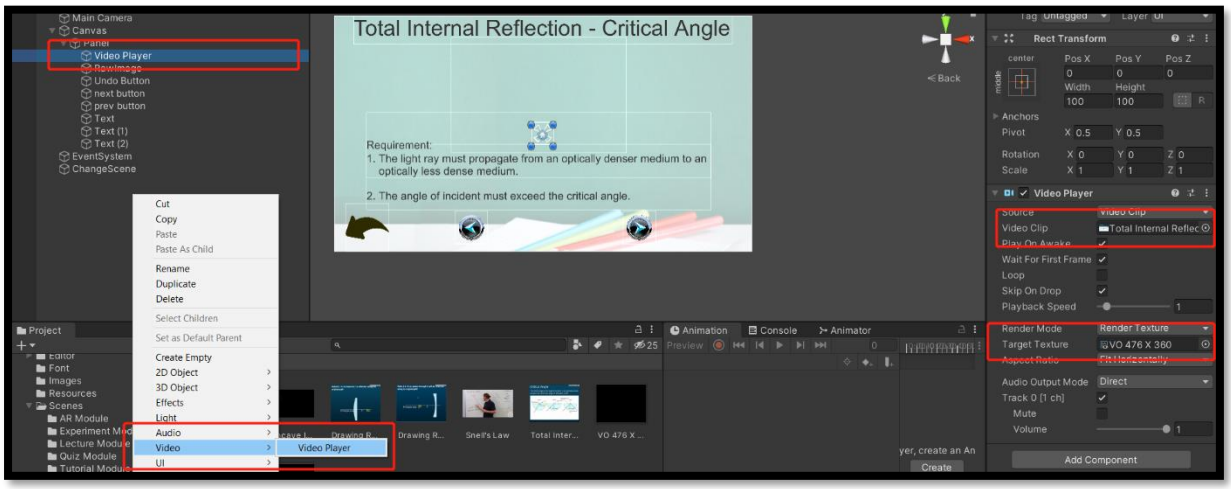


Figure of 4.22 Screenshot of create and setup a Video Player in Unity

Step 3: After that, create a new Video Player, drag the Render Texture created just now into the target texture and drag the video source into the Source.

Step 4: Lastly, user need use React tool to scale the size and move the video position.

4.2.2 Authoring Process

4.2.2.1 Splash screen design

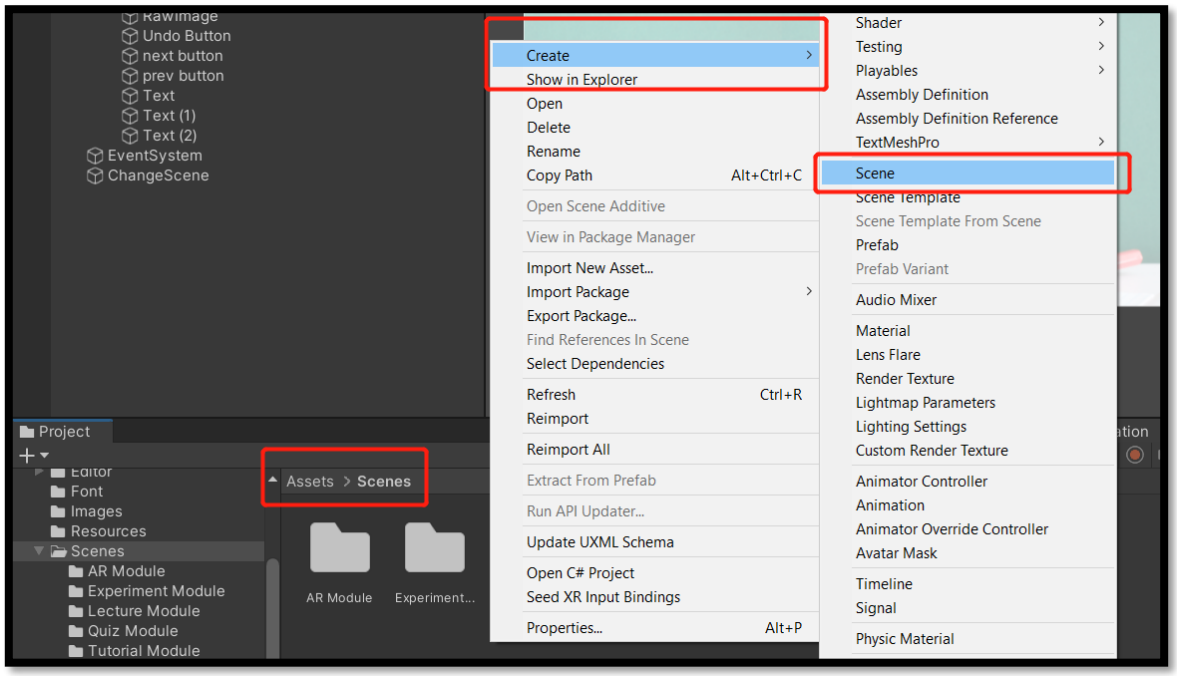


Figure of 4.23 Screenshot of how to create a new scene in Unity

Step 1: Create a new scene and rename it, then create a new Canvas and EventSystem game object will be created as well, create a new panel as the child of canvas and the Source Image needs to be replaced by the background picture of the scene that was prepared early.

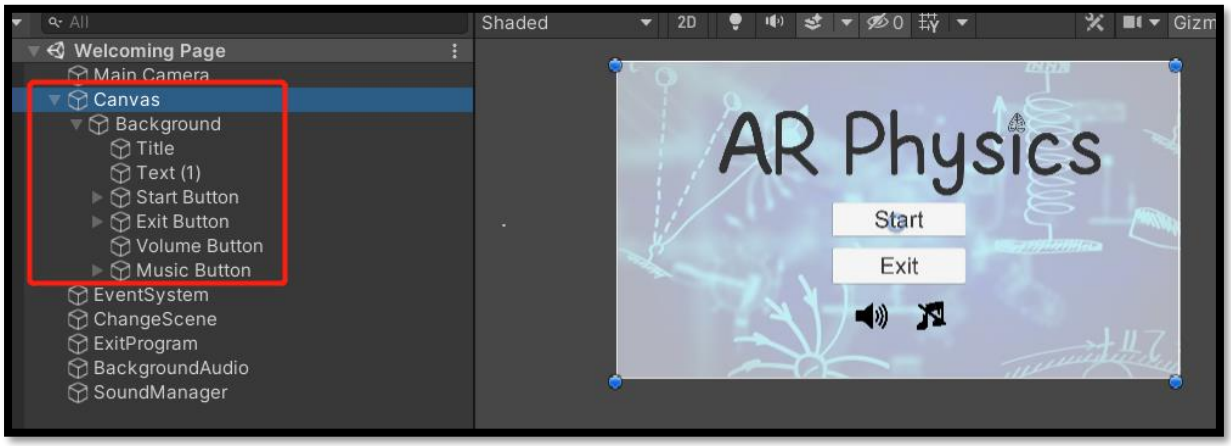


Figure of 4.24 Screenshot of UI element should be include in the Splash screen

Step 2: After that, create a text UI element and edit to the title of the project. For the splash screen we need to design a start button, an exit button and a music button.

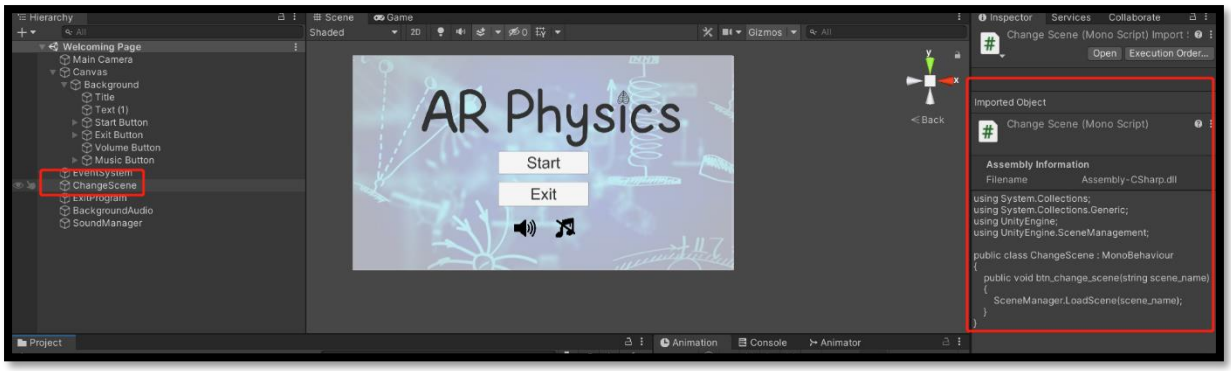


Figure of 4.25 Screenshot of how to add ChangeScene game object and C# script component

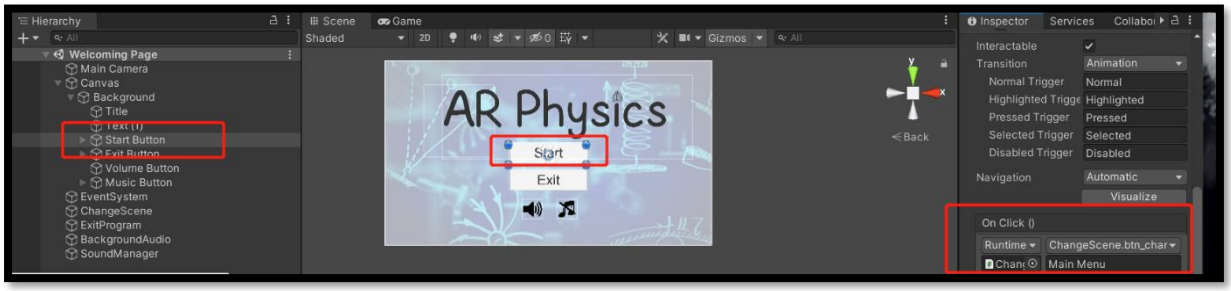


Figure of 4.26 Screenshot of how to apply ChangeScene game object in start button

Step 3: For the click event change to other scene, need to write a C# script name ChangeScene and need to create a game object name ChangeScene and implement this script in the start button On Click ( ) function, then you need drag in the ChangeScene game object and the value will be the name of the scene need change to.

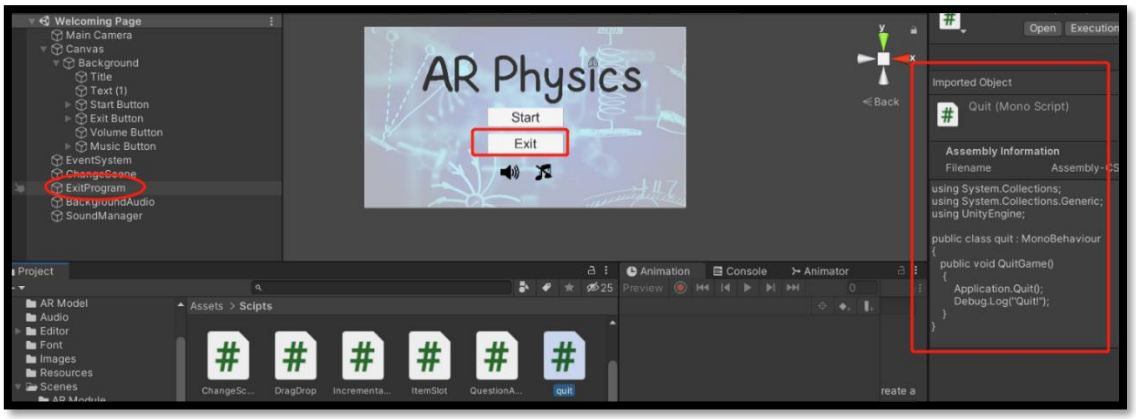


Figure of 4.27 Screenshot of how to add ExitProgram game object and C# script component

Step 4: For exit the application need write a C# script name quit and need to create a game object name ExitProgram and implement this script in the exit button On Click ( ) function, then you need drag in the ExitProgram game object and select the QuitGame function.

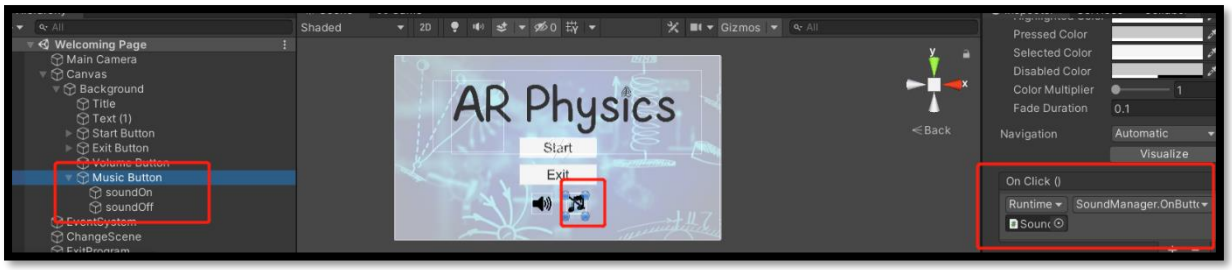


Figure of 4.28 Screenshot of how to add turn on/off music button object in Unity

Step 5: For turn off or turn on music in the application need write a C# script name SoundManager and need to create a game object name SoundManager.

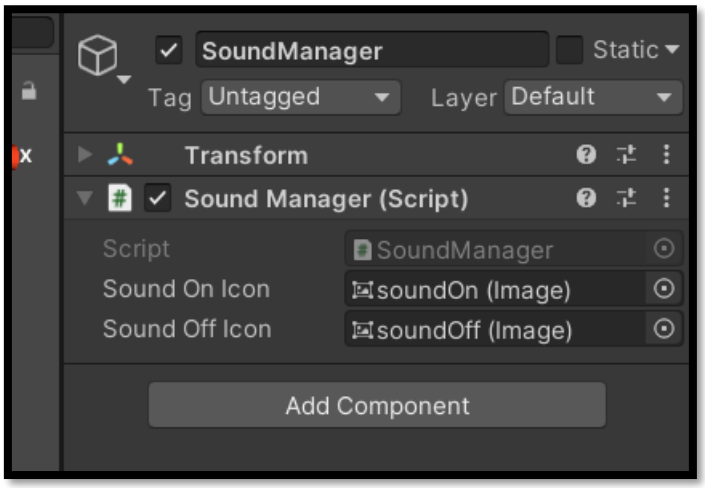


Figure of 4.29 Screenshot of how to setup SoundManager game object in Unity

Step 6: For the Music Button need to create two child image in the same position and select drag these two image into the SoundManager game object script in Sound On and Off Icon and implement this game object in the Music button On Click ( ) function, then you need drag in the SoundManager game object and select the OnButtonPress function.

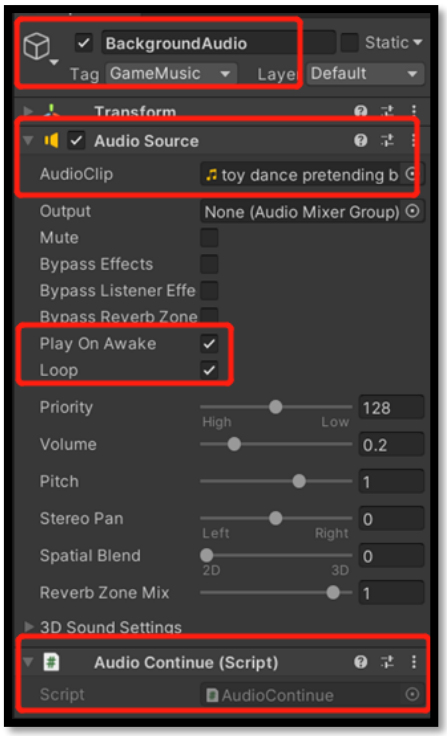


Figure of 4.30 Screenshot of how to setting audio element in Unity

Step 7: Lastly, for the background audio need to create a audio source and drag in the audio mp3 source prepared early into the AudioClip. AudioContinue C# script are also apply in this audio element to let audio continue playing change to other scene.

4.2.2.2 Main Menu Module

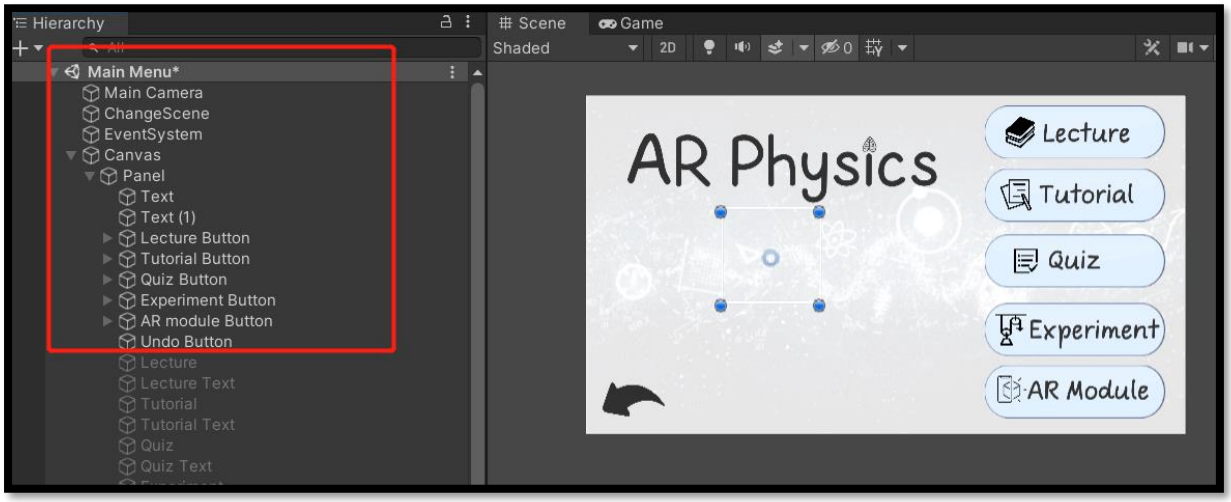


Figure of 4.31 Screenshot of UI element in Main Menu Module

Step 1: For the main menu module, need to create 5 button that user can press and lead the selected module. Each button will be having two child text and image, to edit the text and put the icon. When the user hover each button, the button will become bigger a bit, image and the description of the particular module will be appear.

Step 2: For each button transition need to change from Color Tint into Animation and add new component which is Animator and drag in the controller prepare early.

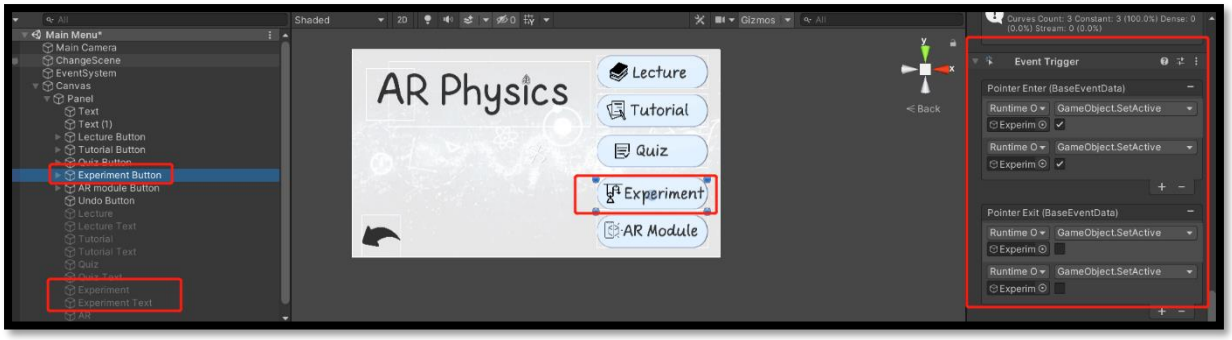


Figure of 4.32 Screenshot of setup condition of button in Main Menu Module

Step 3: Apart from that, need create the Image element and text element for every button and set default to not active. Each button need to add a new component name Event Trigger. In the Event Trigger need add in two event which are Pointer Enter and Pointer Exit, each event add two game object and select the SetActive function, for the Pointer Enter set to true and Pointer Exit set to false which mean when the user pointer hover the button these two game object which are image and text will appear and then user pointer leave it will be disappear again.

Step 4: For the click event change to other scene, need to write a C# script name ChangeScene and need to create a game object name ChangeScene and implement this script to every module button On Click ( ) function, then you need drag in the ChangeScene game object and the value will be the name of the scene need change to.

4.2.2.3 Quiz Module

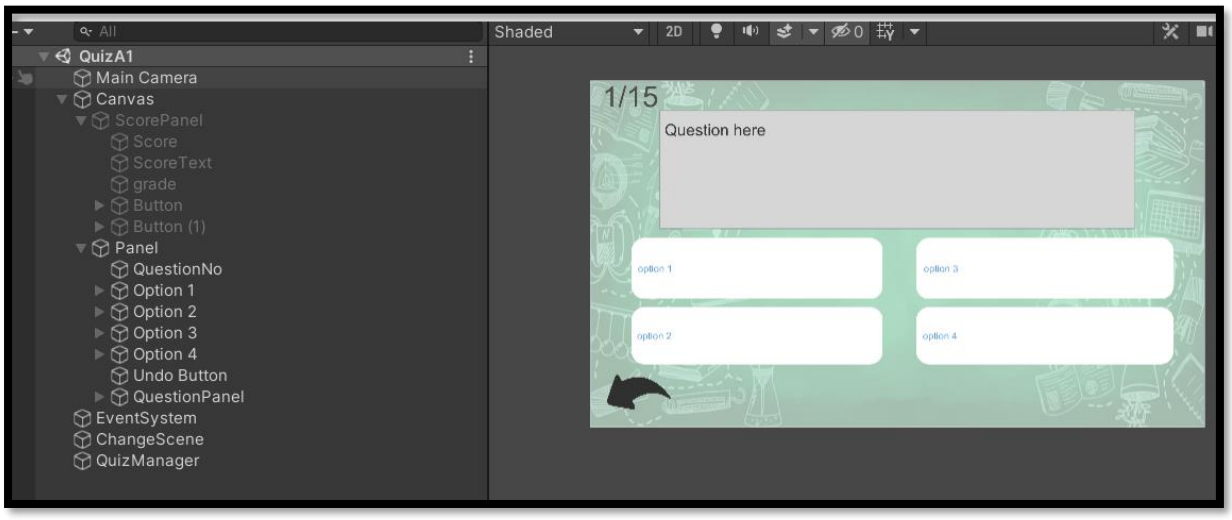


Figure of 4.33 Screenshot of UI element in Quiz Module

Step 1: For the quiz module need to create two panel, one panel is for display the question and option, another panel display the score and review answer button and exit button, the score panel default is set to inactive.

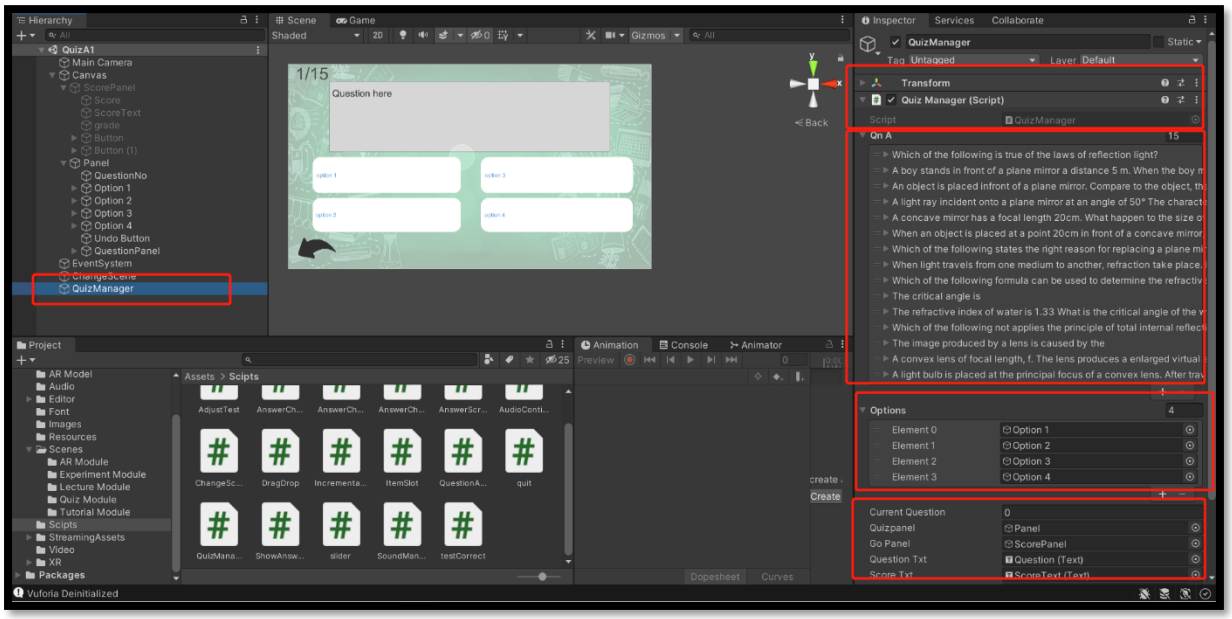


Figure of 4.34 Screenshot of how to create and setup QuizManager

Step 2: Next need to create a game object call QuizManager and apply a C# script QuizManager.

Step 3: After that, paste all the quiz questions, option and set answer.

Step 4:Drag the related UI element into the game object to let the script recognize, which are quiz panel, score panel, four option button, question text, score text and grade.

4.2.2.4 Tutorial Module

For the tutorial module there are three types of interactive can be perform. First is fill in the blank by drag in the answer in the box.

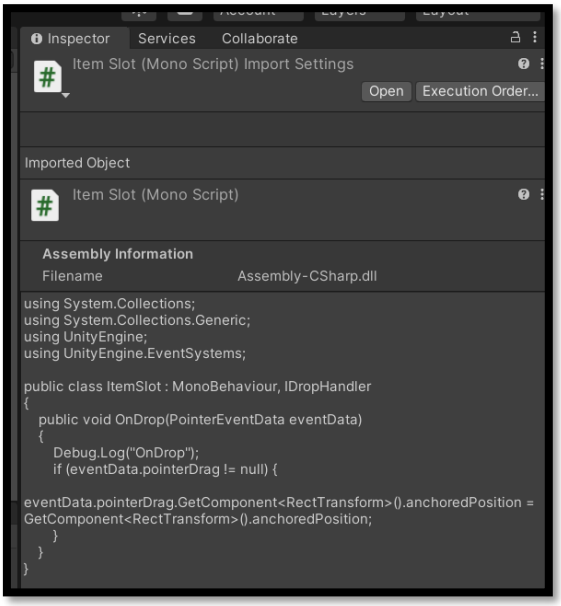


Figure of 4.35 Screenshot of ItemSlot C# Script

Step 1: There are two C# script need to be code, first is the ItemSlot will be apply to the panel act as the answer box can drag in answer item.

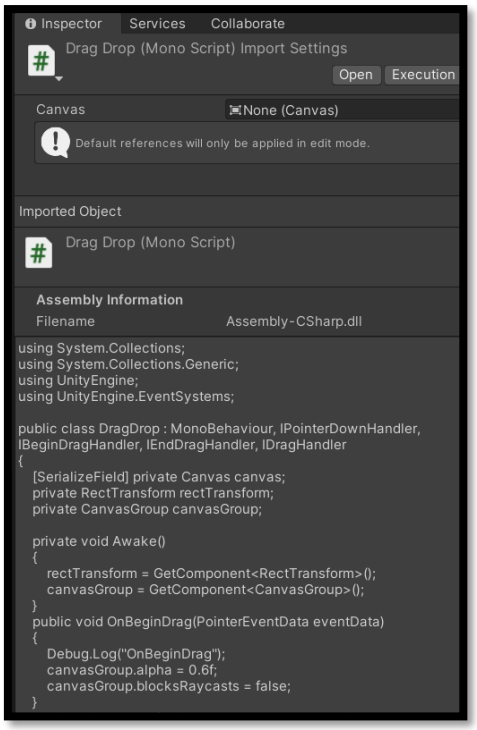


Figure of 4.36 Screenshot of DragDrop C# Script

Step 2: Second it the DragDrop will be apply to the text act as the answer can be drag in the answer box to answer the question.

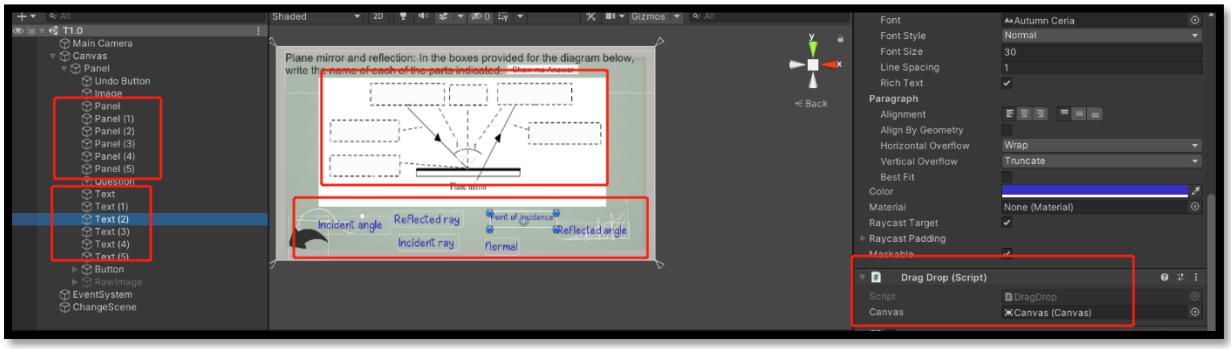


Figure of 4.37 Screenshot of how to apply C# script in to target UI element

Step 3: Apply DragDrop C# Script to every answer text UI element and apply ItemSlot to panel UI element.

The second types will be the objective question but the user cannot fill in the blank only can press show answer button.

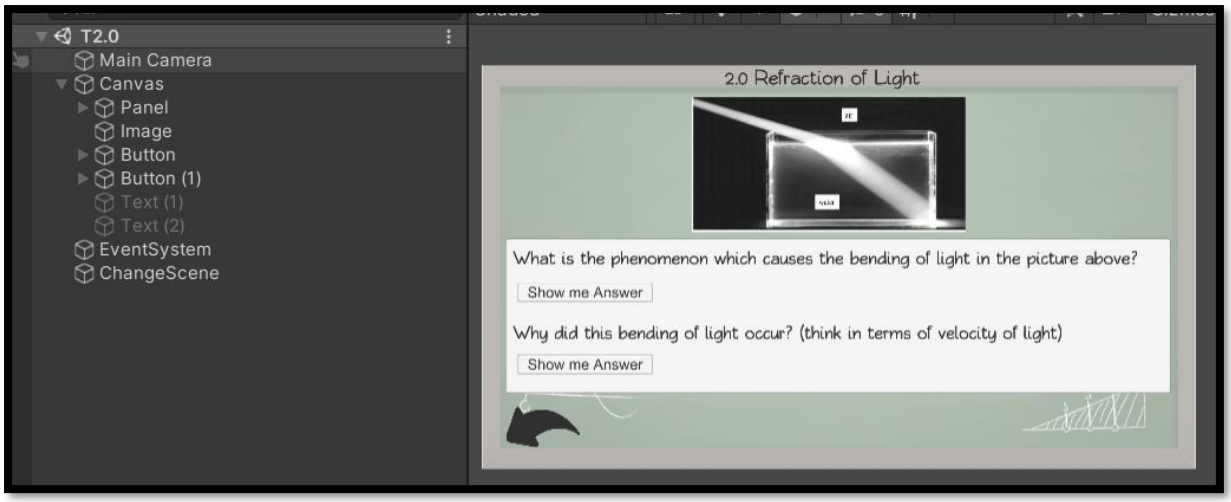


Figure of 4.38 Screenshot of objective question in Tutorial Module

Step 1: First need to create the question and image to put the related diagram and create two answer text and two button.

Step 2: Next, add a new C# script component name Show Answer, to let the user only read and show all answer then can move to next part.

The third type is the choose the correct option between two options.

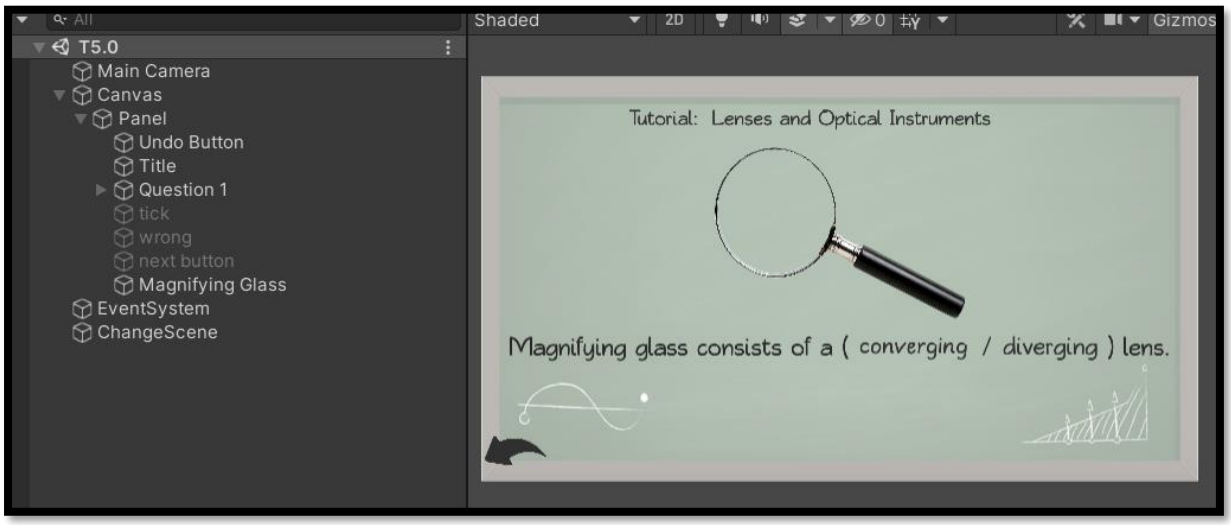


Figure of 4.39 Screenshot of correct option question in Tutorial Module

Step 1: First step needs to create question text, two option button, tick image, cross image and next button.

Step 2: Tick image, cross image and next button are set to inactive in default, only the user select the correct answer can move to next part of the tutorial.

Step 3: For the answer button need to apply C# script AnswerChangeColour to set the answer text become blue when click.

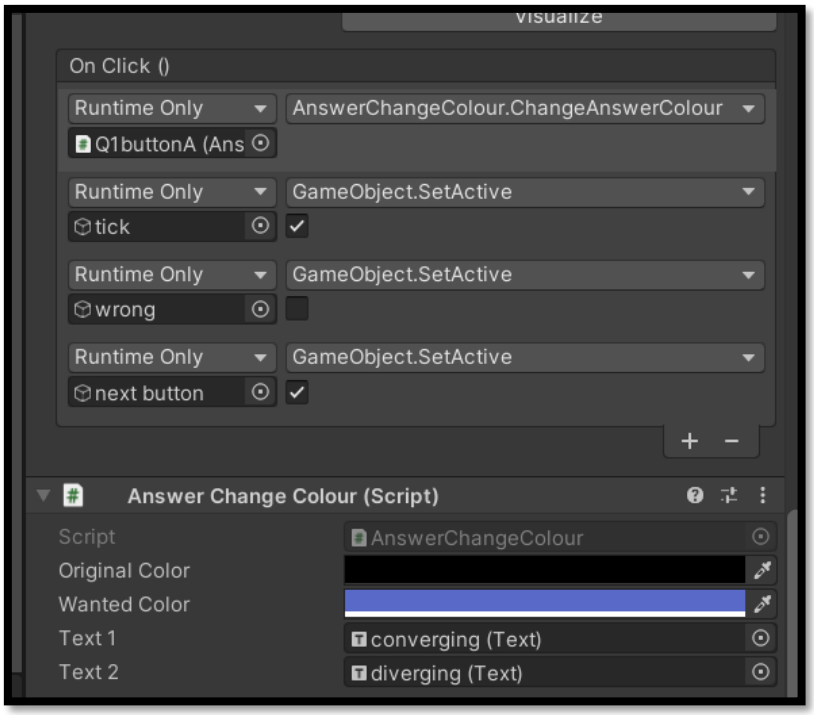


Figure of 4.40 Screenshot of how to setting option button in Quiz Module

Step 4: The answer button needs to drag the image element in the On Click( ) function, if the wrong answer clicks, the cross image will appear and tick remain inactive, and if correct answer click, the tick image and next button appear, the cross image inactive.

4.2.2.5 AR Module

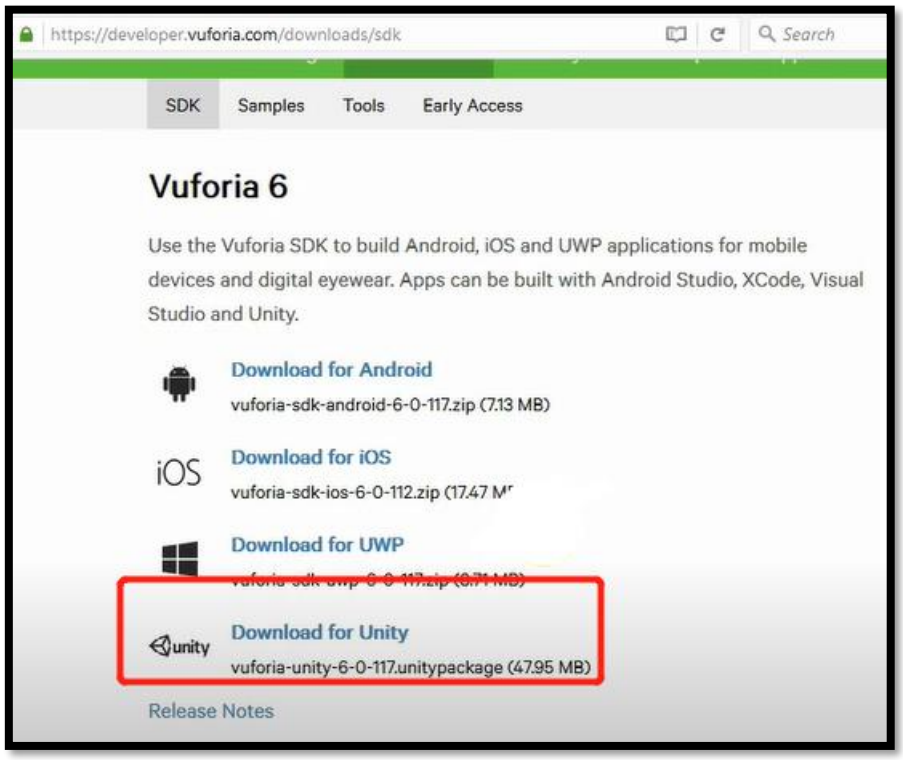


Figure of 4.41 Screenshot of how to Setup Vuforia SDK plugin for Unity

Step 1: Setup Vuforia SDK plugin for Unity, in the website given. https://developer.vuforia.com/downloads/SDK

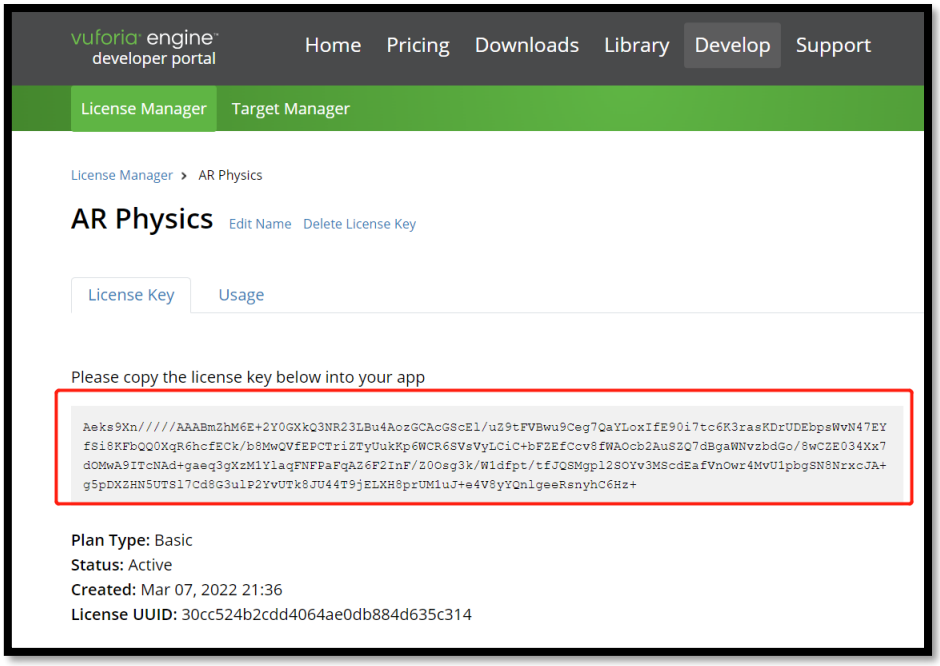


Figure of 4.42 Screenshot of how to get license key in Vuforia developer portal

Step 2: Create a project in development portal and get a license key.

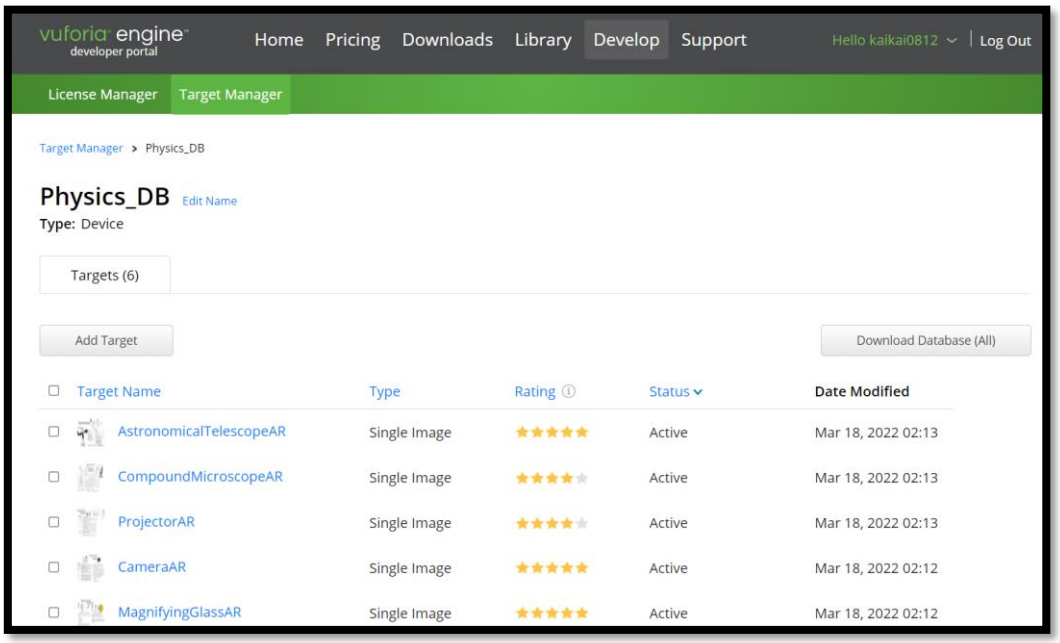


Figure of 4.43 Screenshot of how to create database and add image marker in Vuforia developer portal

Step 3: Create database of the image targets, upload add the prepared image target and download the database.

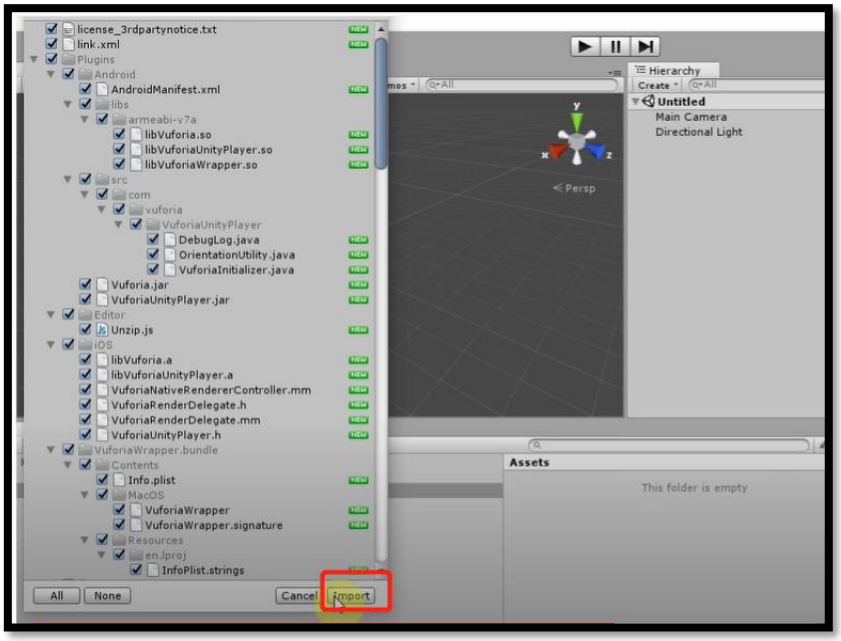


Figure of 4.44 Screenshot of how to import Vuforia plug-in and database into Unity

Step 4: Open Unity Assets >> Import Package >> Custom Package, import the database and the Vuforia SDK plug-in downloaded in above step.

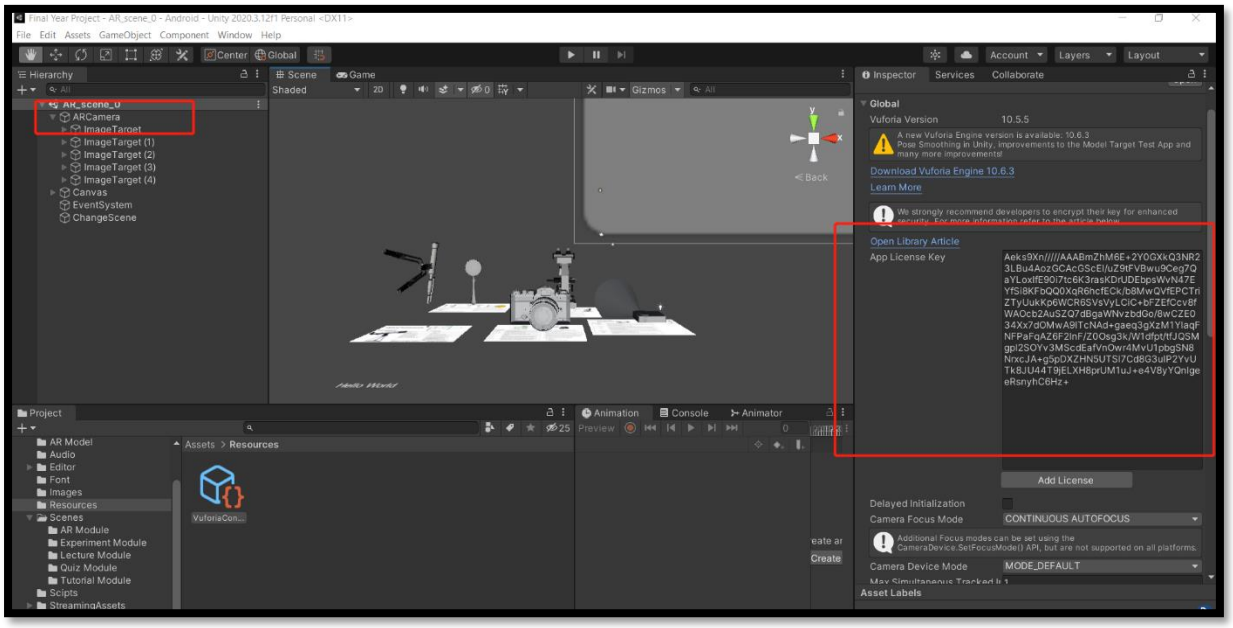


Figure of 4.45 Screenshot of how to add AR camera component and apply license key

Step 5: Create an AR camera, and open Vuforia Engine configuration, key in the license key and add the downloaded database.

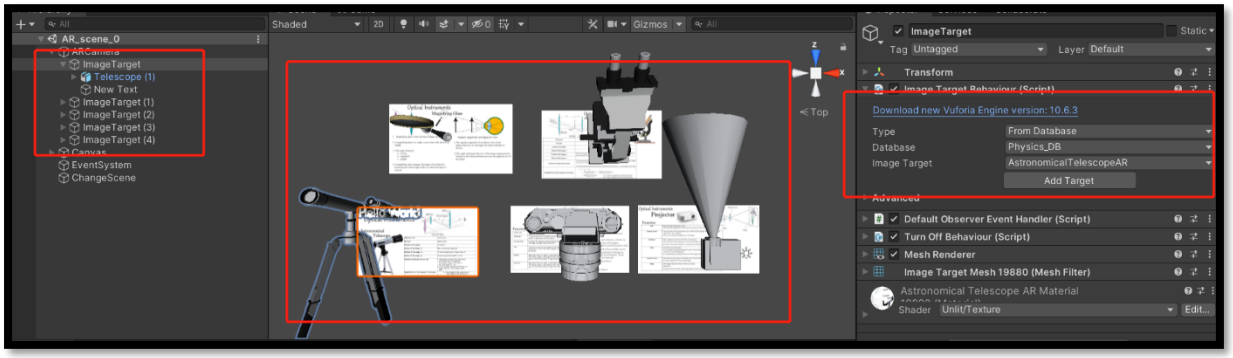


Figure of 4.46 Screenshot of how to image target and AR object in Unity

Step 6: Setup and add the image target and add blender object file on the image target.

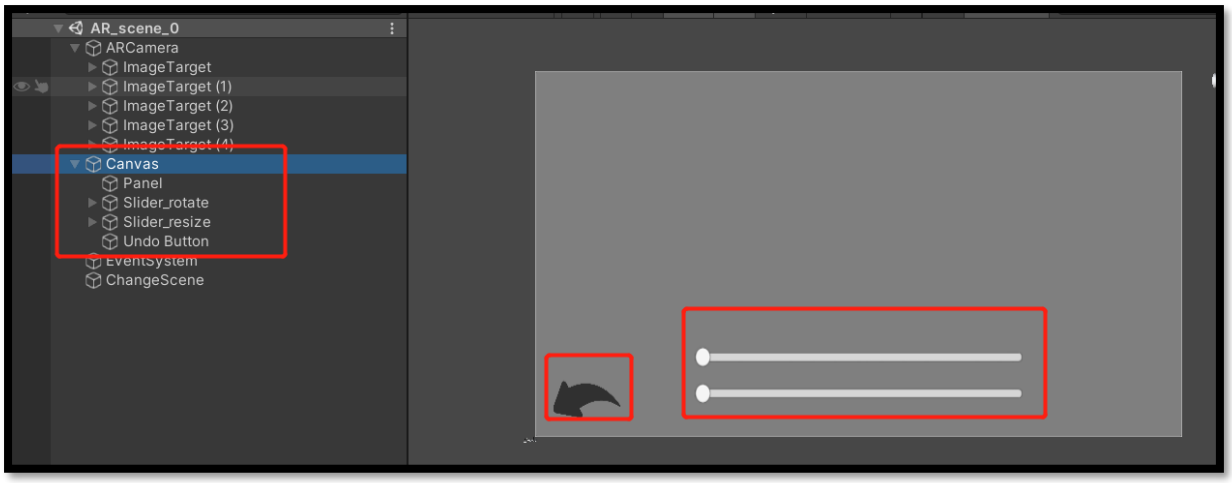


Figure of 4.47 Screenshot of how to add panel and UI element in AR module scene

Step 7: Create the panel and add undo button and two sliders.

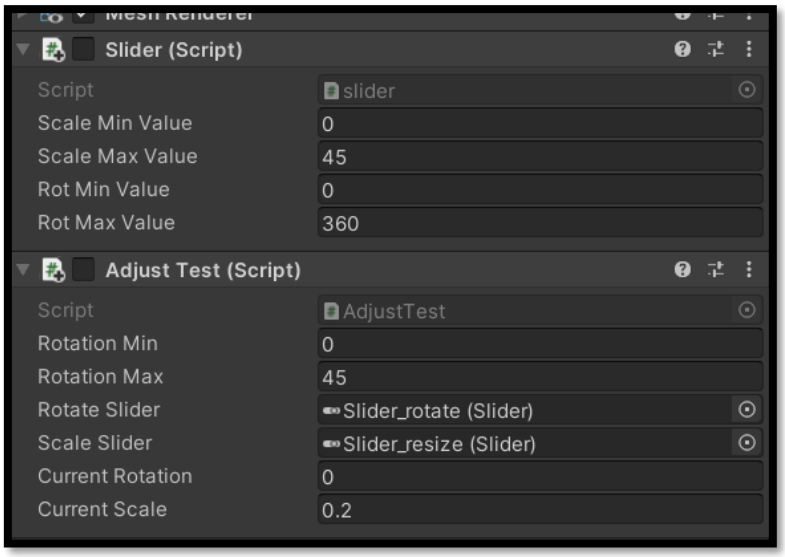


Figure of 4.48 Screenshot of how to apply C# Script component in AR object

Step 8: Slider one is use to rotate the AR object and slider two is use to adjust the size of AR object. You need to write the C# script and apply on the AR object to let it function.

4.2.3 Post-authoring Process

Alpha Testing will be used in the Post-authoring process, it is a type of user acceptance testing; performed to identify all possible issues, error and bugs before releasing or delivered the final product to the end users. Alpha testing is carried out by the author and it is performed at an early stage before beta testing. The main objective of alpha testing is to identify the operation that a typical user might perform and test them.

After that, the author will perform the beta testing, a type of acceptance testing that is done by the real target users of the application in a real environment. Beta Testing is also the final stage of testing before the final application will be delivered. Through this testing, the author is able to get direct feedback from real users, as a result, this will reduce product failure risks and provide increased quality of the application through user validation. The author through video demonstration to let user have a briefly understanding the whole application how the testing can be done, the detail of the beta testing can be found in chapter 5.2 Method of Testing.

CHAPTER 5 TESTING, RESULTS & DISCUSSIONS

5.1 Overview

In this Chapter the author is going to discuss about method of testing will be use in this project and why the method will be chosen and how to perform the testing in details. Apart from that, the author will be going to discuss the testing analysis, result and discussion based on the system testing questionnaire from beta testing collected from the real user and make a summary found from analysis. The testing outcome will be discussed research objectives achieved or not in this chapter.

5.2 Method of Testing

The method of testing used by the author is Alpha Testing and Beta testing. Alpha Testing is a type of software testing performed to identify bugs before releasing the product to real users or to the public. Alpha Testing is one of the user acceptance testing, the author will use it in the Post-authoring process, to identify all possible issues, bugs and errors before releasing or delivering the final product to the end users. Alpha testing is conducted by the author and takes place in the early stages before beta testing.

The main goal of alpha testing is to identify and test what a typical user might do and won't cause any error. The author will perform the Beta Testing after Alpha Testing. Beta Testing is performed by real users of the software application in a real environment. Beta Testing is also the final stage of testing before the final application will be delivered. The authors chose the Alpha and Beta Testing approach because it provides a better view of software reliability early on and helps simulate real-time user behaviours and environments. As a result, many high-profile or critical errors can be detected by testing, providing early detection of design and functional errors. Beta testing allows authors to test post-release infrastructure to improve product quality through user feedback. Beta testing can also reduce the risk of product failure through user validation, which is cost-effective compared to similar data collection methods. Through these two methods of testing, the author is able to get direct feedback from real users, as a result, this will reduce product failure risks and provide increased quality of the application through user validation.

The author through video demonstration to let users have a brief understanding of the whole application and how the testing can be done. The author records a video demonstration

to briefly explain the application content and introduce each module content to guide the user have an idea how to perform the whole testing and what function can be performed in each module. The author sends the .apk file to let the user install the application and the video demonstration link together with the AR marker image. After the user installs the application and watches the video demonstration, they will start to do the testing. A questionnaire is a research tool consisting of a set of questions or other types of prompts designed to gather information from respondents. Research questionnaires are usually a mix of closed-ended and open-ended questions. After the testing is done, the questionnaire of the system testing is distributed to the users by the author to provide feedback and user experience.

5.3 Testing Analysis

Part A: Demographic Data

1. Gender

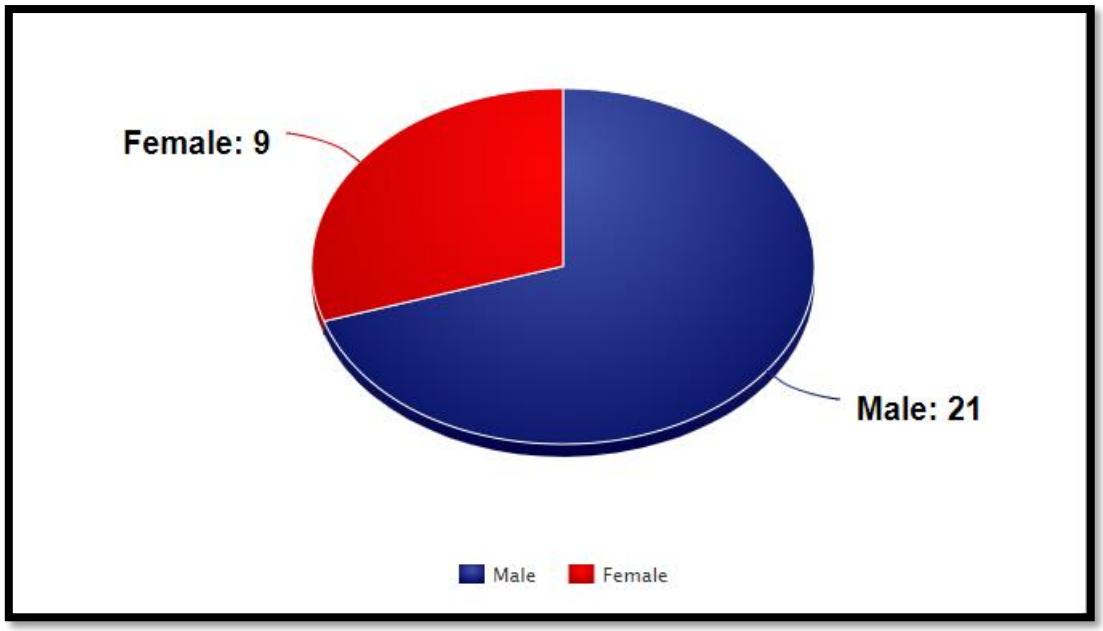


Figure 5.1 Pie chart of Gender of the respondent

As refer to Figure 5.1, there are 30 samples which are secondary school Form 4 students or students taking or taken Physics subject before taking part in this user testing questionnaire. 21 of them is male, 8 of them are female.

2. How will you rate yourself in understanding the content of the Physics?

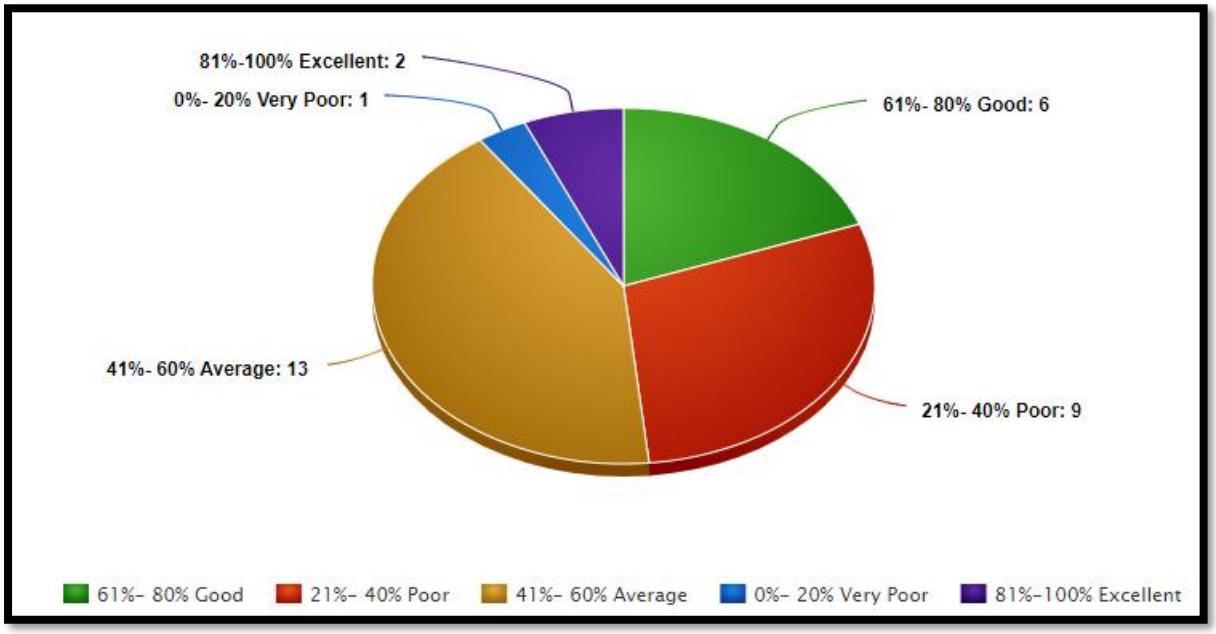


Figure 5.2 Pie chart of "How will you rate yourself in understanding the content of the Physics?"

This pie chart in Figure 5.2 shown about respondent themselves in understanding the content of the Physics subject syllabus. 13 respondents rate themselves about 40% - 60% average in understanding the content of the Physics, 9 respondents rate themselves poor in understanding the content of the Physics, 6 respondents good in understanding the content of the Physics, 2 respondent rate himself/herself excellent in understanding the content of the Physics and only 1 respondent very poor in understanding content of Physics. The result shown that majority of the respondent not confidence rate themselves master and understanding the content of the Physics syllabus and majority is in average and poor. This shown that Physics is a challenging subject and no every student can master it well.

Part B: Usability Testing

1. I think that I would like to use this system frequently.

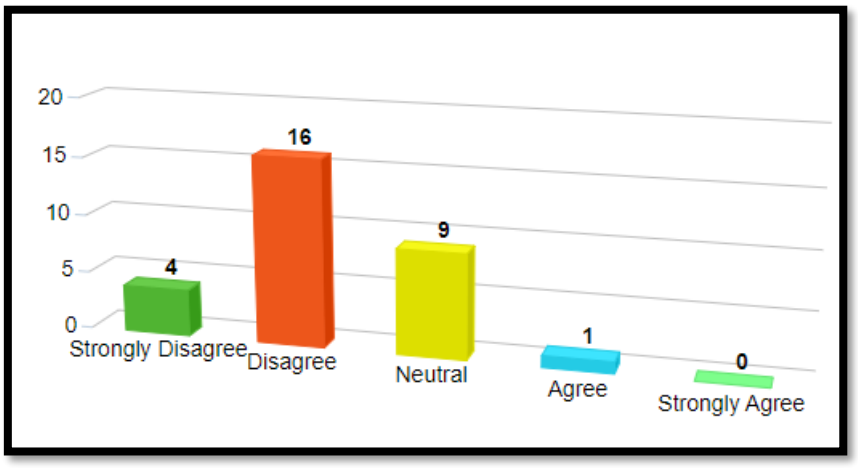


Figure 5.3 Bar chart of "I think that I would like to use this system frequently."

The bar chart in figure 5.3 shown that 16 of the respondents disagree that they would like to use the system frequently, 9 respondents neutral, 4 respondents strongly disagree and only 1 user agree. Based on the result majority and disagree they will use the system frequently probably is due to most of them are not the target user which is Form 4 secondary student currently taking Physics subject. Another reason probably is due to the content of the learning application is limited to only one particular chapter due to the time constraint.

2. I found the system unnecessarily complex.

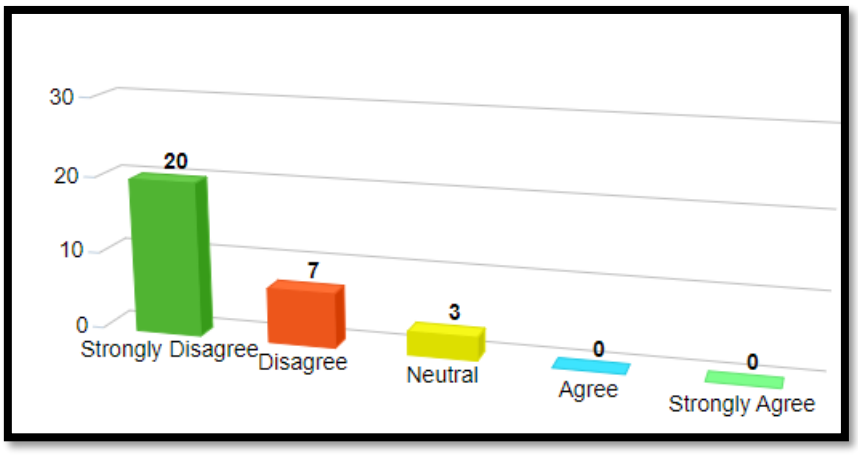


Figure 5.4 Bar chart of "I found the system unnecessarily complex."

The bar chart in figure 5.4 shown that 20 of the respondents (1/3) strongly disagree that they found the system unnecessarily complex, 7 respondents disagree, 3 respondents neutral and no respondent agree. Based on the result analysis the application system is claim to be not complex and user are well understanding how to perform the system testing probably.

3. I thought the system was easy to use.

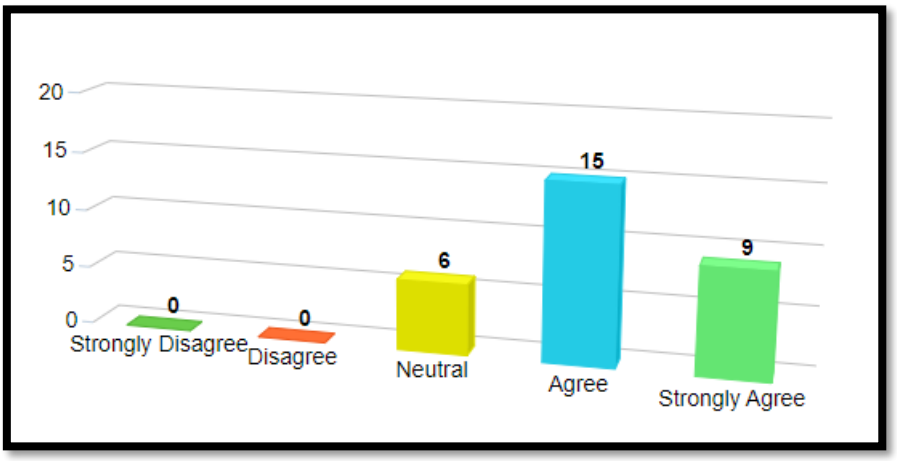


Figure 5.5 Bar chart of "I thought the system was easy to use."

The bar chart in figure 5.5 shown that 15 of the respondents agree that they found the system was easy to use, 9 respondents strongly agree, 6 respondents neutral and no respondent disagree. Based on the result analysis the application system is claim to be not complex and user are well understanding how to perform the system testing probably because the system was easy to use and they can know how to perform testing after watch video demonstration provide by author.

4. I think that I would need the support of a technical person to be able to use this system.

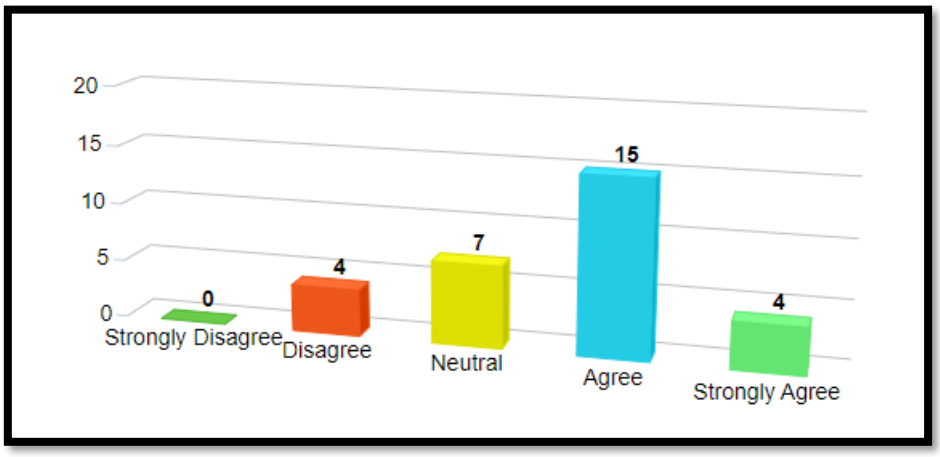


Figure 5.6 Bar chart of "I think that I would need the support of a technical person to be able to use this system."

The bar chart in figure 5.6 shown that 15 of the respondents agree that need the support of a technical person to be able to use this system, 7 respondents neutral, 4 respondents strongly agree, 4 respondents disagree and no respondent strongly disagree. Based on the result analysis most of the user need technical person to support, the main reason is due to the AR module did not provide instruction and AR marker download link to let user can understand how the AR module work.

5. I found the various functions in this system were well integrated.

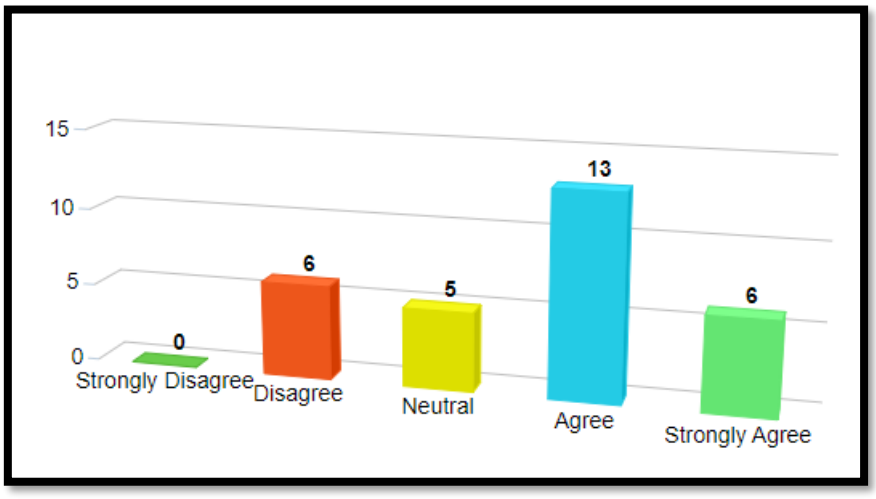


Figure 5.7 Bar chart of "I found the various functions in this system were well integrated."

The bar chart in figure 5.7 shown that 13 of the respondents agree found the various functions in this system were well integrated, 5 respondents neutral, 6 respondents strongly agree, 6 respondents disagree and no respondent strongly disagree. Based on the result analysis most of the user think various functions in this system were well integrated. However, there are still some of the users disagree, the main reason is due to some button is not functioning or the content is incomplete.

6. I thought there was too much inconsistency in this system.

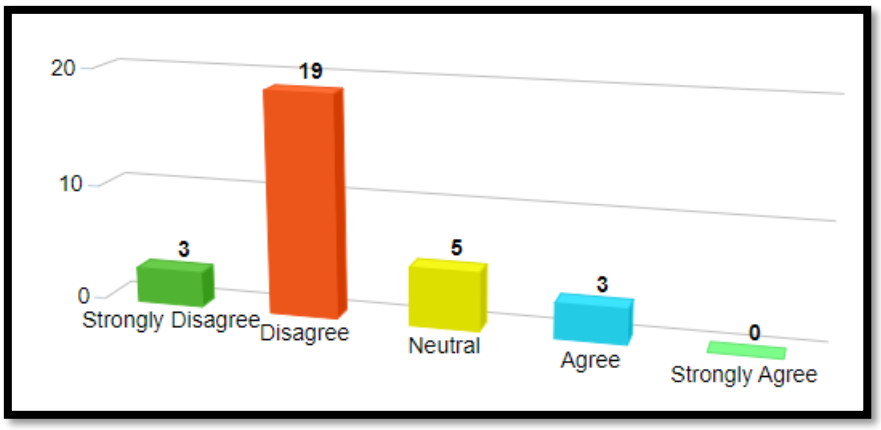


Figure 5.8 Bar chart of "I thought there was too much inconsistency in this system."

The bar chart in figure 5.8 shown that 19 of the respondents disagree that there was too much inconsistency in this system, 5 respondents neutral, 3 respondents strongly agree, 3 respondents agree and no respondent strongly agree. Based on the result analysis most of the disagree the system was too much inconsistency. The system may consist some bugs but the function operations are still consistent.

7. I would imagine that most people would learn to use this system very quickly.

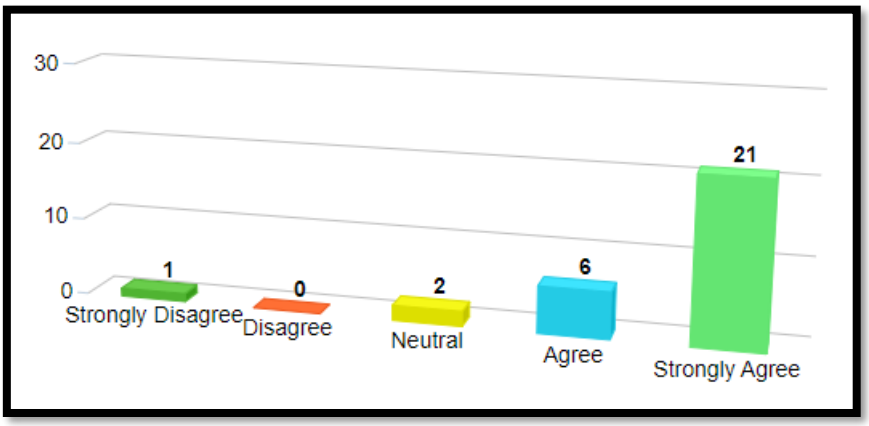


Figure 5.9 Bar chart of "I would imagine that most people would learn to use this system very quickly."

The bar chart in figure 5.9 shown that 21 of the respondents strongly agree that most people would learn to use this system very quickly, 6 respondents neutral, 2 respondents neutral, 1 respondent strongly disagree and no respondent disagree. Based on the result analysis majority of the user agree that most people able to learn and know how to use this system in a short time. This proof that the system is easy to use and did not have a very complex interface or function let user confuse.

8. I found the system very cumbersome to use.

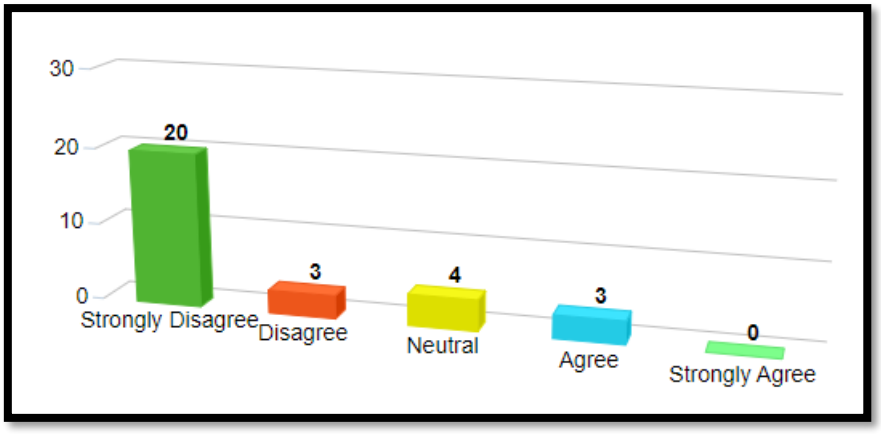


Figure 5.10 Bar chart of "I found the system very cumbersome to use."

The bar chart in figure 5.10 shown that 20 of the respondents strongly disagree that found the system very cumbersome to use, 4 respondents neutral, 3 respondents disagree, 3 respondents

agree and no respondent strongly agree. Based on the result analysis majority of the user disagree that most people able to learn and know how to use this system in a short time. The cumbersome system means that the very complicated and inefficient. From the result analysis, most of the users did not think that the system is complicated and the function and content are useful to the target users.

9. I felt very confident using the system.

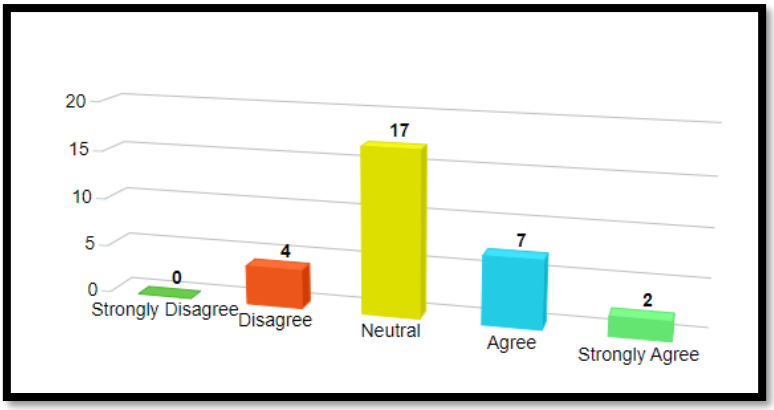


Figure 5.11 Bar chart of "I felt very confident using the system."

The bar chart in figure 5.11 shown that 17 of the respondents towards the statement felt very confident using the system, 4 respondents disagree, 7 respondents agree, 2 respondents strongly agree and no respondent strongly disagree. Based on the result analysis the responses are scale in the middle. The user felt confident or not most of the time is based on when they using the application it is always not functioning or clash out, the result show that the system did not have these issues,

10. I needed to learn a lot things before I could get going with this system.

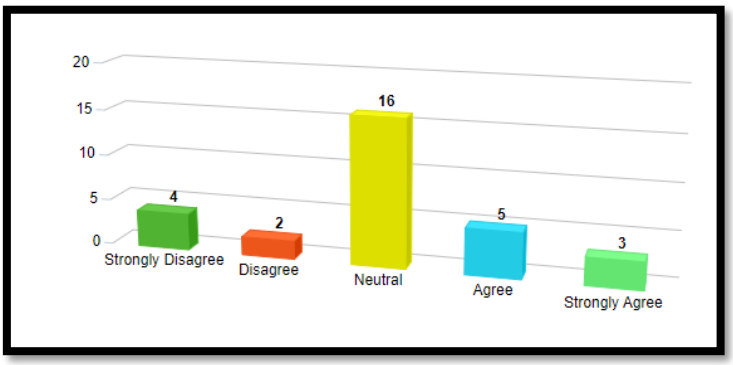


Figure 5.12 Bar chart of "I needed to learn a lot things before I could get going with this system."

The bar chart in figure 5.12 shown that 16 of the respondents towards the statement felt very confident using the system, 5 respondents agree, 4 respondents strongly disagree, 3 respondents strongly agree and 2 respondents disagree. Based on the result analysis the responses are scale in the middle. The statement learns a lot of things may refer the Augmented Reality technology, because some of the user may not know this technology or concepts apply in education application before. Another point is they may need some basic Physics concepts to test the system is well present or not.

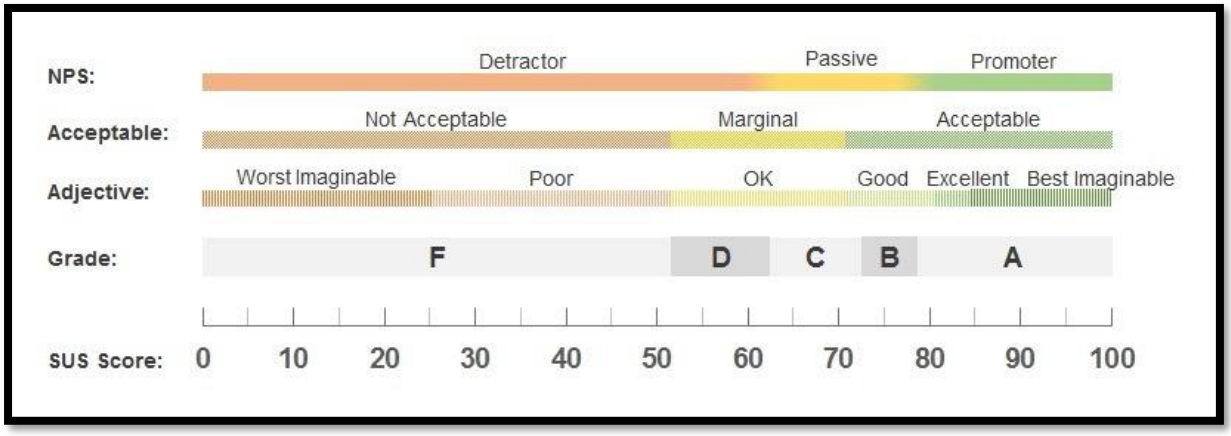


Figure 5.13 System Usability Scale (SUS) score diagram

By looking at a respondent's answers and the corresponding number score for each response, we can tabulate the overall SUS score by using the following framework: add up the total score for all odd-numbered questions, then subtract 5 from the total to get X=18-5=14, add up the total score for all even-numbered questions, then subtract that total from 25 to get Y=25-11=14, add up the total score of the new values (X+Y) and multiply by 2.5, Score =(14+14)*2.5 =70.

The result from the calculations is the score out of 100 but not percentage, it is a clear way of seeing the score. A score below 68 indicates that the design has issues that need to be researched and addressed, and a score above 68 indicates that minor improvements to the design are required.

Part C: General Software Testing

1. With the help of multimedia elements (text, graphic, audio, video and animation) can improve interactivity, so the user can learn more efficiently with better understanding.

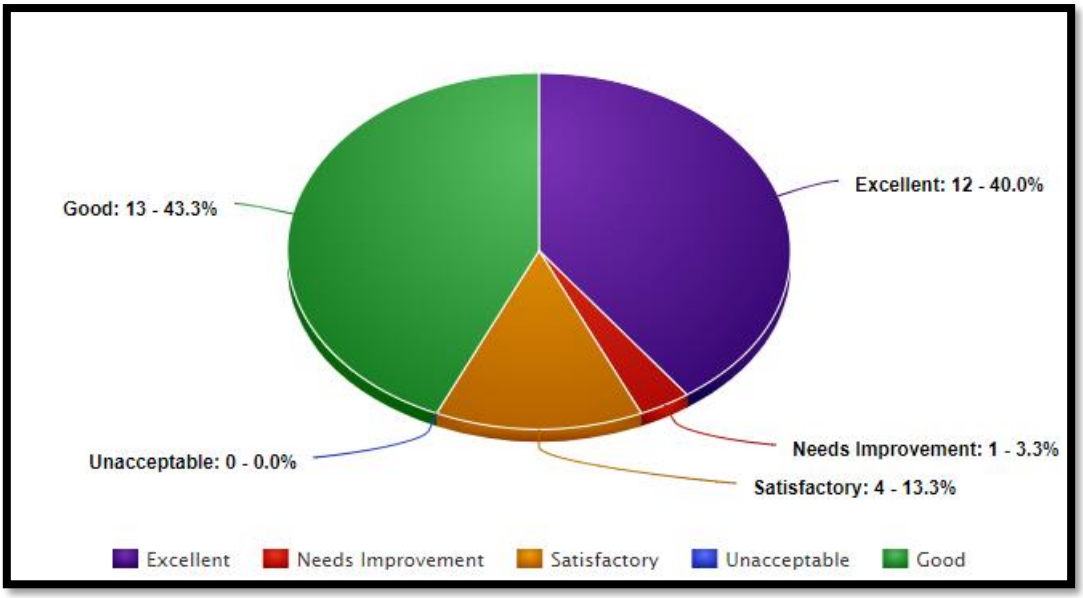


Figure 5.14 Pie chart of "With the help of multimedia elements (text, graphic, audio, video and animation) Can improve interactivity, so the user can learn more efficiently with better understanding"

The pie chart in Figure 5.13 shows that with the help of multimedia elements in the system can improve interactivity, so the user can learn more efficiently with better understanding. 13 respondents (43.3%) rate excellent with the statement and 12 respondents rate good (40%), 4 respondents rate satisfactory (13.3%), only one respondent rate needs improvement (3.3%) and no user rate unacceptable. The result shows that with the aid of multimedia element apply in the application provide a good environment that can improve the interactivity and the user have learned more efficient with better understanding.

2. Virtual Physics experiment module can save a lot of time and effort in understanding, especially supporting visualization.

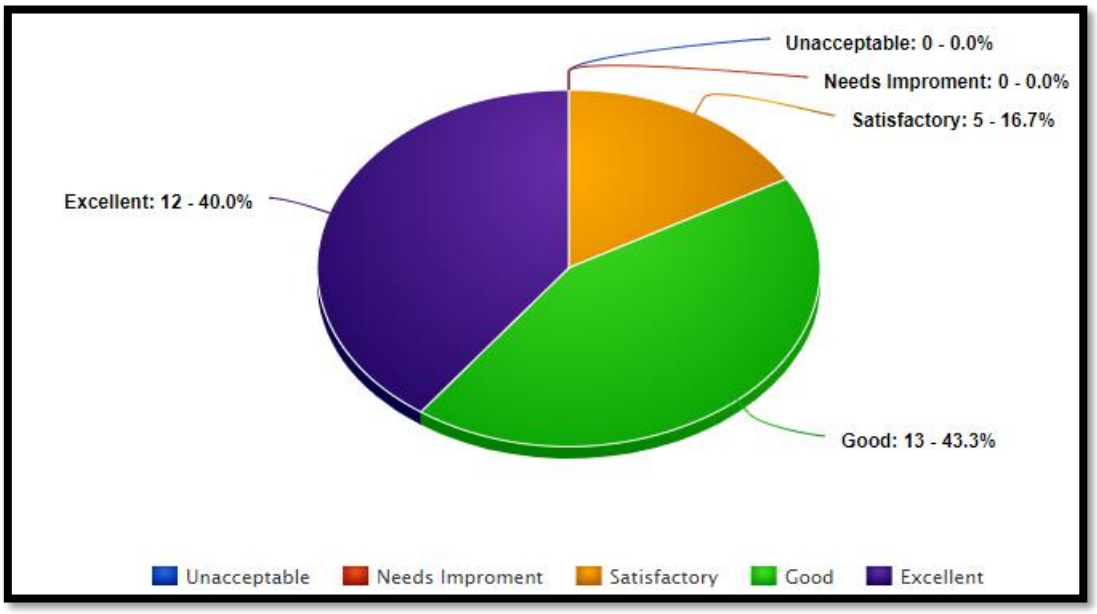


Figure 5.15 Pie chart of "Virtual Physics experiment module can save a lot of time and effort in understanding, especially supporting visualization."

The pie chart in Figure 5.14 shows that Virtual Physics experiment module can save a lot of time and effort in understanding, especially supporting visualization. 13 respondents (43.3%) rate good with the statement and 12 respondents rate excellent (40%), 5 respondents rate satisfactory (16.7%), no user rate unacceptable and needs improvement. The result show that the experiment module provides experiment based different formula or equation, by show the output graph and observe the result shown user able to have a better understanding learning physics theories or ideas.

3. Augmented Reality (AR) technology used in this app will help in visualization for Physics learning.

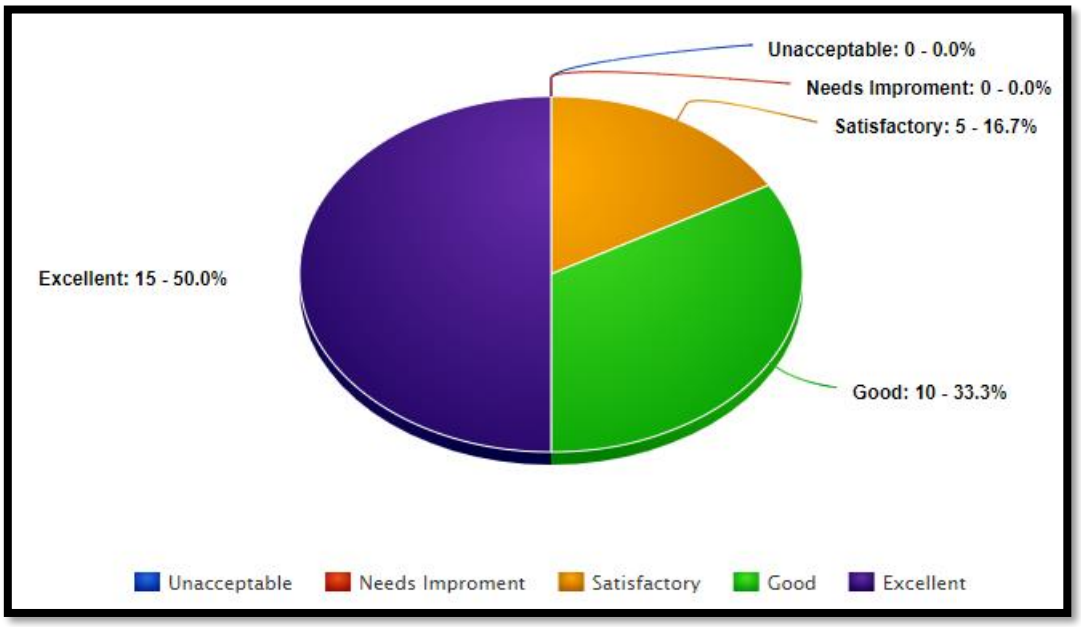


Figure 5.16 Pie chart of gender of "Augmented Reality (AR) technology used in this app will help in visualization for Physics learning."

The pie chart in Figure 5.15 shows that Augmented Reality (AR) technology used in this app will help user in visualization for Physics learning. 15 respondents (50.0%) rate excellent with the statement and 10 respondents rate good (33.3%), 5 respondents rate satisfactory (16.7%), and no user rate unacceptable and needs improvement. The AR technology of the application are applied in the optical instruments inspired and created by using Physics theories. The result shown that the user believe AR technology are able to help target user in visualization for this particular chapter concepts.

4. The depth of coverage for the topic content matched was appropriate and my expectation at the level of study. Adequate coverage of course syllabus in breadth and depth by provide adequate, useful study materials.

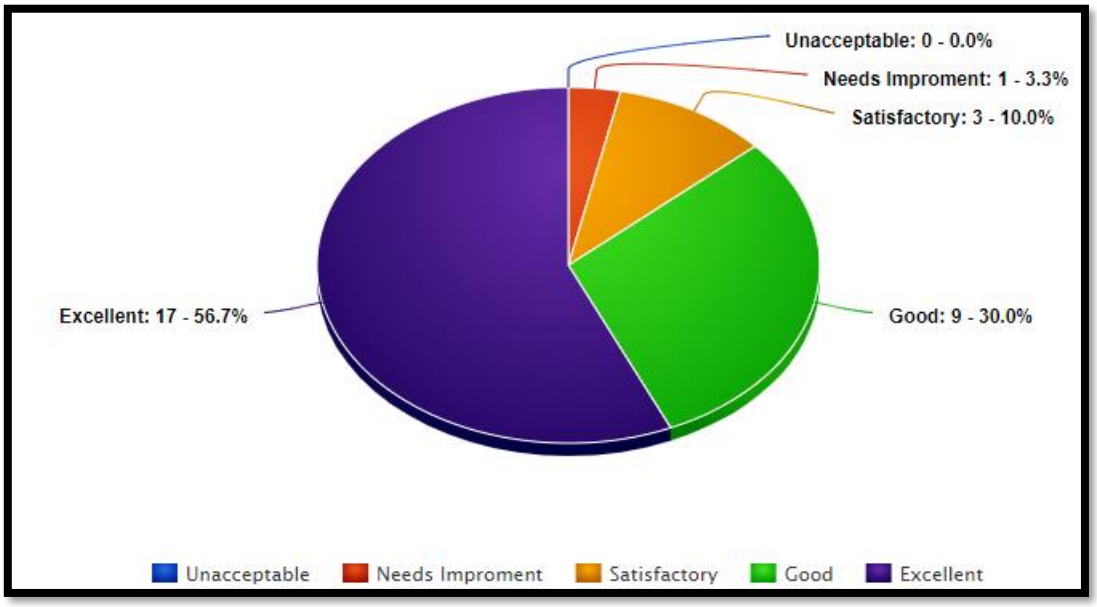


Figure 5.17 Pie chart of "The depth of coverage for the topic content matched was appropriate and my expectation at the level of study. Adequate coverage of course syllabus in breadth and depth by provide adequate, useful study material"

The pie chart in Figure 5.16 shows that the depth of coverage for the topic content matched was appropriate and meet user expectation at the level of study. Adequate coverage of course syllabus in breadth and depth by provide adequate, useful study materials in the application. 17 respondents (56.7%) rate excellent with the statement and 9 respondents rate good (30%), 3 respondents rate satisfactory (10.0%), only one respondent rate needs improvement (3.3%) and no user rate unacceptable. The result shows that most of the user are agree the content learning material in the application are suitable, depth of coverage Form 4 Physics Chapter 5 Light are matched with the syllabus at the level of study.

5. Quiz, tutorials and Lecture modules were adequate (content presentation).

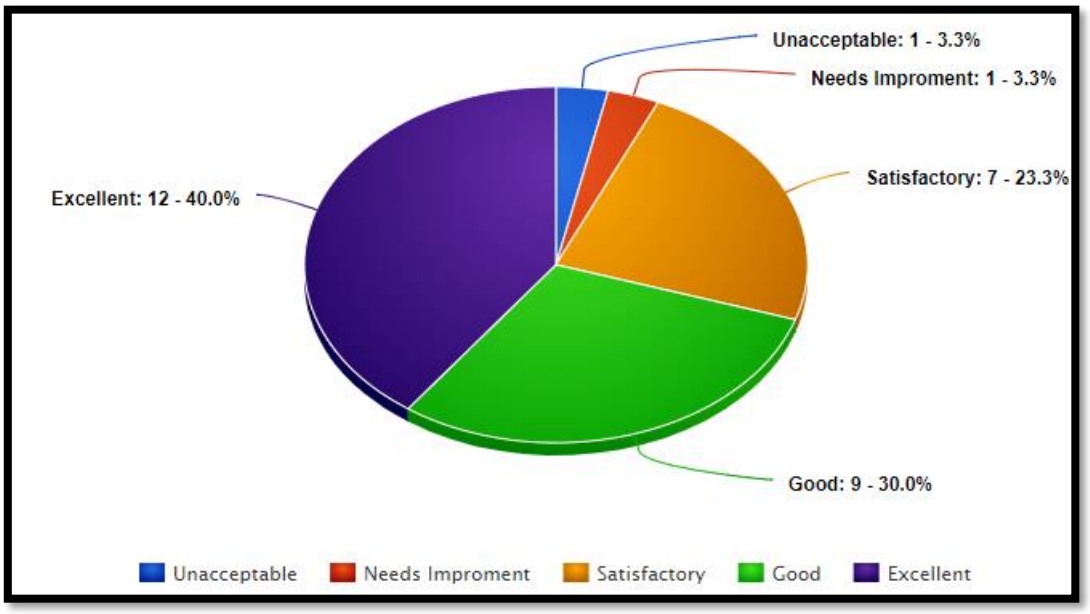


Figure 5.18 Pie chart of "Quiz, tutorials and Lecture modules were adequate (content presentation)."

The pie chart in Figure 5.17 shows that the Quiz, tutorials and Lecture modules were adequate based on content presentation in the application. 12 respondents (40.0%) rate excellent with the statement and 9 respondents rate good (30%), 7 respondents rate satisfactory (23.3%), only one respondent rate needs improvement (3.3%) and one respondent rate unacceptable (3.3%). The author designs the tutorial and quiz module are based on lecture module content, majority of the user agree that these three module are adequate for the target user which are the Form 4 student currently taking Physics subject to study the particular chapter.

6. In overall, the whole app is competent and effective in the delivery of Physics concepts using AR.

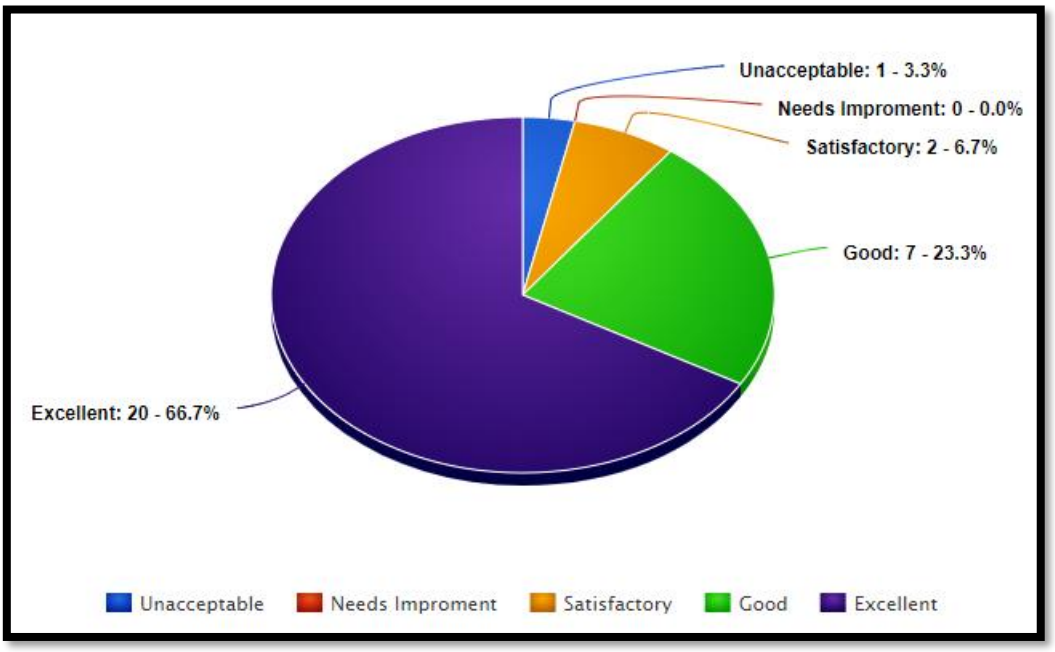


Figure 5.19 Pie chart of "In overall, the whole app is competent and effective in the delivery of Physics concepts using AR."

The pie chart in Figure 5.18 shows that in overall, the whole app is competent and effective in the delivery of Physics concepts using AR. 20 respondents (66.7%) rate excellent with the statement and 7 respondents rate good (23.3%), 2 respondents rate satisfactory (6.7%), only one respondent rate unacceptable (3.3%) and no one rate need improvement. There is one user did not agree that the application is competent and effective in the delivery of Physics concepts using AR, the main reason is due to the AR module are lack interactivity and the future enhancement will stated in the Chapter 6. Majority of the user still agree with that statement most probably the AR technology is still new when applied in education purpose.

7. The interactivity features in the apps can engage students in creative thinking, problem-solving and independent learning.

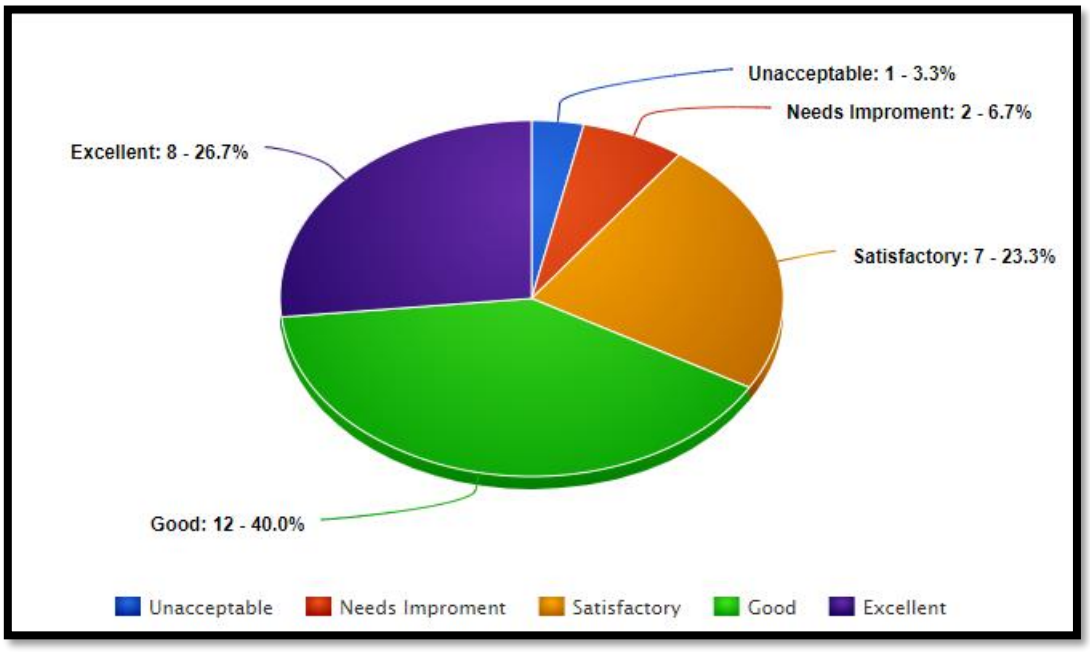


Figure 5.20 Pie chart of "The interactivity features in the apps can engage students in creative thinking, problem-solving and independent learning."

The pie chart in Figure 5.19 shows the interactivity features in the apps can engage students in creative thinking, problem-solving and independent learning. 12 respondents (40.0%) rate excellent with the statement and 8 respondents rate excellent (26.7%), 7 respondents rate satisfactory (23.3%), two respondent rates need improvement (6.7%) and only one user rate unacceptable (3.3%). There are few types of interactivity features provide in the Tutorial module and AR module only, the user agree that these features can engage students in creative thinking, problem solving and independent learning. Minority of the user disagree is due these features lack in AR module and experiment module, and the future enhancement will stated in the Chapter 6.

Part D: Module Testing

1. Some learning videos related to lecture topics put in application will help user understanding much better in the lecture module.

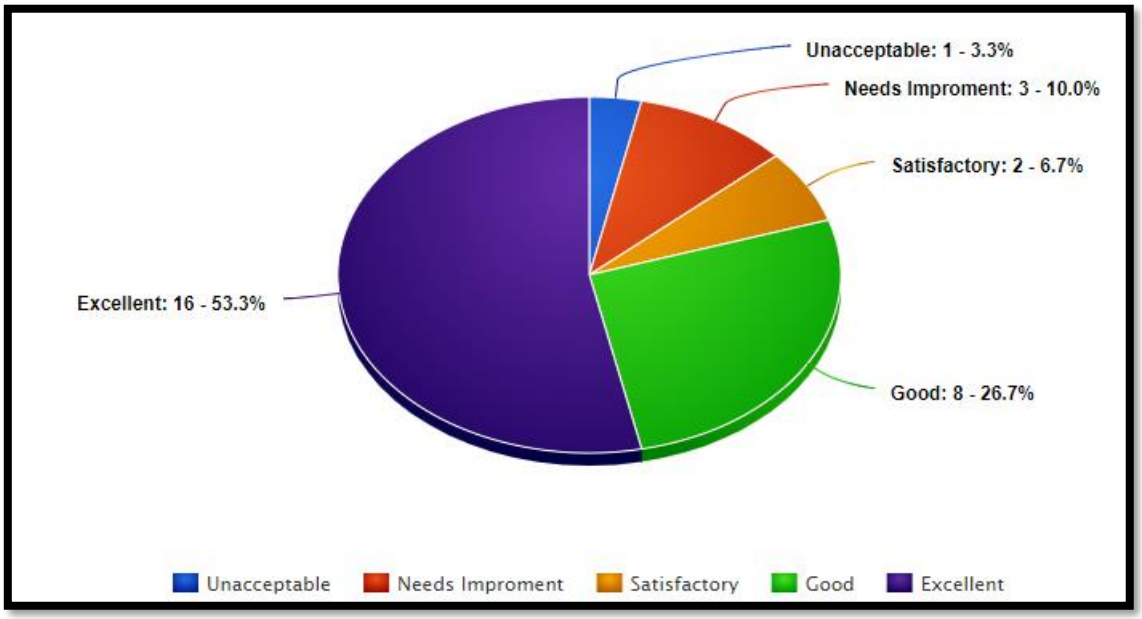


Figure 5.21 Pie chart of "Some learning videos related to lecture topics put in application will help user understanding much better in the lecture module."

The pie chart in Figure 5.20 shows user testing result rate with the statement some learning videos related to lecture topics put in application will help user understanding much better in the lecture module. 16 respondents (53.3%) rate excellent with the statement and 8 respondents rate excellent (26.7%), 3 respondents rate need improvement (10.0%), 2 respondents rate satisfactory (6.7%), and only one user rate unacceptable (3.3%). The learning videos related to lecture topics are put in the application is based the user requirement question gathering and the author successfully implement in the application, majority of the user agree with this statement the videos can help user understanding much better in the lecture module.

2. Different way of doing tutorial like drag and drop features, true or false will improve user understanding in different type of question in tutorial module.

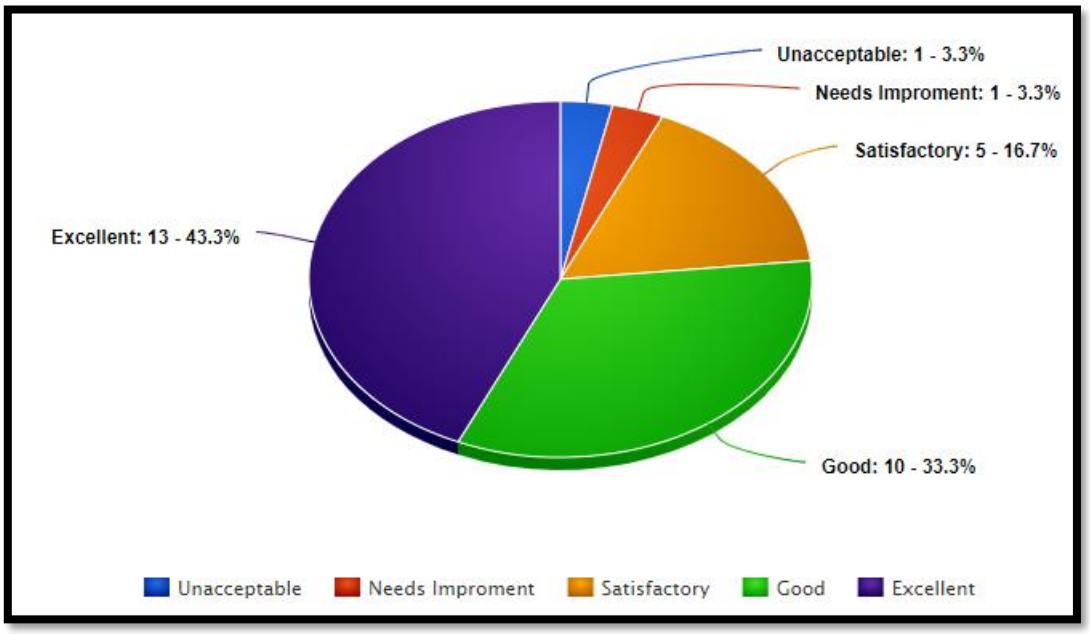


Figure 5.22 Pie chart of "Different way of doing tutorial like drag and drop features, true or false will improve user understanding in different type of question in tutorial module"

The pie chart in Figure 5.21 shows user testing result rate with different way of doing tutorial like drag and drop features, true or false will improve user understanding in different type of question in tutorial module. 13 respondents (43.3%) rate excellent with the statement and 10 respondents rate good (33.3%), 5 respondents rate need satisfactory (16.7%), only one respondent rate needs improvement (3.3%), and only one user rate unacceptable (3.3%).

3. The calculation and analysis of the output dataset with the conclusion save user time in Experiment module.

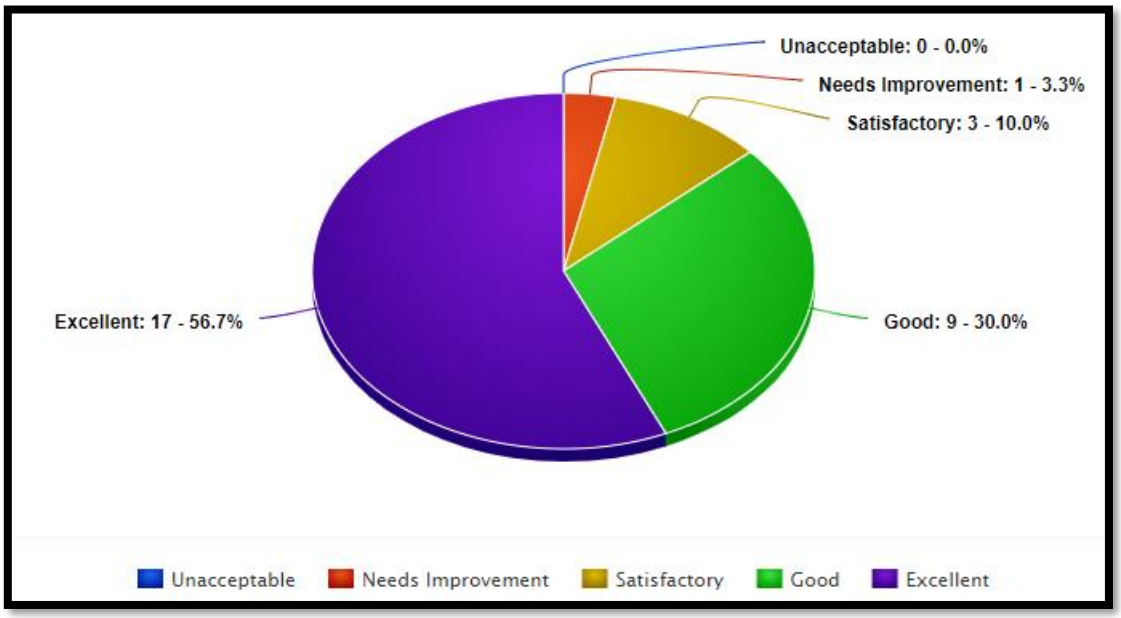


Figure 5.23 Pie chart of "The calculation and analysis of the output dataset with the conclusion save user time in Experiment module."

The pie chart in Figure 5.22 shows user testing result rate the calculation and analysis of the output dataset with the conclusion save user time in Experiment module. 17 respondents (56.7%) rate excellent with the statement and 9 respondents rate good (30.0%), 3 respondents rate satisfactory (10.0%), only one respondent rate needs improvement (3.3%), and no user rate unacceptable. In the experiment module, the user can press button to analysis the experiment result and the results will shown by animation in the table and show the plotted graph, the user can observe the graph pattern and read the conclusion stated to understanding the whole concepts experiment trying to bring out. Majority of the user agree that calculation and analysis of the output dataset with the conclusion can reduce the time spending to understanding the experiment.

4. The Augmented Reality (AR) marker content are detailed and useful for user read to enhance understanding.

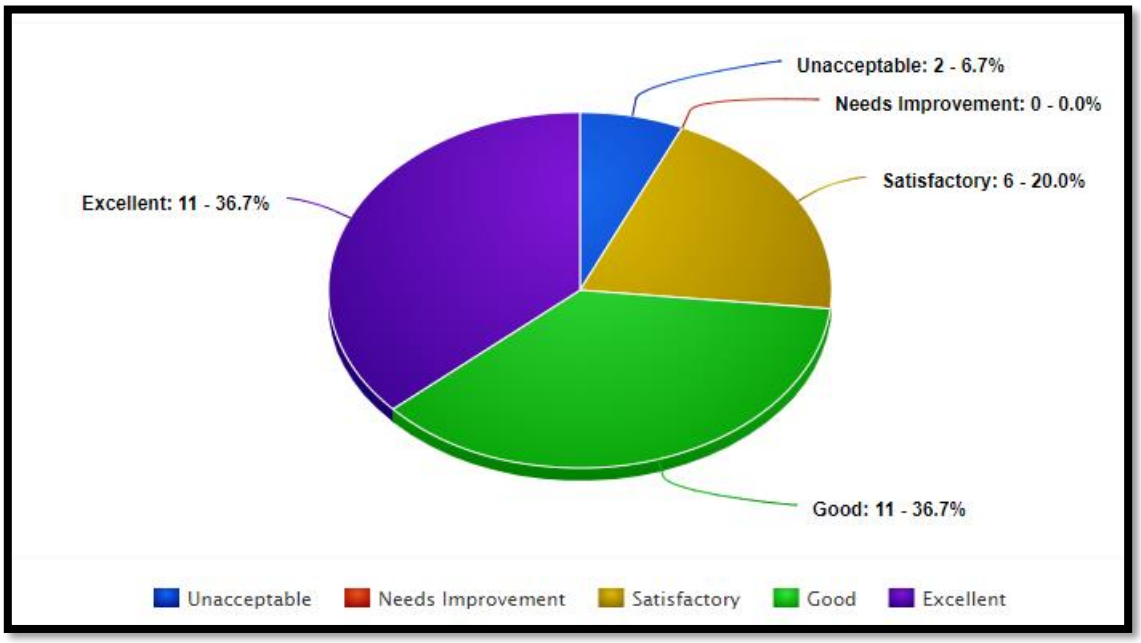


Figure 5.24 Pie chart of "The Augmented Reality (AR) marker content are detailed and useful for user read to enhance understanding."

The pie chart in Figure 5.23 shows user testing result rate The Augmented Reality (AR) marker content are detailed and useful for user read to enhance understanding. 11 respondents (36.7%) rate excellent with the statement and 11 respondents rate good (36.7%), 6 respondents rate satisfactory (20.0%), only two respondent rate needs unacceptable (6.7%), and no user rate need improvement. In the AR module, the user are required to print out the AR marker given, and test with their phone camera, to visualize the AR object. The AR marker is design by the author and the theories and concepts of the optical instruments are explain on the AR marker. Majority of the user agree with the stated this AR marker content are detail and useful for user to read to enhance their understanding.

Please kindly provide suggestion for the improvement of the app features in the near future.

Table 5.1: Suggestion for improvement of app features in the near future from respondent

can add typical exam question and ask student take note in Tutorial module	more interactive elements need put in	Can add instruction how AR module work
show more images in quiz module	AR object can be interacted more	Display image in quiz module for answering
Tutorial module drag and drop can mark the correct answer	improve the interface in Quiz module answer script	Provide link to download AR marker.
Can use different interactive font	Put more multimedia element in graphic and animation	Some undo button no functioning can fix
Explain the quiz question in details	Creative way implements in experiment module	Provide AR-tagged downloads in the app instead of send personally
Fix some bugs for some button	Can put some interesting fact	There can be a button to turn off the narration in the speech use module.
Interesting historical fact can be included for the theory.	Can have a button to close the narrator in the lecture module	Credit the video used in the application.
More interactivity for AR element	More graphic in experiment part	Credit the video used in the application.
Include past year question in the quiz and mark the year	Provide download file for the AR marker in the application	Adapt different screen size for different phone.
It is possible to add typical exam questions in both tutorial & quiz module	It is possible to add typical exam questions in both tutorial & quiz module	Show calculation in experiment module

The system testing questionnaire are collected from 30 users, and the last question are the open-ended question required user to provide suggestion to improve the application. These feedbacks are be separated according to module, multimedia element and some bugs, issues and error.

First, for the Lecture module, the user suggest that the author could search online and some interesting historical fact that did not mention in the normal textbook found to improve user interest in learning Physics. Some parts in the lecture module have narrator function, the user suggest that can have a button to turn off the narrator because some user might don't want have this feature so they can turn off based on their requirement. Lastly, there few lecture videos included in the lecture module; the user suggest that can have credit to the content of the creator.

For the Tutorial module, the drag and drop features are required to improve, when the user drag in the answer can have mark the answer dropped in is correct or not instead of check answer by themselves. The users also stated that the tutorial questions are too less and can add more especially those typical exam question to help student answer question during exam.

For the Quiz module, the users stated that the answer script panel are having a poor user interface design can be improving further. Besides, the users suggest that the quiz question should add image diagram and mark the year if that is the past year SPM question.

For the Experiment module, the user suggest that the author should brainstorming a more creative way to implement in the experiment based on how use of software can make the learning different from traditional text book. One of the users also claim that the calculation part in the experiment should explain more clearly because the experiment could be the exam question in the paper 3, the clear explanation in calculation could help them much in understanding.

For the AR module, the users suggest that the AR object could be interact more, the author will state the future enhancement about this in Chapter 6. Apart from that, the users suggest that add an instruction screen and provide download link button so users can have a basic understanding how this AR module work and can download the AR marker directly to experience the system feature.

Lastly, the user suggest that included more multimedia element such as add more graphic in experiment module, animation, image can be implemented more in whole application. Some users are found some bugs like soe undo button did not work but did not mention which part, and the screen size problem, the author will try to found and fix it.

5.4 Results and Discussions

From the 30 sample results of user testing, Majority of the users rate themselves average or poor in understanding Physics subject, only few users good in understanding Physics concept or theories, we can observe that Physics is a challenging subject. From the user testing result, the author found out learning application and AR technology aided in education is not popular to aided students in Physics learning. The first objective of this project is to study the usage of augmented reality technologies in aid of Physics learning. Based on the result analysis the objective is fully fulfilled and brings out the ideas AR technology can be implemented in Physics learning. Besides, the author hopes the development of this application's contribution will help much in improving the software for future usage. From the users testing result, most of the users did not use AR based learning software in Physics learning, the author successfully develops an AR based learning software for Physics education, the second objectives are partially fulfilled due to the AR learning features are lack of interactivity and still have space to improve further. However, the users are agreeing that the AR aided technology implemented in Physics learning is workable. Apart from that, the users welcome AR technology and agree that the AR element applied in the learning application can enhance the visualization. For five modules, the author has developed the proposed idea from user requirements. The result from general software testing and module testing showed all the ideas and strongly agreed by the majority, but it is still having much space to improve, some of the features might not be developed due to time constraint. The third objective of this project is to evaluate the effectiveness of AR based software that can support the learning of Physics ideas and theories that can be claimed to be fully fulfilled.

CHAPTER 6 CONCLUSION

6.1 Overview

In this Chapter the author is going to discuss about research findings based on the objective of the project to rediscuss again the objectives of the project are achieved or not. The author will also discuss the problem faced in this project based on the technical issue. Besides the author will share about the knowledge gained in the whole project what the author learnt. Apart from that the author will list out the limitations of application based on each module. Lastly, the author will also list out the possible future enhancement for this project.

6.2 Research Findings

The first objective of this project is to study the usage of augmented reality technologies in aided the Physics learning. Physics is a varied discipline that involves many logics, the understanding of abstract theories, and complex calculations. Augmented reality is an interactive experience of a real-world environment in which objects present in the real world are augmented with computer-generated perceptual information. With the aid of interactive augmented reality, the author tries to present the theory or idea behind it, to allow student visualize the image behind the theory and enhance their understanding. Based on the analysis of the results, the goal is fully achieved and the idea that AR technology can be implemented in physical learning is presented. The authors hope that the contributed development of this application will help to improve the software for future use in education domain.

The second objective of this project is to develop an AR based learning software for Physics education. The main reason is that some Physics theories may have underlying ideas, it is an abstraction of physical theory, and most students may not be clear about how the real thing works. Students may also have difficulty remembering theories or computational formats where we can easily trace this information back in learning applications so we can focus on comprehension or memorization. The author tries to help target users visualize the concept through multimedia elements and aid of AR technology, computational details are covered in the application. From the user testing results, most users did not use AR-based learning software in physics learning. The author successfully developed AR-based physics education learning software. Due to the lack of interactivity in AR learning, the second goal was partially

achieved and there is room for further improvement. However, users agree that AR-assisted technology implemented in physical learning is possible.

The third objective of this project is to evaluate the effectiveness the AR based software can support the learning of Physics ideas and theories. The author did move the learning platform to digital gadget though application which are a lot of difference from traditional learning way. Some ideas and theories can be present in interactive multimedia element, student can do some self-learning and observe the ideas behind. The authors developed the proposed ideas from user needs in five modules. The results of general software testing and module testing show all the ideas and are strongly agreed by most people, but there is still a lot of room for improvement, and some features may not be developed due to time constraints. According to the analysis of system test results, the third objective of the project is claimed to be fully achieved.

6.3 Problems Faced

In this project, the author did use different development platforms to complete, and they include Unity, Blender and Vuforia. These development platforms the author did not have any experience learning in any course lecture how to use them, so all the time the author had to watch video tutorials to learn from zero to know how to operate, use the features provided. The most difficult software is Blender, Blender is a free and open source 3Dcomputer graphics software toolset for creating virtual reality, animated films, visual effects, art, 3D printed models, motion graphics, interactive 3Dapplications, and formerly video games. The author is able to done the AR object through Blender. Over the years, there have been many people who have tried to learn Blender but quit within the first hour of using the software. For various reasons, beginners often find Blender difficult to learn, unintuitive, and confusing, which are various excuses for not continuing to learn Blender. The main reason Blender is considered difficult to learn is that it requires a set of skills that are often new to beginners, namely the ability to navigate and build models in 3D space [25]. There are so many different tools and tabs in the Blender interface that it quickly turns potential users off the software. This is really the huge hurdle that new users struggle to overcome when trying to learn skills like 3D modelling.

Apart from that, the main development used in this project will be Unity. Unity is very effective while rendering 2D and 3D scenes. In this era of visual treats, Unity can very well be used for rendering 3D images also. The quality offered is also relatively good compared to

other apps. Platforms like Unity have made the development process become quite simple and easy to use when compared to previous times. The Unity game engine is considered easier to use compared to many other technologies. However, this is the first time the author learns this kind of software, the author spends a lot of effort to familiar the operation.

Lastly, the language applied and used in Unity, called C#, is used to connect to the scripts and components of GameObjects and how they interact with each other to create your gameplay. C# is a general-purpose multi-paradigm programming language. However, it is very different from pure programming [26]. The author did spend a lot of time getting acquainted with the libraries and variables applied in Unity, and eventually the author could write C# scripts without having to copy the code directly from the video tutorial.

6.4 Knowledge Gained

The knowledge the author gain is the Augmented Reality technology. Before starting the project, the author did not have much idea about this technology and only have impression on a game called PokomenGo are implement that. Basically, Augmented Reality is an interactive experience and modification of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, addition of sound, visual elements, or other sensory stimuli. There are three different types of AR available which are Marker-based, Markerless and Location based. The types implement in this project is the Marker-based. To achieve the marker-based AR applied in this project, the author also learnt how to applied Vuforia Engine integrated with Unity. Vuforia Engine is a software development kit (SDK) for creating augmented reality applications. Developers can easily add advanced computer vision capabilities to any application, enabling it to recognize images and objects and interact with real-world spaces. The author also learnt that the differences between Virtual Reality and Augmented Reality.

Apart from that, the author able to know how to develop a mobile application with professional user interface design. With the professional interface design, the user use learning application to aid their study frequently. The AR element can improve the first impression of user toward the application. After that, the user will tend to use the application frequently and solve their learning difficulties in different aspects compare to traditional learning method. We can observe the professional user interface from these aspect, Usage of colour, Consistency Navigation Panel, Simplicity, , Clarity of Contents and Interactivity. The author also gained

this knowledge through literature review from other similar learning application. As mentioned above, if a software has a poorly designed interface that makes it difficult to use and may causes users to make mistakes, or if it hinders the user's efforts to get the job done, users will not like it regardless of the computing power it exhibits or the functionality it provides, because it simulates the user's perception of the software, the interface must be well designed.

Lastly, the author able to know how develop a software with applied software engineering principles. Software engineering principles are applied from the early stages of system specification to testing phases. The methodology being used is ADDIE model to develop the system, the author has a real experience develop a system from sketch and know why software principles is important due to need deliver a good quality software in the given time.

6.5 Limitations

The first limitation of the Lecture module is the lecture videos cannot select the play time frame; it will only play once till the end, so the user may not catch up with the content needed to play the video again. Second, some parts in the lecture module have a narrator function, the module did not have a feature to turn off the narrator because some users might not want to have this feature so they cannot turn off based on their requirement. Third, the lecture module is lacking an animation element to have a different compare to traditional way of learning in textbooks in order to enhance user study interest.

The first limitation of the Tutorial module is the drag and drop features cannot mark the answer option, when the user drag in the answer did not have mark answer features to know whether the dropped in is correct or not, users need to check the answer by themselves. Second, due to the time constraint the tutorial question being developed by the author is not enough. Third, the tutorial module did not have some typical exam question for the particular topic.

The first limitation of the Quiz module is the answer script review scene has a poor user interface design. Second, the answer script review developed by the author is not completed and lacks an answer explanation due to the time constraint. Third, the quiz question did not have an image provided with the question given.

The first limitation of the Experiment module is the lack of interactivity to let users perform to change the variables and observe the result. Second, due to time constraints only one experiment is able to be developed. Third, the experiment module content contains too many words and users may feel a bit messy.

For the AR module, the first limitation is the AR object only can interact with scale and rotate, lack of interactivity features. Second, the AR module did not have a download link button to let user download AR marker. Third, the AR module did not have instruction to let users can have a basic understanding how this AR module work.

6.6 Future Enhancement

For the future enhancement of this project, first will include more multimedia elements such as adding more graphics, animation, and images that can be implemented in 5 modules. For example, some ideas and theories can be present in 2D and 3D interactive virtual experiments, students can do some self-learning and observe the ideas behind, and add more animation to describe the content in the lecture module to make a different learning application compared to the traditional learning method through textbooks.

Furthermore, the user interface of the system can be further improved. For example, the Experiment module had too many words in one scene, did not follow the rule in simplicity and the answer script review in the Quiz module can be organised nicely, providing answers, explanations, and images for every question. The drag and drop features can be improved when a user drops in an answer in the panel slot, can identify if the answer drop is correct or not and have further interaction like show cross image or tick image instead of letting users check the answer by themselves. For the quiz module, the image can be added to the panel. For the Experiment module, it should be brainstorming a more creative way to implement in the experiment based on how use of software can make the learning different from traditional textbooks. From the user testing result, one of the users also claimed that the calculation part in the experiment should explain more clearly because the experiment could be the exam question in the paper 3, the clear explanation in calculation could help them much in understanding.

Last but not least is the Augmented Reality aid component in this project. For the AR module, it is suggested that the AR object could interact more, like create some button to let the AR object interact by animation or can select different manipulated variables and show different forms of the AR object such as can change the focal point etc. Apart from that, it is suggested that add an instruction screen and provide a download link button so users can have a basic understanding of how this AR module works and can download the AR marker directly to experience the system feature.

REFERENCES

[1] S. Klaus. (2016, Jan.), "The Fourth Industrial Revolution: what it means, how to respond",World Economic Forum [Online]. Available:https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

[2] Cai, S., Liu, C., Wang, T., Liu, E. and Liang, J. (2020). Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning. British Journal of Educational Technology.

[3] Saleh, S. (2014). Malaysian students' motivation towards Physics learning. European Journal of Science and Mathematics Education, [online] 2(4), pp.223–232. Available at: https://files.eric.ed.gov/fulltext/EJ1107653.pdf.

[4] Peters, P. C. (1982). Even honors students have conceptual difficulties with physics. American Journal of Physics, 50(6), 501–508. doi:10.1119/1.12797

[5] Jazuli, S., & Ugowachukwu, O.,(2019). Computer Application in Education [online] Available at : https://www.researchgate.net/publication/334448599_COMPUTER_APPLICATIONS_IN_EDUCATION.

[6] Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C., & LeMaster, R. (2006). PhET: Interactive Simulations for Teaching and Learning Physics. The Physics Teacher, 44(1), 18–23.

[7] Faghih, B., Reza Azadehfar, M. and Branch, B., 2013. 'User Interface Design for E-Learning Software', vol. 3, no. 3, pp. 2.

[8] Cho, V., Cheng, T. C. E., & Lai, W. M. J. (2009). The role of perceived user-interface design in continued usage intention of self-paced e-learning tools. Computers & Education, 53(2), 216–227. doi:10.1016/j.compedu.2009.01.014

[9] Mustafa, F., & Tuncel, M. (2019). Integrating augmented reality into problem-based learning: The effects on learning achievement and attitude in physics education. Computers & Education, 103635

[10] Ibáñez, M.-B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. Computers & Education, 123, 109–123.

[11] Hayes, A. (2020). Augmented reality. [online] Investopedia. Available at: https://www.investopedia.com/terms/a/augmented-reality.asp.

[12] Digital Promise. (n.d.). Types of AR. [online] Available at: https://digitalpromise.org/initiative/360-story-lab/360-production-guide/investigate/augmented-reality/getting-started-with-ar/types-of-ar/ [Accessed 24 Aug. 2021].

[13] Blippar (2018). 3 Different Types of AR explained: Marker-based, Markerless & Location [online] Blippar. Available at: https://www.blippar.com/blog/2018/08/14/marker-based-markerless-or-location-based-ar-different-types-of-ar.

[14] Assignment Help 4 Me. (2019). What are the advantages and Disadvantages of Augmented Reality?. [online] Available at: https://assignmenthelp4me.com/discussions/what-are-the-advantages-and-disadvantages-of-augmented-reality.html

[15] Porter, M.E. and Heppelmann, J.E. (2017). Why Every Organization Needs an Augmented Reality Strategy. [online] Harvard Business Review. Available at: https://hbr.org/2017/11/why-every-organization-needs-an-augmented-reality-strategy.

[16] MinasKan,N., Rambach,J., Pagani,A., Stricker,.D (2019) Augmented Reality in Physics education: Motion understanding using an Augmented Airtable

[17] Turtle (2018) Physics Lab (Version 2.2.4) [Mobile app]. Available at: Google Play (Downloaded:28 February 2021).

[18] University of Colorado Boulder (2020) PhET Simulations (Version 2.0.2) [Mobile app]. Available at: Google Play (Downloaded:28 February 2021).

[19] Maza Learn (2013) Physics Studio (Version 4.3.0) [Mobile app]. Available at: Google Play (Downloaded:28 February 2021).

[20] A_K (2018) Physics-Experiments for High School and College(Version 1.7.9) [Mobile app]. Available at: Google Play (Downloaded:28 February 2021).

[21] Tsuri LLC (2020) The Physics Machine:Physics Classroom and Tools (Version 1.0.6) [Mobile app].Available at: Google Play (Downloaded:28 February 2021).

[22] Usability.gov (2017). User-Centered Design Basics [online] Available at: https://www.usability.gov/what-and-why/user-centered-design.html

[23] The Interaction Design Foundation. (2019). What is User Centered Design? [online] Available at: https://www.interaction-design.org/literature/topics/user-centered-design.

[24] Kraeling, M. and Tania, L. (2019) Software Engineering Process for Embedded Systems (Second Edition)

[25] Blender Base Camp, “Why Is Blender 3D Hard To Learn?” [Online]. Available: https://blenderbasecamp.com/home/why-is-blender-3d-hard-to-learn/

[26] Unity, “Coding in C# in Unity for beginners” Unity. [Online]. Available: https://unity.com/how-to/learning-c-sharp-unity-beginners

APPENDICES

A.1 Questionnaire Survey Design

This is a user requirement gathering design by See Wen Kai from UNIVERSITI TUNKU ABDUL RAHMAN current taking subject UCCC3583 Project I in order to collect information from secondary school student to develop my Final Year Project. All the information collected will be acted as the education purpose without any commercial value and strictly confidential.

This will help me make improvements and better understanding on user requirement and prioritize new features in learning application in Physics.

The survey should only take 5 minutes, and your responses are completely anonymous.

You can only take the survey once, but you can edit your responses until the survey is closed on August 12, 2021.

Questions marked with an asterisk (*) are required.

If you have any questions about the survey, please feel freely to email me: kaikai0812@1utar.my

I’m' really appreciate your input!

A)Demographic Design

1.Gender

Male Female

2.How will you rate yourself in understanding the content of the Physics?

81%-100% Excellent

61%- 80% Good

41%- 60% Average

21%- 40% Poor

0%- 20% Very Poor

B)General Questions (Learning Difficulties)

1.For Form 4 Physics Syllabus, which chapter you think is most difficult for you?

Introduction to Physics

Forces and motion

Forces and pressure

Heat

Light

2.Among the chapters you select from Q1, can you provide some reasons why you think it is the most difficult chapter?

_____

3.What are the most challenging part for physics learning? (multiple/select only one)

hard to understanding the content

not able to visualize the Physics concept

not able to memories mathematical calculation

understand concept from Physics experiment

Others____

C)General Knowledge on Computing and exposure AR

1.Did you expose to the learning software to learn physics?

Yes No

2.Did the software help you much in understanding Physics content? Please provide reason. (IF ANSWER YES in Q1)

Yes/No_____

3.How often you use ICT learning software to aid in your study?(IF ANSWER YES in Q1)

Very Frequently

Frequently

Seldom

Rarely

Never

4.If you have chances to expose to a new learning application, what did you expect to see in the software? (IF ANSWER NO in Q1)

_____

5.Did you aware about Augmented reality technology?

Yes No

6.Did you use any Augmented reality aided components in your daily life?

Yes No

7.What is the AR application you use before? Please list down.(IF ANSWER YES in Q6)

8.If augmented reality elements are included to support the learning of Physics contents especially for visualization,

Do you think it is necessary?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

D)Specific Questions (expectation of the software)

Lecture module

1.In lecture module, the content will be separate each topic into concept, calculation format, example in reality will enhance user understanding and have better learning outcome.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

2.In lecture module, provide more 2D diagram or animation about the topics will enchance user understanding and have better learning outcome.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Tutorial module

1.Tutorial module should have different types of question including objective, calculation, multiple choice question.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

2.Tutorial module should design based on what expected to be learnt in lecture module, Experiment module and AR module.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

3.If user answer wrong in tutorial module, system will show some explanation why the answer provided is wrong and let the user try again or given some hint based on the question.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Experiment module

1.Do you want to have more interactive elements in virtual experiment?

Yes No

2.In experiment module, user can adjust parameters and show different results based on user input to manipulate variable

that can increase effectiveness of learning.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

3.In experiment module, it should provide lab manual for reading to have a better understanding about the virtual experiment.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Quiz module

1.User need to answer all the questions within the given time as a training for real exam.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

2.Past year questions applied in quiz module will be useful.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

AR learning module

1.In AR module, the model should include "drag and rotate" features to have better interactivity.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

2.In AR module, manipulated variables should be shown to the user and allow adjustment to get different outputs for better interactivity.

Do you agree?

Strongly Disagree

Disagree

Neutral

Agree

Strongly Agree

Did you have any suggested improved/added component for any module ?

If yes, please stated out

_____

Thank you for your participant.

I hope your input and contribution will help much in improve the software for future usage.

A.2 System Testing Questionnaire

This is a system testing questionnaire by See Wen Kai from UNIVERSITI TUNKU ABDUL RAHMAN current taking subject UCCC3596 Project II

in order to collect System Testing feedback from secondary school student to develop my Final Year Project.

All the information collected will be acted as the education purpose without any commercial value and strictly confidential.

This will help me do analysis to make improvements and better understanding on user requirement and prioritize new features in learning application in Physics.

The survey should only take 5 minutes, and your responses are completely anonymous.

You can only take the survey once, but you can edit your responses until the survey is closed on April 20, 2022.

Questions marked with an asterisk (*) are required.

Section A) Demographic Data

1.Gender

Male Female

2.How will you rate yourself in understanding the content of the Physics?

81%-100% Excellent

61%- 80% Good

41%- 60% Average

21%- 40% Poor

0%- 20% Very Poor

Section B) Usability Testing

Strongly Strongly

Disagree Agree

1 2 3 4 5

1. I think that I would like to use this system frequently.

2. I found the system unnecessarily complex.

3. I thought the system was easy to use.

4. I think that I would need the support of a technical person to be able to use this system.

5. I found the various functions in this system were well integrated.

6. I thought there was too much inconsistency in this system.

7. I would imagine that most people would learn to use this system very quickly.

8. I found the system very cumbersome to use.

9. I felt very confident using the system.

10.I needed to learn a lot things before I could get going with this system.

Section C) General Software Testing

5-Excellent

4-Good

3-Satisfactory

2-Needs Improvement

1-Unacceptable

1.With the help of multimedia elements (text, graphic, audio, video and animation)

Can improve interactivity, so the user can learn more efficiently with better understanding.

2.Virtual Physics experiment module can save a lot of time and effort in understanding, especially supporting visualisation.

3.Augmented Reality (AR) technology used in this app will help in visualisation for Physics learning.

4.The depth of coverage for the topic content matched was appropriate and my expectation at the level of study.

Adequate coverage of course syllabus in breadth and depth by provide adequate, useful study materials.

5.Quiz, tutorials and Lecture modules were adequate (content presentation).

6.In overall, the whole app is competent and effective in the delivery of Physics concepts using AR.

7.The interactivity features in the apps can engage students in creative thinking, problem-solving and independent learning.

Section D) Module Testing

5-Excellent

4-Good

3-Satisfactory

2-Needs Improvement

1-Unacceptable

1.Some learning videos related to lecture topics put in application will help user understanding much better in the lecture module.

2.Different way of doing tutorial like drag and drop features, true or false will improve user understanding in different type of question in tutorial module.

3.The calculation and analysis of the output dataset with the conclusion save user time in Experiment module.

4.The AR marker content are detailed and useful for user read to enhance understanding.

Please kindly provide suggestion for the improvement of the app features in the near future.

_____

Thank you for your participant.

I hope your input and contribution will help much in improve the software for future usage.

POSTER

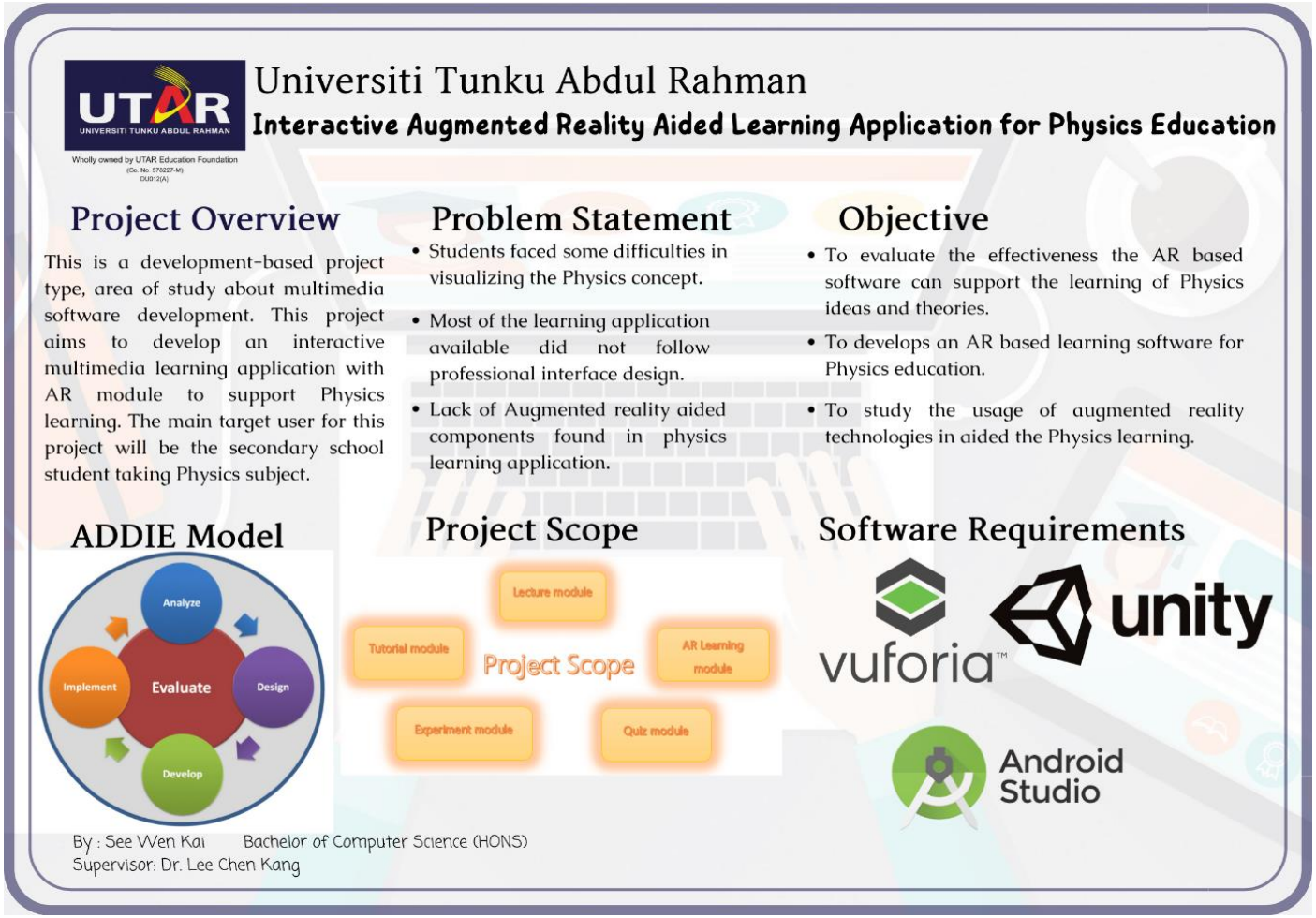


Figure 6.1 Poster of the project title

WEEKLY LOG

FINAL YEAR PROJECT WEEKLY REPORT

(Project II)

Trimester, Year: Y3T3	**Study week no.:** 2
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Collect and integrate Physics subject lecture material.
2. Backup of the project file.

2. WORK TO BE DONE

1. Develop Lecture module.
2. Improve user interface.
3. Learn develop quiz module through YouTube Tutorial.

3. PROBLEMS ENCOUNTERED

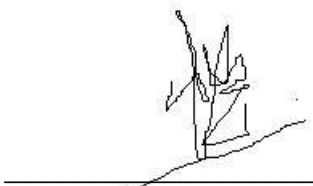
1. Did not have clear past year question answer explanation found online.
2. Not familiar with C# Script component.

4. SELF EVALUATION OF THE PROGRESS

1.Spend more time to learn and research through video and tutorial.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 3
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Lecture module content.
2. Quiz module function through implement C# Script.

2. WORK TO BE DONE

1. Collect suitable past year question and answer for quiz module.

3. PROBLEMS ENCOUNTERED

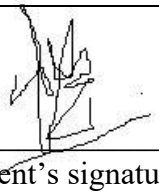
1. No problems encountered.

4. SELF EVALUATION OF THE PROGRESS

1. Develop the system as much as possible.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 4
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Quiz Module function completed.

2. WORK TO BE DONE

1. Quiz module rate score based on number of answers correct.

3. PROBLEMS ENCOUNTERED

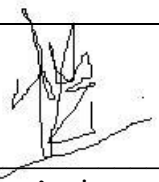
1. No problems encountered.

4. SELF EVALUATION OF THE PROGRESS

1. Develop the quiz module as much as possible.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 5
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Exposure on development tools (Vuforia and Blender) for AR module.
2. Quiz Module Set A and B completed.

2. WORK TO BE DONE

1. Add scroll panel to let user review answer of the quiz.

3. PROBLEMS ENCOUNTERED

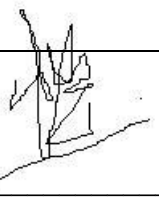
1. Did not have clear past year question answer explanation found online.

4. SELF EVALUATION OF THE PROGRESS

1. Develop the quiz module as much as possible.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 6
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Lecture module completed.
2. Watch and learn video tutorial development Augmented Reality application using Blender, Unity and Vuforia

2. WORK TO BE DONE

1. Start develop AR module.
2. Design AR marker and upload in Vuforia database.

3. PROBLEMS ENCOUNTERED

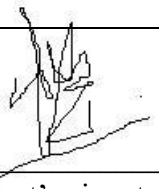
1. Less familiar with Blender to design the Physics model object.

4. SELF EVALUATION OF THE PROGRESS

1. Spend more time watch YouTube tutorial to learn Blender basic function.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 7
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. AR marker content.
2. Backup of the project file.

2. WORK TO BE DONE

1. Create database in Vuforia and install in Unity.
2. Use blender to create AR object.

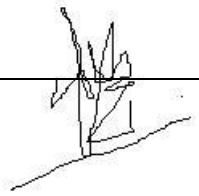
3. PROBLEMS ENCOUNTERED

1. Less familiar with Blender to design the model.

4. SELF EVALUATION OF THE PROGRESS

1. Spend more time watch YouTube tutorial to learn Blender basic function.

Lee Chen Kang



Supervisor's signature

Student's signature

Trimester, Year: Y3T3	**Study week no.:** 8
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Drag and drop function in Tutorial module

2. WORK TO BE DONE

1. Develop more content for Tutorial module.
2. Brainstorming more ideas to let user answer question in Tutorial module.

3. PROBLEMS ENCOUNTERED

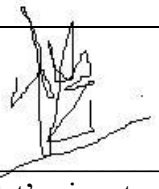
1. Less familiar with Blender to design the model.

4. SELF EVALUATION OF THE PROGRESS

1. Spend more time watch YouTube tutorial to learn Blender basic function.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 9
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. AR object model design using Blender.
2. AR module basic function completed.
3. True false option function in Tutorial module completed.

2. WORK TO BE DONE

1. Development of the user interface of the AR module.

3. PROBLEMS ENCOUNTERED

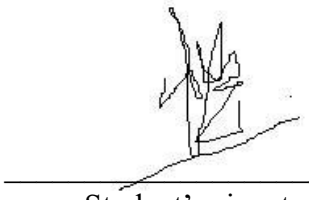
1. Less interactivity in AR module.

4. SELF EVALUATION OF THE PROGRESS

1. Develop the system as much as possible.
2. Brainstorming idea to improve AR module.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 10
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Improve User interface of the system based on feedback given from supervisor.
2. Add in answer script in Quiz module
3. Change layout of UI element in Tutorial.
4. Idea of Interact with AR object and learn through video tutorial to implement

2. WORK TO BE DONE

1. System Testing questionnaire design.
2. Add slider to let AR object scale and rotate to increase interactivity.

3. PROBLEMS ENCOUNTERED

1. No problem encountered.

4. SELF EVALUATION OF THE PROGRESS

1. Improve the user interface based on feedback given by supervisor.

Lee Chen Kang

Supervisor's signature

Student's signature

Trimester, Year: Y3T3	**Study week no.:** 11
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Improve User interface of the system.
2. System Testing questionnaire design.
3. Improve AR module interface and interactivity.

2. WORK TO BE DONE

1. Collect 30 samples system testing from user.
2. Improve the user interface in main menu and lecture module.

3. PROBLEMS ENCOUNTERED

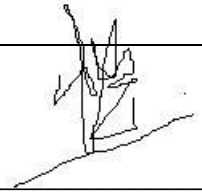
1. No problem encountered.

4. SELF EVALUATION OF THE PROGRESS

1. Study and research how to design a good user interface.

Lee Chen Kang

Supervisor's signature



Student's signature

Trimester, Year: Y3T3	**Study week no.:** 12
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Improve Experiment Module content and animation.
2. Improve Tutorial Module function and interface design.
3. Improve lecture and main menu User interface of the system.

2. WORK TO BE DONE

1. Collect 30 samples questionnaire system testing
2. Writing the Chapter 4,5,6 of FYP 2 report.

3. PROBLEMS ENCOUNTERED

1. Not familiar with IEEE references format.

4. SELF EVALUATION OF THE PROGRESS

1. Develop the system as much as possible.
2. Read the IEEE references guideline given from supervisor.

Lee Chen Kang

Supervisor's signature

Student's signature

Trimester, Year: Y3T3	**Study week no.:** 13
Student Name & ID: See Wen Kai, 18ACB04713	
Supervisor: Ts. Dr. Lee Chen Kang	
Project Title: Interactive Augmented Reality Aided Learning Application for Physics Education	

1. WORK DONE

1. Chapter 4 of FYP 2 report.
2. Collect 30 samples questionnaire system testing.
3. Backup of the project file.

2. WORK TO BE DONE

1. Complete the whole FYP 2 report
2. Continue improve the system and fix the bugs found in testing.

3. PROBLEMS ENCOUNTERED

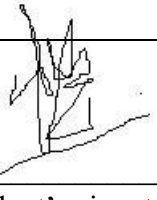
1. No problem encountered.

4. SELF EVALUATION OF THE PROGRESS

1. Improve the system based on feedback given as much as possible.
2. Fix bugs and error found in testing.

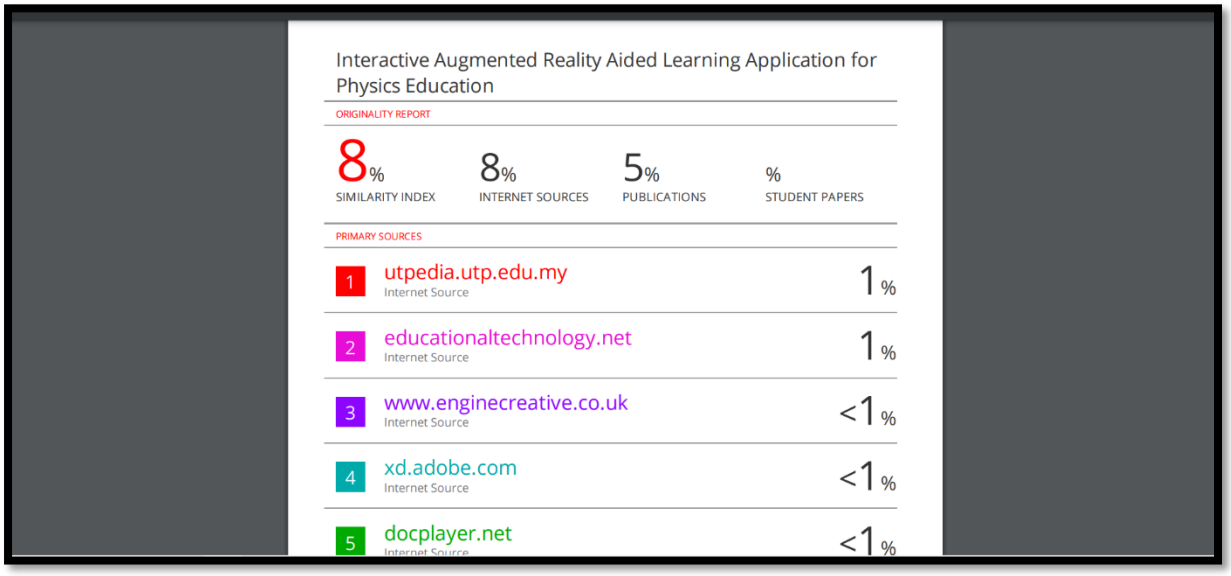
Lee Chen Kang

Supervisor's signature



Student's signature

PLAGIARISM CHECK RESULT



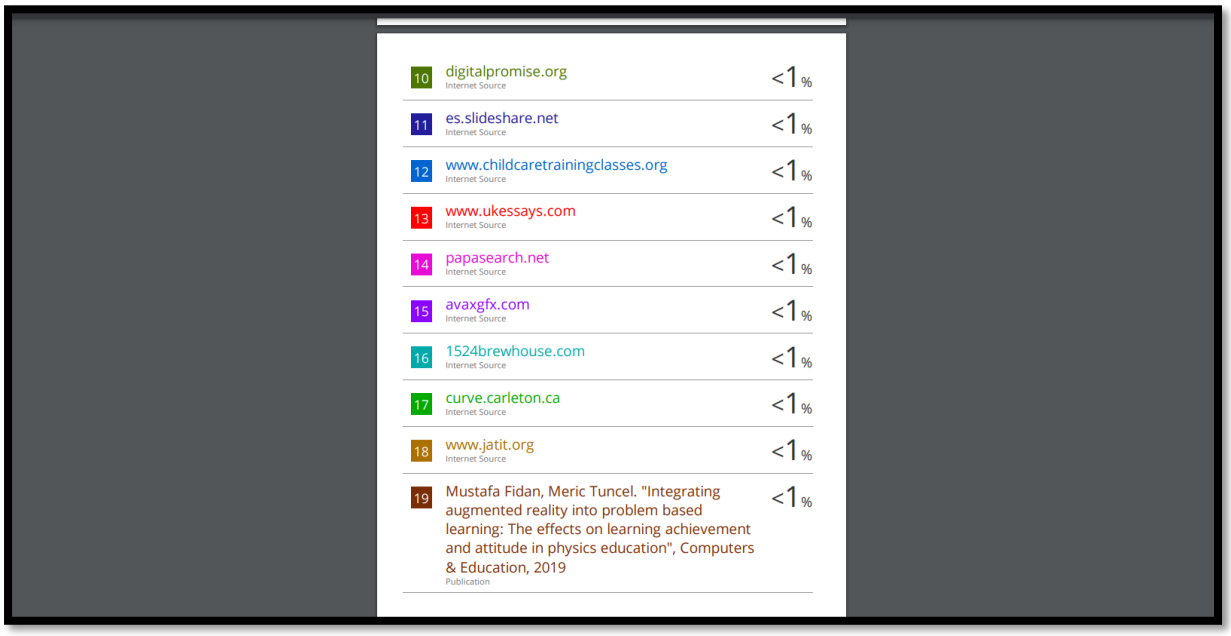
Interactive Augmented Reality Aided Learning Application for Physics Education

ORIGINALITY REPORT

8%	8%	5%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	utpedia.utp.edu.my Internet Source	1%
2	educationaltechnology.net Internet Source	1%
3	www.enginecreative.co.uk Internet Source	<1%
4	xd.adobe.com Internet Source	<1%
5	docplayer.net Internet Source	<1%



10	digitalpromise.org Internet Source	<1%
11	es.slideshare.net Internet Source	<1%
12	www.childcaretrainingclasses.org Internet Source	<1%
13	www.ukessays.com Internet Source	<1%
14	papasearch.net Internet Source	<1%
15	avaxgfx.com Internet Source	<1%
16	1524brewhouse.com Internet Source	<1%
17	curve.carleton.ca Internet Source	<1%
18	www.jatit.org Internet Source	<1%
19	Mustafa Fidan, Meric Tuncel. "Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education", Computers & Education, 2019 Publication	<1%

Form Title: Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1of 1

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	See Wen Kai
ID Number(s)	18ACB04713
Programme / Course	Bachelor of Computer Science (Honours)
Title of Final Year Project	Interactive Augmented Reality Aided Learning Application for Physics Education

Similarity	**Supervisor's Comments (Compulsory if parameters of originality exceed the limits approved by UTAR)**
Overall similarity index: 8 % **Similarity by source** Internet Sources: 8 % Publications: 5 % Student Papers: 0 %	
Number of individual sources listed of more than 3% similarity: 0	
Parameters of originality required, and limits approved by UTAR are as Follows: **(i) Overall similarity index is 20% and below, and** **(ii) Matching of individual sources listed must be less than 3% each, and** **(iii) Matching texts in continuous block must not exceed 8 words** ***Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.***	

Note: Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Lee Chen Kang

Signature of Supervisor

Name: Ts Dr Lee Chen Kang

Date: 22/4/2022

Signature of Co-Supervisor

Name: _____

Date: _____

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

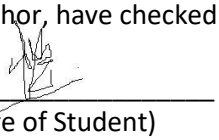
CHECKLIST FOR FYP2 THESIS SUBMISSION

Student ID	18ACB04713
Student Name	See Wen Kai
Supervisor Name	Ts. Dr. Lee Chen Kang

TICK (√)	DOCUMENT ITEMS Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.
-	Front Plastic Cover (for hardcopy)
√	Title Page
√	Signed Report Status Declaration Form
√	Signed FYP Thesis Submission Form
√	Signed form of the Declaration of Originality
√	Acknowledgement
√	Abstract
√	Table of Contents
√	List of Figures (if applicable)
√	List of Tables (if applicable)
-	List of Symbols (if applicable)
-	List of Abbreviations (if applicable)
√	Chapters / Content
√	Bibliography (or References)
√	All references in bibliography are cited in the thesis, especially in the chapter of literature review
√	Appendices (if applicable)
√	Weekly Log
√	Poster
√	Signed Turnitin Report (Plagiarism Check Result - Form Number: FM-IAD-005)
√	I agree 5 marks will be deducted due to incorrect format, declare wrongly the ticked of these items, and/or any dispute happening for these items in this report.

*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report.



(Signature of Student)
Date: 22/4/2022