AUGMENTED REALITY ARC WELDING LEARNING APPLICATION TO ENHANCE STUDENT'S MOTIVATION

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Abstrak

Kajian ini memperkenalkan aplikasi mudah alih bersepadu dengan realiti luasan yang boleh digunakan oleh pelajar Kejuruteraan Mekanikal untuk belajar subjek kimpalan. Tambahan lagi, kajian persepsi dalam kalangan sampel responden yang pernah menggunakan aplikasi tersebut telah dijalankan. Kebiasaannya pelajar akan mempelajari konsep teori kimpalan di dalam kelas diikuti dengan latihan berasaskan arahan di bengkel. Namun begitu, pelajar menghadapi kesukaran untuk mengikuti semua yang telah diajar di dalam kelas dalam masa yang terhad. Kimpalan adalah merbahaya untuk mereka yang baru mula belajar dan persekitaran kimpalan juga merbahaya serta memudaratkan kesihatan. Tambahan pula, kajian awal mendapati pelajar kekurangan bahan yang mencukupi untuk membantu mereka semasa ulang kaji dan memerlukan bahan tambahan untuk pembelajaran kimpalan. Kajian ini mencadangkan aplikasi Pembelajaran Kimpalan Arka Mudah Alih (MAWL) yang menggunakan aplikasi mudah alih yang disepadukan dengan teknologi realiti luasan untuk mengkaji persepsi pengguna berdasarkan kemudahan penggunaan, penglibatan, kebolehbelajaran, kepuasan dan kebergunaan. Metodologi kajian dalam kajian ini telah diadaptasi daripada Kuechler and Vaishnavi yang terdiri daripada lima fasa: kesedaran tentang masalah, cadangan, pembangunan, penilaian, dan kesimpulan. Kajian ini menggabungkan ARCS motivasi model dan teori konstruktivis untuk menyediakan bahan pembelajaran yang efektif. Hasil penilaian menunjukkan bahawa pembolehubah tidak bersandar (Penglibatan, Kepuasan dan Kebergunaan) mempunyai hubungan yang signifikan dengan pembolehubah bersandar (Motivasi). Hasil kajian persepsi menunjukkan bahawa pengguna sangat bersetuju dengan kemudahan penggunaan, keupayaan belajar, kepuasan, kebergunaan dan motivasi, manakala mereka bersetuju dengan penglibatan. Sumbangan utama kajian ini ialah aplikasi MAWL yang merupakan alat pembelajaran tambahan bertujuan untuk memotivasikan pelajar dalam pembelajaran kimpalan. Keputusan menunjukkan bahawa ARCS motivasi model dan teori konstruktivisme boleh diaplikasikan untuk membangunkan bahan pembelajaran berkesan yang terdapat dalam aplikasi Pembelajaran Kimpalan Arka Mudah Alih (MAWL). Selain itu, penglibatan, kepuasan dan kebergunaan mempunyai pengaruh positif terhadap motivasi. Oleh itu, semasa mereka bentuk dan membangunkan aplikasi mudah alih pembelajaran kimpalan berasaskan realiti luasan, faktor termasuk penglibatan, kepuasan dan kebergunaan perlu disepadukan ke dalam aplikasi untuk meningkatkan motivasi pelajar terhadap alat tersebut.

Kata kunci: TVET, Pembelajaran mudah alih, Aplikasi MAWL, Realiti luasan, Pembelajaran kimpalan

Abstract

This study introduces a mobile application integrated with augmented reality that can be used by Mechanical Engineering students to learn welding subject. Moreover, a study of perception among a sample of respondents who have used the app has been conducted. Normally, students will learn the theoretical concepts of welding in the class followed by instruction-based training in the workshop. However, students have difficulty to follow everything that has been taught in the class in a limited time. Welding is dangerous for beginners and the welding environments are harmful and injurious to the health. Furthermore, the preliminary study revealed that the students lacked sufficient materials to assist them during revision and need additional materials for welding learning. This study proposes the Mobile Arc Welding Learning (MAWL) app which use mobile app integrated with augmented reality technology to study user's perceptions based on ease of use, engagement, learnability, satisfaction and usefulness. The research methodology in this study was adapted from Kuechler and Vaishnavi which consists of five phases: awareness of problems, suggestions, development, evaluation, and conclusion. The study incorporates the ARCS motivation model and constructivist theory to provide effective learning material. The evaluation results showed that the independent variables (Engagement, Satisfaction and Usefulness) are significantly related to the dependent variable (motivation). The results of the perception study indicate that the users strongly agreed on ease of use, learnability, satisfaction, usefulness and motivation, while they agreed on engagement. The main contribution of this study is the MAWL app which is a supplementary learning tool with the purpose to motivate students in welding learning. The results show that the ARCS motivation model and constructivist theory can be applied to develop effective learning materials found in the Mobile Arc Welding Learning (MAWL) app. Besides that, engagement, satisfaction and usefulness have positive influence on motivation. Thus, when designing and developing AR mobile-based welding learning app, factors including engagement, satisfaction and usefulness need to be integrated into the app to improve the student's motivation towards the tool.

Keywords: TVET, Mobile learning, MAWL app, Augmented reality, Welding learning

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter focuses on the research background of the study. The introduction presents topics that are important to the research. It starts with the research background followed by the problem statements and the preliminary study. It continues with the research question, objective, and scope before concluding with the research significance.

1.2 Research Background

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines Technical and Vocational Education and Training (TVET) as technical and vocational education which include general education, technologies study related to sciences and improve job-related skills, knowledge, and attitudes in different economic sectors and in social life. (UNESCO, 2021). TVET refers to a range of learning experiences such as from educational institute or workplace which are relevant to the world of work (UNESCO, 2021). By helping youngsters and adults develop their skills to fulfil the demands of work and business, TVET is able to meet the economic, environmental, and social demands ("TVET Skills Equip Youth for Jobs," 2016). The Malaysia Education Blueprint 2013–2025 (KPM, 2013) states that technical education educates students for higher education while vocational education develops professionals with specific expertise and technical or vocational skills. TVET was no longer second-class education for those who dropout or did not excel in study but in contrary TVET based jobs can provide lucrative salaries ("Institusi TVET Malaysia Antara Terbaik Di Dunia," 2021).

According to Tan Sri Muhyiddin Yassin ("Institusi TVET Malaysia Antara Terbaik Di Dunia," 2021), TVET is important for human resources development in ensuring new highly workforce could be produced that is important to the country's development especially for the new fields of work. Malaysian government gives a lot of commitment to enhance TVET education infrastructure and the allocation for the TVET field also increases from year to year. Malaysia introduced the Economic Transformation Programme (ETP) which has been launched on September 25, 2010 which focuses on 12 National Key Economic Areas (NKEAs) as a strategy by the government to develop Malaysia into a country with high income by the year 2020 ("Kerajaan Isytihar 2017 Tahun TVET," 2017). ETP expected that the labour demand to outgrow the labour supply because the demand and supply for labour in Malaysia have been growing annually at 2% (Ismail & Hassan, 2013) and by 2020, an additional 1.5 million TVET-related jobs will be created which is 60% require TVET skills ("TVET Skills Equip Youth for Jobs," 2016). As such, there is a need to review the current process and approach of teaching, learning as well as training for TVET education to upgrade and improve the student's learning performance.

The Polytechnic Education Department had initiated its own Massive Open Online Courses known as the Malaysian Polytechnic MOOC (PoliMOOC) where their main purpose is to provide courses related to TVET programs through OpenLearning as an online platform ("TVET Skills Equip Youth for Jobs," 2016). In addition, The Star ("TVET Skills Equip Youth for Jobs," 2016) reported that there are about 34 polytechnics in Malaysia are included in the PoliMOOC with each starting its own MOOC according to its niche. The programs that are offered at the polytechnics ranges from certificate up to advanced diploma levels.

Polytechnic students who enroll in the Mechanical Engineering program have to take several field-related courses including welding. In the welding class, the students have to understand the theoretical concept of welding whereby step-by-step instructions using paper handouts and PowerPoint presentation are given to them before proceeding to the practical sessions in the workshop. Students will be guided by the lecturer beginning with the basic foundation in welding up to the advance stage of welding. In the first and second semesters, the students have to take basic welding classes which comprise of gas and arc welding. Next, students will have to learn more advanced welding techniques namely; Tungsten Inert Gas (TIG) and Gas Metal Arc (GMA commonly known as Metal Inert Gas (MIG)).

Furthermore, welding is a commonly used process for joining metal parts by congelation of materials by melting the boundaries using heat where it is used to join together parts of many things from atomic reactors, ships, bridges, to bicycles, and so on (Hashimoto, 2015). According to Hess (2019), there are three common types of welding namely; MIG, TIG and Stick (also known as shielded metal arc welding and flux-shielded arc welding). Besides, there are another several types of welding techniques including Flux-cored arc welding (FCAW), Electronic beam welding (EBW), Atomic hydrogen welding (AHW), Plasma Arc welding, Electroslag welding, Submerged Arc welding, Carbon Arc welding, Oxy-Fuel welding, Resistance Spot welding, Resistance Seam welding, Projection welding and Cold welding (Hess, 2019). In many mass production industries, the welding processes have been automated utilizing robots and machine tools, however, human welders are still widely required to perform most welding processes such as for shipbuilding, heavy equipment production, and small parts fabrication's industries (Fast et al., 2004; Hashimoto, 2015). For beginners, welding is dangerous because it requires proper equipment, tools, materials, skills, and time (Hashimoto, 2015). Thus, there is a need for alternative training methods to overcome the limitations of the existing training approach. Training and educate new welders are very important both for the vocational education community and industry where there still largely manual process done by human operators despite mostly done by automated machinery (Fast et al., 2004).

Nowadays, new approaches in education and training have been introduced in various forms. These are because a lot of new technologies have been introduced that make the learning processes become simpler and easier and can be conducted anytime and anywhere. The rapid development of the internet technology enables education nowadays to be delivered through e-learning. The development and widespread use of e-learning as alternative methods is replacing the conventional methods for education. E-learning has already been used widely in educational area for delivering information to students; for example, in science and mathematics subject (Lee, 2012). E-learning is learning with the help of electronic resources such as laptop, computer and mobile phone. Beside laptop and computer, mobile phone is easy to bring everywhere where people can also learn via mobile phone which is known as Mobile learning (M-learning). M-learning is one of the methods that combine the multimedia elements to make it easier to deliver information. The use of multimedia motivates learner during the learning process where it could initiate, maintain, and energize the learner's effort to engage (Mayer, 2014).

Mobile learning has evolved rapidly, many educators started exploring the use of mobile technologies in their teaching for learning environments also some pilot projects about mobile teaching started in the beginning of 2000s (Brown & Mbati, 2015). Moreover, mobile phone is able to implement some of the technologies including; Multimedia, Animation, Virtual Reality (VR), Augmented Reality (AR), Internet and Mobile application. For instance, by using AR as a tool for learning will make the students learn and can access the capabilities and resources in increasing the effectiveness of self-study by using AR learning tools (Yuen et al., 2011). According to Schmalstieg. D et al. (2010), AR allows the enhancement of user's perceptions and interaction with the real world and also has the capability to enhance productivity in real world tasks. Furthermore, AR technology afforded immersive experience to users in environment of computer simulation that provides learning effects to user. Based on a previous study by Lin et al. (2017), students are able to improve their learning outcome whereby learners showed positive attitudes toward the AR learning system such as satisfaction and perceived usefulness which motivate the students in learning (Gopalan et al., 2018).

According Rost (2006), learners choose to exert effort, how long they are willing to continue an activity, how assiduously they are going to pursue it, and how connected they feel to the activity are all influenced by motivation. Based on previous research, mobile learning could motivate students in learning (Huang et al., 2016; Lin et al., 2017). Besides, mobile learning with intervention of AR in learning and training (Diegmann et al., 2015; Lee, 2012) potentially improve the user's motivation by using a real-world learning and training technique (Billinghurst & Dunser, 2012; Diegmann et al., 2015; Rasalingam et al., 2014). The features of immersion, interaction and navigation in AR could enhance student's motivation to learn, assist with knowledge understanding, and useful in learning tasks that require experimentation, simulation, spatial ability, and collaboration (Dalgarno & Lee, 2010; Di Serio et al., 2013; Dunleavy et al., 2009). As a result, the purpose of this study was to delve more into the use of mobile learning for welding and its impact on students' motivation.

1.3 Preliminary Study (PS)

PS was used to gather information about the needs, requirements, and expectations of users in a particular study topic. Besides that, PS is to find and confirm the research problems. In this study, questionnaire was used in data gathering approach. Questionnaire is a method for gathering data in survey research which it's a set of standardized questions or items in order to gather individual data about certain topics (Lavrakas, 2008). The results of the preliminary study would assist the researcher in determining the existing learning methods. In addition, the preliminary study could also reinforce the problems to be investigated in this study. The aim of the study is to find out what student needs in their learning session pertaining to welding.

In this study, a survey was carried out on a group of Politeknik Tuanku Syed Sirajuddin students who were learning welding subject in the class. The preliminary study involved 50 students of semester one. They were all required to take the welding course as one of their required subjects. The questions concentrated on welding learning as seen in Appendix A. The results from the preliminary study show that there are some problems faced by the students in welding learning. Table 1.1 lists the key questions that indicate the problems faced by the students. The questionnaire consists of two parts; Part A is Demographic and Part B is welding learning-related information. The results of Part B questionnaire as shown in Figure 1.1.

Table 1.1

Important questions faced by students

Question number	Questions	Yes	No
5	Do you need other type of source in order to acquire more understanding about welding?	92%	8%
6	Do you having problem to find learning sources for revision about details and the use of welding machine?	84%	16%
7	Tick (√) in the box for method of learning that can be used to get more understanding about welding. Method of learning includes: i. 3D animation ii. Video iii. Picture iv. Book v. Others.		
8	Do you need changes in your learning approach?	86%	14%
9	Does learning in the form of simulation with the help of video, 3D animation, pictures and text could help in welding learning?	86%	14%
10	Overall, do you understand all the explanation about welding?	74%	26%

Based on Table 1.1, the results are shown in Figure 1.1 and Figure 1.2.

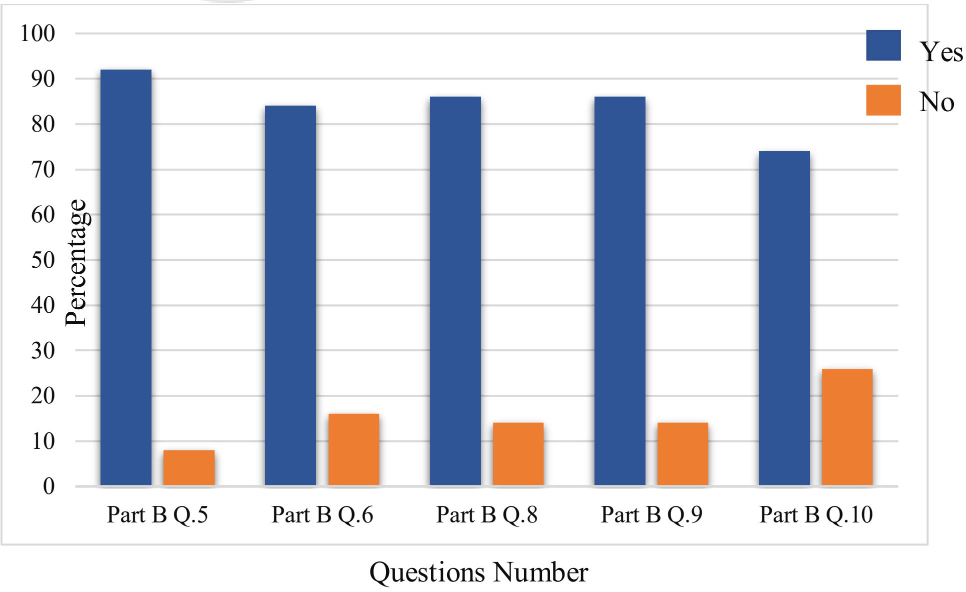

Figure 1.1. Result from Questions No. 5, 6, 8, 9, 10

Figure 1.1 shows that 92% of the students need other type of sources in order to acquire more information and make them understand about welding. Besides that, the PS shows that 26% of the students could not understand the overall explanation about welding. So, these prove that the students need other form of resources in order to acquire more information. From the result of the preliminary study, it can be concluded that the students did not have enough materials to help them during revision. It is because 84% of them have problem to find learning sources for revision. Besides that, the study also shows that 86% of the students need some changes in their learning approach.

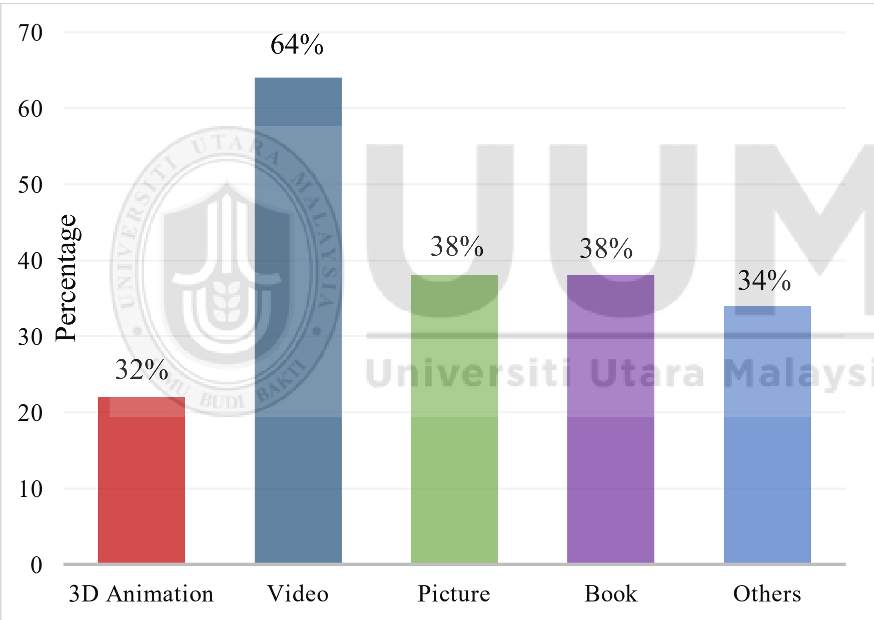

Figure 1.2. Results for Question no. 7 for type of learning method.

Based on the responses pertaining to the method of learning, 86% of them agreed that 3D simulation, video, text and picture can help them in learning as shown in Figure 1.2. Figure 1.2 also shows that the highest choice for learning method is video. It shows that 64% of the students chose video as one of the alternative methods for learning. Students also chose picture and books as the second methods that can be used for welding learning. From the result of the study, 22% has chosen 3D animation as the third method for welding learning. So, based on the result, the students can learn using mobile application which the multimedia elements can attracts user to use the app. Furthermore, the basic attributes of AR which are based on the multimedia elements are includes text, graphics, video, audio, 3D model and also animation whereby these elements are able to give multi-sensory learning experience (Gopalan et al., 2015). So, AR can be an academic tool that are able to make teaching and learning interactive and students are more involving also the will enhance the student's cognitive learning (Dakeev et al., 2021). In conclusion, the study will use AR mobile-based learning so that the students can learn effectively and increase their motivation towards the learning.

1.4 Problem Statement

There are various methods for people to acquire information that they need for learning purposes. In learning, student can use textbooks, laptop, computers, handheld devices and other electronic tools in classroom which also one of the methods to acquire information (Lee, 2012). Politeknik Tuanku Syed Sirajuddin (PTSS) trains their students in welding using the conventional method in class by using Powerpoint slide, lecture notes and instructor-based training (IBT). According to Negron (2018), IBT is experiential or hands-on training where instructor or facilitator guides students in classroom learning IBT involves the step-by-step explanation about the procedures to do welding by the lecturer. So, the lecturer also explains about the safety inspections during the welding process and also during the IBT and while using the welding machines. The lecturer usually explains to a group of students at once in the class in order to save time. However, this method causes some students not able to participate in certain lessons or miss the training materials that the trainer gave (Georgiev et al., 2004).

However, there are some drawbacks of instructor-based training while using the welding machines in the workshop. The welding procedure could be put at risk, as well as the students' safety, if they are unable to adhere to all the processes effectively. While using IBT, the students require more time to be supervised by their trainer because they do not have enough information to guide them throughout the welding process. Whenever the students faced some problems during the training, they have to wait for the trainer to attend to their problems before they can proceed. Thus, it is difficult for the trainer to conduct the training for all the students at one time. In such a scenario, it is advantageous if the students are well-prepared with the knowledge needed before the training session.

Additionally, a prevalent issue with the current educational system is that students find it challenging to retain everything they are taught in a short period of time (Mahamad et al., 2010). The learning process using IBT needs the students to memorize all the steps involved in the instruction at one time. The trainer normally explains the steps once and has limited time to repeat the steps all over again for all the students. As a result, in order for the students to fully comprehend and be able to follow the procedures on their own, they must investigate alternate methods. There are several more learning resources available for welding, including websites, books, and YouTube. As a result, a creative method of training is needed to enable students to follow step-by-step instructions for using welding equipment. This is so that students can develop their hand skills, technological knowledge, welding experience, and training in welding joints (Oz et al., 2012). This will guarantee both the proper execution of the welding process and the protection of the students' safety. To help the students with their revision, the new learning methodology must also offer thorough knowledge about the welding process.

Furthermore, from previous research, when the module was taught in a slide-based learning environment, the students were only moderately motivated but more motivated when it was taught in an augmented reality learning environment (Di Serio et al., 2013). The conventional learning method and teacher’s boring teaching style can make student easily lost focus in their studies and bored after some time (Cicekci & Sadik, 2019; Rasalingam et al., 2014). In addition, a study by (Huang et al., 2016) indicated that students learning only with conventional approach was uninteresting and less motivating in contrast to learning using mobile especially with AR which could make the learning process easier to understand and interesting (Tarng et al., 2015). There are a lot of benefits of AR technology in teaching and learning proven in past studies. AR has been experimentally applied in education during the last two decades where the current technologies available nowadays are more powerful to deliver AR experiences to learning than before (Lee, 2012). AR technology have positive potential in education has been proven and could increase student engagement also their motivation towards learning (Dakeev et al., 2021; Lee, 2012; Rasalingam et al., 2014). Thus, in order to engage and enhance student’s motivation in learning, this study proposes ease of use, engagement, learnability, satisfaction and usefulness as measurements to be integrated in AR mobile-based welding learning app.

1.5 Research Questions

The issue mentioned above elicits a few questions about the arc welding learning approach in giving valuable input to the students. The questions are:

i. What are the AR attributes for learning for the AR mobile-based welding learning app?
ii. How should the AR attributes for learning be applied in the AR mobile-based welding learning app?
iii. What is the relationship between the AR attributes for learning and motivation in using the AR mobile-based welding learning app among the students?
iv. What is the learning performance of the students in relation to the intervention of the Mobile Arc Welding Learning (MAWL) app for welding learning?

1.6 Research Objectives

Referring to the above problem statements of the preliminary study, the main research objective is to propose an AR mobile-based welding learning app. The following four sub-objectives have been established in achieving the main objective.

i. To identify the AR attributes for learning for the AR mobile-based welding learning app.
ii. To design and construct the AR mobile-based welding learning app.
iii. To determine the relationship between the attributes of AR for learning and motivation among the students.
iv. To assess students' learning performance when using the AR mobile-based welding learning app.

1.7 Research Hypotheses

For this study, six research hypotheses have been developed. The inferential statistical significance of the hypotheses was tested at a probability level of 0.05. In Chapter 5, all of the hypotheses are also discussed (Data Analysis and Result). The following are the study's hypotheses:

Hypothesis$_{01}$: There is no significant positive relationship between ease of use and motivation.

Hypothesis$_{a1}$: There is a significant positive relationship between ease of use and motivation.

Hypothesis$_{02}$: There is no significant positive relationship between engagement and motivation.

Hypothesis$_{a2}$: There is a significant positive relationship between engagement and motivation.

Hypothesis$_{03}$: There is no significant positive relationship between learnability and motivation.

Hypothesis$_{a3}$: There is a significant positive relationship between learnability and motivation.

Hypothesis$_{04}$: There is no significant positive relationship between satisfaction and motivation.

Hypothesis$_{a4}$: There is a significant positive relationship between satisfaction and motivation.

Hypothesis$_{05}$: There is no significant positive relationship between usefulness and motivation.

Hypothesis$_{a5}$: There is a significant positive relationship between usefulness and motivation.

Hypothesis$_{06}$: There is no substantial difference in the students' learning performance.

Hypothesis$_{a6}$: There is a substantial difference in the students' learning performance.

1.8 Research Scope

The goal of this study is to design and develop a mobile-based welding app that incorporates Augmented Reality (AR) for learning. As TVET programs are in demand due to job requirements where TVET is predicted to address the economic, social and environmental demands by helping youth to gain and hone the skills needed for their job and in the entrepreneurship fields. Polytechnics in Malaysia provide courses that are suitable for TVET to train their students and develop their skills ("TVET Skills Equip Youth for Jobs," 2016). This study will be conducted at the Politeknik Tuanku Syed Sirajuddin (PTSS). A sample of 67 PTSS students who enrolled in the welding class was selected as respondents for this study. The MAWL app for welding learning is based on mobile platform was developed specifically for this study. For the purpose of proof-of-concept, the app will only cover three modules as shown in Table 1.2. The three modules used as contents for MAWL App include Safety in welding, Component if welding and Steps in welding.

Table 1.2

Contents of the MAWL app

No.	MAWL App Contents
1	Safety in welding
2	Components of welding
3	Steps in welding

The students were able to use and interact with the app in order to learn step-by-step instructions on the safety aspect as well as the steps in welding. Students will also be able to access comprehensive information pertaining to welding in order to facilitate them during revision. The contents of the app are based on the modules that are implemented at PTSS for welding learning.

Furthermore, Unity3D and Vuforia software were used to develop this app. Unity3D is a development platform that enables user to create high quality 2D and 3D multi-platform games and interactive experiences and could be deployed across more devices easily where it supports different multi-platform which include; mobile, virtual environment, desktop, Web, console and television. In addition, Vuforia was used for the development of AR feature which was incorporated into the app.

1.9 Research Significance

This study will provide several significances for students, teachers, educators and researcher about welding learning by using AR mobile-based learning. The students agree that they need supplementary welding learning materials and interesting learning environment so that they can focus on the learning. So, to increase their interest towards welding learning is where they can learn interactively such as by using AR mobile-based learning as the study was proposed. The expected main contributions from the study is the development an easier, faster and systematic learning tool for welding with AR. Furthermore, this interactive AR mobile-based learning tool can readily accessible by using mobile phone anytime and anywhere. The proposed MAWL prototype provide inxpensive, attractive and interactive learning environment outside the class so that the student can do self-paced and individualized style of learning which can optimize the time to complete the learning process. It is hoped that through the intervention MAWL, students can enhance their motivation towards welding learning and eventually continue their careers in welding based professions.

By the end of this study, two contributions are expected to the body of knowledge. Firstly, the guideline for the design and development of the AR mobile-based welding learning app for the mechanical engineering student. Secondly, an empirical study for AR mobile arc welding learning to the research study. The results from the perceived welding learning motivation evaluation based on the intervention of the proposed prototype will show that the prototype's potential in motivating students and increase their interest towards welding learning. Finally, this study could help students, teachers, educators and researchers in welding learning.

1.10 Conclusion

The problem statements and research questions of this study have been discussed in this chapter. It also covers the research objective, research questions, research scope, expected outcome and significances of the solution that have been proposed. Thus, this chapter discussed the overall background of the study.

1.11 Summary of the study

A summary of this study is listed in Table 1.3. It consists of the research problem, research questions, research objective, methodology and research hypotheses.

Table 1.3

Summary of the study

Research Problem
When the trainer employs instruction-based training (IBT) to teach welding to a group of students at the Polytechnic, some of the students are unable to fully participate in certain lessons. In addition, the students did not have enough resources to guide them through the welding learning. It is difficult for the trainer to conduct the training for all the students at one time and some student could be overlooked. The main issue with the current educational system is that students find it challenging to retain what they are taught in a short amount of time (Mahamad et al., 2010). As a result, in order to motivate students, this study proposes learning with the use of augmented reality in welding classes.
Research Questions
i. What are the AR attributes for learning for the AR mobile-based welding learning app? ii. How should the AR attributes for learning be applied in the AR mobile-based welding learning app? iii. What is the relation between the AR attributes for learning and motivation among the students? iv. What is the students' learning performance when using the welding learning?
Research Objective
i. To identify the AR attributes for learning for the AR mobile-based welding learning app.

ii. To design and construct the AR mobile-based welding learning app. iii. To determine the relationship between the attributes of AR for learning and motivation among the students. iv. To assess students' learning performance when using the AR mobile-based welding learning app.
Research Methodology
Adapted the general research methodology by (Kuechler & Vaishnavi, 2011)
Research Hypothesis
Hypothesis$_{01}$: There is no significant positive relationship between ease of use and motivation. *Hypothesis*$_{a1}$: There is a significant positive relationship between ease of use and motivation. *Hypothesis*$_{02}$: There is no significant positive relationship between engagement and motivation. *Hypothesis*$_{a2}$: There is a significant positive relationship between engagement and motivation. *Hypothesis*$_{03}$: There is no significant positive relationship between learnability and motivation. *Hypothesis*$_{a3}$: There is a significant positive relationship between learnability and motivation. *Hypothesis*$_{04}$: There is no significant positive relationship between satisfaction and motivation. *Hypothesis*$_{a4}$: There is a significant positive relationship between satisfaction and motivation.

Hypothesis$_{05}$: There is no significant positive relationship between usefulness

and motivation.

Hypothesis$_{a5}$: There is a significant positive relationship between usefulness and motivation.

Hypothesis$_{06}$: There is no substantial difference in the students' learning performance.

Hypothesis$_{a6}$: There is a substantial difference in the students' learning performance.

1.12 Summary of all chapters

There are six chapters in this thesis. The summaries for each chapters are in the following sections below.

Chapter One: Introduction

The first chapter sets the stage for the rest of the thesis. It comprises of sub-sections that include; research background, problem statement, preliminary study, research questions, research objective, research scope, research significance, research hypotheses, and conclusion.

Chapter Two: Literature Review

Chapter two is in-depth grasp the subject of the study and provide the background knowledge of the study. It also addresses previous studies and the attributes and theories that were used in this study. Furthermore, for this study, it examines computer technologies such as mobile applications, augmented reality (AR), and multimedia (MM), as well as appropriate theories and how to apply them in learning.

Chapter Three: Research Methodology

The research methodology as well as how it has been applied to the MAWL app in this study are discussed in this chapter. There are 4 phases to this study comprising of; awareness of the problem, suggestion, development, evaluation and conclusion. It also explains the wireframe as a guide for developing and designing the app.

Chapter Four: Design and Development of MAWL App

The wireframe for the MAWL app is used in Chapter 4 to design and develop the app. This chapter covers the entire method of developing the MAWL app.

Chapter Five: Data Analysis and Results

The outcomes of the evaluation that was undertaken are discussed in Chapter 5. There was expert evaluation, user evaluation, perception study, Pearson Correlation Coefficient, regression, and performance study.

Chapter Six: Conclusions

This research study's concluding chapter is Chapter 6. It summarizes all of the study's findings and discusses the study's limitations and recommendations. It also elaborates on the contribution towards the body of knowledge and makes recommendations for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

Chapter two describes how mobile and Augmented Reality (AR) technologies are applied in Technical and Vocational Education and Training (TVET) for Polytechnic students for the purpose of learning about the welding process. The literature from past studies relevant to the subject needs to be examined to see the ideas of the chosen area of study. The following literature review covers the study's background knowledge of mobile technology and AR attributes. In addition, this chapter discusses theories related to motivation in learning as well as the AR elements that should be applied in mobile learning.

2.2 Technical and Vocational Education and Training (TVET)

Malaysia has designated year of 2017 as the TVET's year with the goal of transforming Malaysia into a high-income nation ("Kerajaan Isytihar 2017 Tahun TVET," 2017; Pang, 2011) and to become an developed nation that is inclusive and sustainable ("11MP: 60% of 1.5m Jobs Created by 2020 to Require TVET-Related Skills," 2015). Therefore, with the increasing challenges in the global environment, Malaysia needs to become more competitive to become a high-income country by adopting an integrated approach involving government and economic transformation programs (Pang, 2011). Students should not ignore TVET as an option to further their studies because the skills they acquire through TVET make them the most desired graduates in the market because TVET offers and creates so many job opportunities ("TVET a Viable Choice for Building Great Future Careers," 2020). (Pang, 2011) also reported that TVET programs were introduced to provide skilled workforces, promote economic growth, and environmental stability conforms with the Government's Vision of Shared Prosperity 2030, TVET encourages forces that can contribute to a prosperous development and an inclusive nation ("TVET a Viable Choice for Building Great Future Careers," 2020). Moreover, TVET is not new in Malaysia where according to Muhamad (2001), back in the late 1890's, TVET could be traced in Malaysia where government hired local youth through trade schools to work on the national railways as mechanics and fitters. TVET programs are important in which they could help youth and adults in the employment and entrepreneurship field and develop their skills.

TVET is an educational process including general education, technologies and related science study, develop practical skills, understanding the attitude, and knowledge in occupation in diverse of economics sector and social life (Okoye & Okwelle, 2014; UNESCO, 2021). It also trains the graduates into highly skilled and future-ready workforce (Rafidi, 2020). Technical education allows individuals to practice applied science techniques and mathematical principles to the benefit of humanity, while vocational education prepares and trains individuals to ensure them to be highly qualified for a given profession (Okoye & Okwelle, 2014). Technical education, according to Okoye & Okwelle (2014), is biased toward cultivating an individual's talents and practical growth, whereas vocational education is infused with a strong devotion to guiding principles for successful professional performance in the workplace. In other words, technical refers to the characteristics of applied science and industry, while vocational refers to the skills required for a particular job.

In the budget 2020, the Malaysian government has provided about RM5.9 billion to

TVET programs ("Budget 2020: RM5.9 Billion for TVET Programmes," 2019) in institution such as Polytechnic, vocational colleges and training institutes to produce workforces that meet the industrial requirement ("2017 Budget: RM4.6b for Technical Vocational Education and Training," 2016). The government provided RM50 million to Perbadanan Tabung Pembangunan Kemahiran (PTPK) to fund TVET, RM20 Million for grant fund to support customized TVET courses and RM30 million to train about 3000 youth from low income household for TVET training ("Budget 2020: RM5.9 Billion for TVET Programmes," 2019). Furthermore, in 2022 the government sees the importance of TVET to the industry so the government had increased the budget and allocated RM6.6 billion to empower TVET to enhance the quality of TVET institutes and boost the industry's active involvement ("Government-Industry TVET Coordination Body Set up to Steer National TVET Agenda," 2022).

Youth who finished their SPM and wanted to take TVET courses can follow the TVET pathway by taking Sijil Kemahiran Malaysia (SKM) until level three's certificate and can further their study in Diploma in Skills Malaysia (DKM) for certificate level 4 and level 5. They can get certificate level 6 by further their study in Bachelor of Technology as illustrated in Figure 2.1.

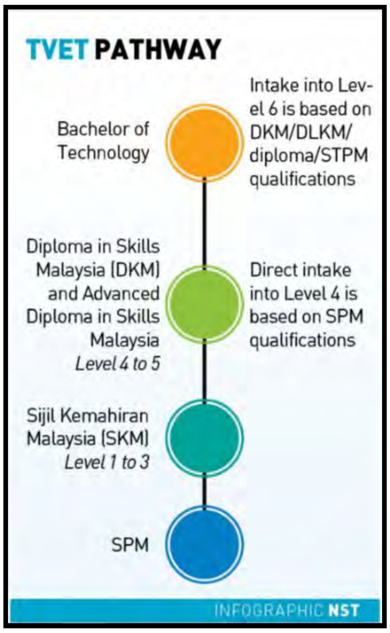

Figure 2.1. TVET pathway (Rafidi, 2020).

Pang (2011) stated that higher education was divided into three categories in Malaysia which is skills training sector, vocational and technical sector, and higher education sector. Currently, it is estimated that there are 1000 institutes in Malaysia that offer TVET whereby 506 are public institutions including polytechnics, community colleges, and vocational colleges and the rest are higher learning institutions (*Technical and Vocational Education and Training (TVET) in Malaysia*, 2016).

According to Mohd Zain (2008), there are various TVET providers in Malaysia which the government is the main providers involved as shown in Table 2.1. Based on the Table 2.1, the ministries and agencies involved in TVET education were first is Ministry of Education provided TVET education in secondary schools as being called as technical or vocational secondary schools. Second, Ministry of Higher Education offered TVET education in community colleges, polytechnics and technical universities. Third, Ministry of Human Resource and Development provided TVET education under Department of Skills Development's Department, National Vocational Training Council (NVTC) and Industrial Training Institutes. The National Vocational Training Council (NVTC) was then reorganized and set up as National Industrial Training and Certification Board in 1971. Fourth, the TVET education offered by Ministry of Youth was under National Youth Skills instituted. Fifth, The Ministry of Community Development also provides TVET under theirs. Sixth, the institutions under the State government such as Terengganu Advanced Technical Institute (TATI) and Skills Training Centre also offered TVET education. Lastly the private providers such as Institut Kemahiran MARA, Pusat Giat MARA, Universiti Kuala Lumpur (UniKL), German-Malayisa Institute and British-Malaysia Institute offered TVET learning. All of these institutions have produced lots of graduates possessed with TVET skills to work in TVET's sector.

Table 2.1

TVET providers (Mohd Zain, 2008)

Ministry of Education ▪ TVET is provided in secondary schools (technical or vocational secondary schools).
Ministry of Higher Education ▪ TVET is offered in community colleges, polytechnics and technical universities.
Ministry of Human Resource and Development ▪ Department of Skills Development's Department, National Vocational Training Council (NVTC) and Industrial Training Institutes.
Ministry of Youth and Sports ▪ National Youth Skills Institute.
Ministry of Community Development
State governments ▪ Institutions such as Terengganu Advanced Technical Institute (TATI)Skills Training Centers, etc.
Private providers ▪ Institut Kemahiran MARA, Pusat Giat MARA, Universiti Kuala Lumpur (UniKL), German-Malaysia Institute and British-Malaysia Institute.

2.3 Technology Based Learning (TBL)

Technology based learning (TBL) is a learning method through electronic technology, internet, intranet, satellite broadcast, audio and video conferencing, bulletin board, chat room, webcast and CD-ROM (Koller, et al., 2006; Moore et al., 2011). Thus, student can learn using electronic technology instead of traditional learning which is more convenient. Despite having plenty of electronic technologies, the emotions (enjoyment, curiosity, anxiety, frustration, confusion, boredom) of students differ through different of technology based learning's environment (Loderer et al., 2020). So, this is mean different used of electronic technology provides different acceptance from the user.

Students learn through online learning and web-based learning via internet and computer-based learning by using computer and laptop (Koller et al., 2006) especially when the global was gotten hit by COVID-19 where the schools and higher education institution change to online learning (Patricia Aguilera-Hermida, 2020). Ertl et al. (2010) defined online learning as a learning that occurs not entirely or completely used over the internet that makes no time restriction and geographic proximity for user to search all information needed. Moreover, the widely used of smartphone in recent years enable students to also learn through their smartphone which is more convenient than computer whereby it is easier to access anytime and anywhere. Bernacki et al. (2020) reported that the use of mobile technologies can improve learning and understand the learning. Furthermore, TBL is easy to use by teachers and most teachers are like to adopt the technology in their classroom to teach (Robertson, 2007). There are five advantages of TBL compared to face-to-face learning which include; accessibility (offering anytime and anywhere delivery), self-paced training and matched to the learners' needs, full scalability, up-to-date information, streamlined delivery, and effective learning delivery (Koller et al., 2006).

Learning via online and web-based also called as E-learning is widely used and synonymous with TBL (Koller et al., 2006). E-learning enables user access to online resources for learning or teaching through information and communication technologies (Arkorful & Abaidoo, 2015). E-learning plays an crucial role in the learning activities where it enhances interaction, communication, working, coordination activities, and socializing (Aparicio & Bacao, 2013). E-learning changed the interaction between teachers and students where they don't need to rely on their teacher to identify and collect information (Arunachalam, 2014). Besides, Arunachalam (2014) also stated that the big changes in the process of teaching-learning was the changed to home-based learning from the institutional-based learning, specified curricula to personal curricula, knowledge transmission for easy learning, and front-end education to distant learning. E-learning has been proven to engage students in their learning environment and improve learning performance (Arunachalam, 2014; Klašnja-Milićević et al., 2011). The advantages of E-learning are flexible time and place, enhance knowledge, cost effective, and self-pacing.

2.4 Motivation

According to Kleinginna & Kleinginna (1981), as referenced by Di Serio et al. (2013), there is no generally accepted for motivation's definition in educational research. Motivation is defined as "the force that initiates and leads conduct," as well as the fuel that allows humans to move and execute an activity indefinitely while being connected to it (Di Serio et al., 2013). Furthermore, according to Jaemu et al. (2008), failure might be hampered by lack of motivation. Educator's teaching values also give impact towards the student's motivation inside and outside (Alcivar, 2020). In previous studies, researchers have shown how crucial motivation is for fostering student learning. Motivation is the motive for a person's actions (Ainley, 2004; Broussard & Garrison, 2004; Ryan R. M. & Deci E. L., 2002). Motivation is concerned with the difficulty of generating conditions that allow students to perform to their maximum capacity in academics in a learning environment. Two of the most crucial factors in students' learning and success are motivation and willpower (Dermitzaki et al., 2013; Rost, 2006). In a nutshell, motivation emphasizes the elements that either enhance or impede a person's desire to engage in certain behaviors. Two types of motivation, intrinsic and extrinsic have been employed in teaching strategies regularly (Ryan R. M. & Deci E. L., 2002).

Promoting motivation to learn is one of the most important concepts for effective education (Harandi, 2015). Motivation has been defined as the process of initiating, guiding, and sustaining goal-oriented actions through leading people to act in order to obtain an objective, meet a need or expectation (Gopalan et al., 2015). Table 2.2 lists some of the definitions for motivation from previous studies. Based on the previous researchers as shown in Table 2.2, motivation is the driving force behind various behaviors (Ainley, 2004; Alcivar, 2020; Brophy, 2004; Broussard & Garrison, 2004; Cole et al., 2004; Georgeon et al., 2012; Guay et al., 2010; Rheinberg & Engeser, 2018; Rost, 2006; Ryan & Deci, 2000; Sevinc et al., 2011). Motivation from students can stimulate the student to study and improve their productivity in learning environment. Moreover, poor learning motivation from the student could decrease their performance in learning and struggle to understand the subject matter well (Putra, 2021). Hence, the student's motivation is crucial for them in order to enhance their performance in study and achieve good results for their education.

Table 2.2

Definitions for Motivation

First Author	Year	Definitions for Motivation
Alcivar, Quimi and Barberan	2020	The teaching values from educators help students feel motivated both inside and outside the learning context which enhance productivity in education environment.
Rheinberg and Engeser	2018	The stimulating direction of present life endeavors toward a goal state that is positively regarded.
Georgeon, Marshall and Gay	2012	A driving force that initiates and directs behaviors.
Sevinc	2011	A factor that influences behaviour and determines its direction, force, and persistence.
Guay et. al	2010	The explanation behind the behaviour.
Rost	2006	Motivation is an energy source that influences why students choose to put forth an effort, how long they are willing to engage in an activity, how hard they are willing to pursue it, and how devoted they are to it.
Cole, Feild, and Harris	2004	The willingness to attend and learn content in a development program.
Brophy	2004	Theoretical concept that describes goal-oriented behavior's commencement, direction, force, and persistence.
Ainley	2004	"What" and "why" we do, as well as energy, direction, and the rationale for our actions.
Broussard	2004	An attribute that influences our decision to do or not do something.
Ryan	2000	To feel inspired to take action.

Students' motivation usually divided into two types which are intrinsic motivation and extrinsic motivation. According to Harandi (2015), a student is intrinsically motivated when they feel motivated from inside and in order to attain their own scholarly and personal goals they devote themselves entirely to learning out new thing, interest, or gratification. Furthermore, they favor selecting strategies that demand more effort and enable them to thoroughly process information (Harandi, 2015). Extrinsically motivated students are most probable to put out the minimum amount of effort required to reap the greatest benefit (Harandi, 2015).

2.4.1 Intrinsic Motivation in learning

According to Thomson & Jaque (2016), intrinsic motivation define to an individual engross in an activity which holds their interest and obtain pleasure's feeling for own satisfaction. Intrinsic motivation also refers to an activity that bring inherent satisfaction and feelings of competence instead of some separable consequence (Ryan & Deci, 2000). This means an individual intrinsically motivate by doing an activity because it is enjoyable to do without hoping to get rewards. Previous study by Lepper & Malone (1987) as cited by Hartnett (2016) identified that there are four factor that effect the intrinsic motivation which are challenge, curiosity, novelty and fantasy. In learning, student can have intrinsic motivation if the learning and the environment is enjoyable and fun. Previous studies proved that intrinsic motivation has immense outcome on academic achievement (Areepattamannil et al., 2011; Badri et al., 2014; Siddiqui et al., 2020; Trevino & DeFreitas, 2014). It has been shown that intrinsic motivation is an important factor in determining if or not a learner keep on in an activity, shows the degree of engagement, the produce of work's quality, and the degree of achievement obtained (Hartnett, 2016). Thus, the enjoyable learning environment can enhance the student's intrinsic motivation and engage on what they are learning. So, through the interesting learning environment such as learning using mobile application can increase student's intrinsic motivation and will brings out the positive behavior towards learning in welding subject. Therefore, the AR mobile app will be develop for this study is to increase the student's intrinsic motivation which the app can make the learning is enjoyable and fun.

2.4.2 Extrinsic Motivation in learning

Individuals that engage in an activity for an external aim, such as gaining praise and approval, winning a competition, or winning an award, are referred to as extrinsic motivation (Thomson & Jaque, 2016). Extrinsic motivation contradicted to intrinsic motivation. Extrinsic motivation is defined as behavior that is primarily motivated by the achievement of a goal that is distinct from the action itself (Legault, 2020). According to Ryan & Deci (2000), individual able to perform an action reluctantly and disinterest condition. Thus, this is mean that they can perform an action without having any interest or willingness from their heart. However, when extrinsic rewards are able to change the individual's reason for completing the behavior from internal (interest, fun) to external (profit), the source of motivation and site of causality for action might shift (to receive the reward) (Legault, 2020). Furthermore, because students are not always intrinsically motivated, they must be extrinsically motivated in order to maintain their desire to complete an action (Tohidi & Jabbari, 2012). Moreover, in academics, a student can only attain their aim and receive a high score (rewards) if they focus on exam-oriented learning.

2.5 Mobile Technology for learning

Nowadays, a lot of time is consumed on mobile devices by people. Mobile devices are used for a wide range of applications in addition to calling, sending SMS, sending emails, and chatting. Mobile learning, which has revolutionized how individuals think about and process information, is a result of this development and it represents a brand-new manner of learning (Ge & Ifenthaler, 2018). Mobile learning is the process of learning and teaching using low-tech gadgets like cellphones, tablets, iPods, and PDAs (Abachi & Muhammad, 2014). Due to the engaging learning environment it offers students, mobile learning capable to satisfy the fundamental requirements of learning (Carvalho et al., 2015; Connolly et al., 2012; Crookall, 2010; Sandholtz et al., 1997). In order to support learners, mobile learning has a number of aspects, such as mobility, independence and self-study, availability, facilitating student and instructor engagement, and information exchange (Bidin & Ziden, 2013; Ozdamli & Cavus, 2011; Viberg & Grönlund, 2013). The transition to discovery-based learning may include mobile learning that is based on widely available technologies (Lugmayr et al., 2017; Wouters et al., 2013). Mobile learning can improve students' motivation and raise their interest in learning (Ebner & Holzinger, 2007) and enhance their motivation (Burguillo, 2010; Dickey, 2011). The use of mobile learning technologies in informal learning could improve students' knowledge, skills, and performance (Camilleri & Camilleri, 2017; Hwang & Wu, 2012). According to Abachi & Muhammad (2014) and O'Bannon & Thomas (2014), mobile learning positively affects students in higher education in terms of their attitudes toward learning and perceptions of how to access the learning activities. The short amount of time professors spend with students in a classroom face-to-face can be overcome by mobile learning (Suprianto et al., 2019). It also benefits lecturers, who can anytime access the learning materials and from any location, as well as students, who can access additional teaching and learning resources outside of class hours (Suprianto et al., 2019). Mobile learning is widely used across many disciplines however it is still underutilized in TVET education.

2.6 Augmented Reality (AR)

Over the time, new technology has benefited a variety of industries, including education. One educational technology that can be used to improve learning, improve academic achievement and knowledge retention for students is augmented reality (AR) technology (Badilla-quintana et al., 2020; Billinghurst & Dunser, 2012). Beside, AR also increase engagement of the student, motivation, attention, interactivity, concentration, and spatial abilities, and provides information (Alzahrani, 2020). Thus, its proved that AR give lots of benefits to the user and for student's learning. AR is a system that generate computer graphics which comprise three basic attributes such as a blending of real and virtual environment, interaction in real time, and 3D registration of virtual and real objects accurately (Wu et al., 2013). User can experience AR world by super-imposed virtual information in reality (Lavingia & Tanwar, 2020) which the designers apply virtual graphics atop of real objects and the user can manipulate digital content via physical manipulation (Billinghurst & Dunser, 2012). AR also defined as the formation of experience to user in the real world (RW) and improved by content which is computer-generated that bind to particular locations and activities (Yuen et al., 2011). Furthermore, AR is a technology that shows text, pictures, and video (computer-generated materials) onto users' perceptions of the real world (Yuen et al., 2011). Meanwhile, (Krevelen & Poelman, 2007) defines AR as part of the common area of mixed reality, where AR provides virtuality of local not just artificially but also user transportation. The augmented reality (AR) system uses a real camera to collect the image, recognition by marker, the addition of virtual elements by software, and the projection of these elements, which truly associate real and virtual elements in time (Okimoto et al., 2015).

From the last decades, AR is a concept developed that enhance information content in the real world. A clear concept of AR can be seen on Reality-Virtuality (VR) continuum by (Milgram et al., 1995) as shown in Figure 2.2 and Figure 2.3. According to the Milgram continuum, AR is more like the real world on the left end, with the control perception of the real environment enhanced by digital data or assets, whereas the virtual environment on the right end of the continuum is made up of items that are essentially not real (Yuen et al., 2011). AR users experience the actual environment or real world with overlying virtual objects where it coexists in the same space by using a device. Furthermore, Yuen et al. (2011) stated that virtual objects (texts, images, videos and 3D objects) can be attached to a marker in the real world by using AR application and could be displayed by smartphone and computer, and users able to interact with the virtual objects.

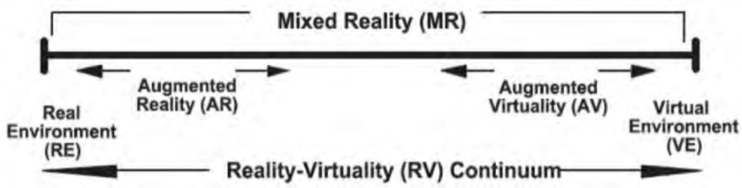

Figure 2.2. Reality-Virtuality Continuum (Milgram et al., 1995)

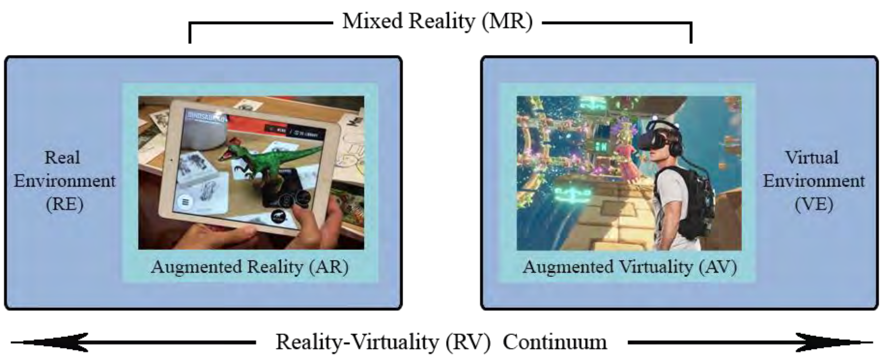

Figure 2.3. Reality-Virtuality Continuum

Augmented Reality and Virtual Reality are two different technologies, where user can experience computer-generated virtual world in VR while AR provides the real world and enhanced it with information and image from the system (Lee, 2012). The prominent difference between AR and VR is VR tends to replace the real world while AR respectfully enhance the real world (Kesim & Ozarslan, 2012). VR is defined as a computer-based technology where it provides multi-sensorial environment which the user can interact with it (Levin, 2011). Furthermore, VR gives users the ability to manipulate the learning environment and deliver more in-depth learning experiences. (Levin, 2011). VR applications enable users to engage in the virtual environment and experience the real environment like an imaginative virtual environment (Chan et al., 2011). AR and VR use the same hardware technologies and have same elements such as computer-generated virtual scenes, three-dimensional objects and interactivity (Kesim & Ozarslan, 2012). Figures 2.4 and 2.5 show examples of AR and VR technologies used in education respectively. Figure 2.4 shows a user learning science using AR technology with the use of a web camera that captures a marker and consequently produce an image or video on the screen of the laptop. Meanwhile, Figure 2.5 shows a user wearing an Oculus Rift, a head mounted display device to view an immersive virtual environment of an education setting.

Figure 2.4. AR (Gopalan et al., 2015)

Figure 2.5. VR (Craig, 2016)

2.6.1 Features of Augmented Reality (AR)

According to Wu et al. (2013), AR is a computer graphics system that merge the real and virtual worlds, grant the interaction in real time, and precisely registers virtual and real objects in three dimensions. AR and VR share a few features such as engagement, motivation, and interactive (Di Serio et al., 2013; Dunleavy et al., 2009). Cheng & Tsai, (2013) stated that AR consists of two types namely; image-based AR and location-based AR where both share similarity such as technical features, where users able to see in their mobile screen the location-based augmented information in real-time. In essence, picture-based augmented reality is also known as marker-based augmented reality, and it requires certain labels or images in order to register the location of the 3D object on the real-world picture, such as the AR book (Cheng & Tsai, 2013). The AR book used fundamental equipment such as a web-camera, marker labels and computer or mobile phone. The marker label has to be detected and captured by the webcam, and then the AR software generated the virtual element. The virtual element will appear on the book and the computer screen displays it. The marker label could be a card that have AR marker label on it to control the three-dimensional object projected on the screen. Artificial markers and natural graphic recognition are type of image-based AR. Figure 2.6 shows an example of the image-based marker with the use of the AR book and the basic AR equipment. AR equipment includes personal computer or laptop and webcam.

Figure 2.6. Image-based marker AR

Location-based AR, as depicted in Figure 2.7, employs Global Positioning System (GPS) data to identify locations before superimposing computer-generated content onto the actual image in the mobile device. Several past studies have demonstrated location-based AR, for example, (Dunleavy & Dede, 2014) developed a mobile AR for immersive learning for students to explore various habitats and animals in a pond.

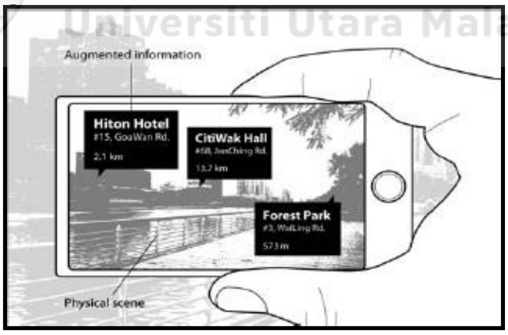

Figure 2.7. Location-based AR (Cheng & Tsai, 2013)

The basic AR attributes for learning which are based on the multimedia elements are text, graphics, video, audio, 3D model and also animation whereby these elements are able to give multi-sensory learning experience (Gopalan et al., 2015). Furthermore, these characteristics can give an engaging and interactive learning experience, and they are commonly used in AR books and AR mobile-based learning. So, by developing an

AR mobile-based welding learning app using AR in this study is to engage the students towards learning and enhance their level of motivation which the multimedia elements able to attract the student. Furthermore, according to Liang & Roast (2014), based on their study on previous researches, there are five features in modelling the AR which include; changeability (virtual information can be changed dynamically), synchronicity and instant (virtual information updated synchronously and instantaneously), antecedent (real-world content happening before the virtual counterpart), partial one-to-one (only one real-world content to correspond with the virtual content), and hidden reality (real content more or less hidden). Furthermore, there are four types of AR application including Marker-less AR, Marker-based AR, Projection AR and Superimposition-based AR (*Understanding the Types of Augmented Reality App*, 2019). Figure 2.8 shows the four types of AR app.

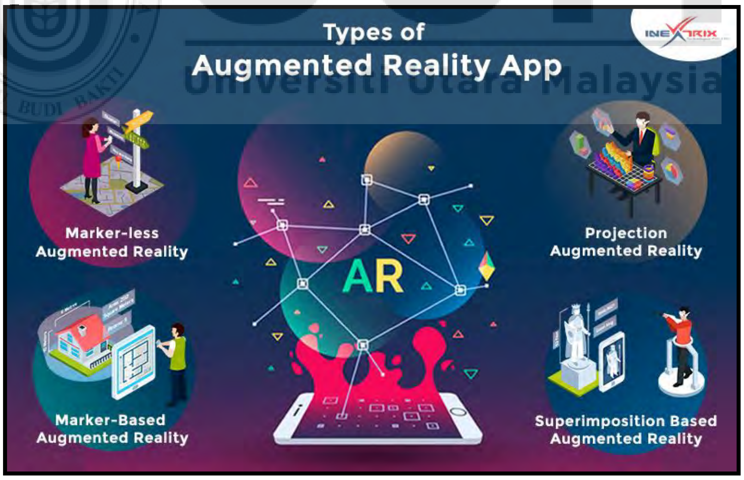

Figure 2.8. Types of AR App (*Understanding the Types of Augmented Reality App*, 2019)

Firstly, marker-less AR is also called as location-based AR which it has features of a mobile phone that detect the location using mobile application. This AR feature provides location information about an object at the mobile screen which can be view via mobile phone's camera (*Understanding the Types of Augmented Reality App*, 2019). Secondly, marker-based AR is also called as image recognition based AR or Image-based AR. This type of AR lay out detailed information about an object via object recognition which is it detects objects by the camera and give information about the objects on the mobile phone's screen (*Understanding the Types of Augmented Reality App*, 2019). Thirdly, based on Mine et al. (2012) projection-based AR is use projection technology which to projecting images onto the visible surfaces by augmenting 3D object and spaces in the real environment. Projection-based AR basically uses one or more projectors organized around an object or distributed throughout a 3D space so their images can be independent of one another or mixed together by manually or automatic techniques (Mine et al., 2012). According to *Understanding the Types of Augmented Reality App* (2019), user can experience augmented reality using AR app which the virtual objects were created for larger batches using this technique. Lastly, superimposed AR describes the nesting of the target. It views the enlarged view by replacing the full or partial view of the focused object which object recognition replaces an object's view with an augmented view (*Understanding the Types of Augmented Reality App*, 2019). AR technology has brought a big change to the current market and lots of mobile application have interesting AR features to attracts the users.

2.6.2 Attributes of Augmented Reality (AR) in Learning

AR attributes are composed of variables that have been used by previous researchers in studies related to AR. Table 2.3 list some of these attributes. The table shows past studies of using AR in learning. Some of attributes used in past studies such as motivation, efficient, engagement, learnability, enjoyment, ease of use, usefulness, immersive, interaction, navigation, simplicity, satisfaction and fun. These attributes used to study whether AR can enhance student's learning. Based on the results from the studies, AR give positive impact to the learning environment and students' learning. Thus, in this research, the attributes such as ease of use, engagement, learnability, satisfaction usefulness were used to study students' motivation in welding learning using mobile app incorporates with AR.

Ease of use is the degree which a user thinks utilizing a system could be effortless (Davis, 1989). When a system is easier to operate, saves energy, and is intended to be used often, this is referred to as its perceived ease of use (Nasution, 2004). When a user feels fully invested in their environment, they are said to be engaged (Bierbaum et al., 2008). The degree to which a user thinks that using the application will be simple to learn and improve his or her learning skills is known as learnability (Lin et al., 1997). The level of satisfaction is determined by how much the customer feels that using the service makes them happy, pleased, or fulfilled (Mohd Amin et al., 2021). The degree to which a user believes that employing a piece of technology will improve their performance is known as usefulness (Davis, 1989). Last but not least, motivation is how strongly a person feels compelled to take an activity (Guay et al., 2010).

Table 2.3

Augmented Reality Attributes for Learning

Researchers	Title of articles	AR attributes for learning													Results
		Motivation	Efficient	Engagement	Enjoyment	Ease of use	Usefulness	Immersive	Interaction	Navigation	Simplicity	Satisfaction	Fun	Learnability	
Hafsa et al. (2021)	Learnability of AR usage performance: Validating through survey.													*	The study was done to determine the effect of AR usage in learning. The study found that AR impact better learnability and performance with AR usage
Zulkifli et al. (2021)	Prototyping and Usability Evaluation of Road Safety Education Courseware for Primary Schools in Malaysia					*						*		*	The results showed that all the three measurements were strongly agreed by the students. Students give positive response on the usage of the ROSE courseware.
Baker et al. (2020)	Mobile augmented reality for hearing impaired museum engagement (MARHIME): A conceptual model	*	*		*					*			*		The finding revealed the elements such as aesthetics, curiosity, usability, interaction, motivation, satisfaction, self-efficacy, perceived control, enjoyment, focused attention and interest was used for Museum HI visitor's engagement which the elements give positive impact to the Mobile augmented reality for hearing impaired museum engagement (MARHIME).
Mohd jelani et al. (2018)	Virtual Taekwondo Training Environment Prototype: Development and Evaluation.			*		*	*					*			The results show that the use of the VT2E prototype able to help increase trainees skills and enhancing their performance in Taekwondo training.

Cheng (2017)	Reading an augmented reality book: An exploration of learners' cognitive load, motivation, and attitudes	*					*								The results showed that, from the student's experiences in using AR book, the students perceived low cognitive load, higher motivation, and positive attitudes towards it. The perceptions of motivational factors include attention or confidence were significant, the perceived usefulness and cognitive load play will affect their behavioral intentions to use AR learning.
Durairaj & Sagaya Aurelia, (2017)	A modernistic and contemporary mobile augmented reality erudition system.													*	The study proved that learnability was increased when the learner's interest was stimulated. Augmented reality has a great scope and impact in the education field.
Gopalan et al. (2016a)	A study of students' motivation using the augmented reality science textbook	*		*	*	*							*		The Study showed that AR could motivate student in learning also students are engaging and have fun while using AR. Besides, it gives enjoyment and the ease of use for AR learning.
Okimoto et al. (2015)	User Experience in Augmented Reality applied to the Welding Education.			*											The results of this study show that the students are motivated to do pre-training and satisfied with the AR mediation teaching tools. Student also gave positive feedback where learning occurs fast, safe and more efficient.

Martín-Gutiérrez et al. (2015)	Augmented reality to promote collaborative and autonomous learning in higher education.					*						*			Students feel comfortable and satisfied with the tools. They consider the tools are nice, easy, and useful to the learning contents, training performance, and design of installations machines.
Di Serio et al. (2013)	Impact of an augmented reality system on students' motivation for a visual art course.	*		*	*			*				*			The study found that using augmented reality technology had a good effect on motivation of the student, as well as high levels of engagement, enjoyment, and satisfaction.
Lee (2012)	Augmented reality in education and training.		*								*				The study proved how AR can impact on the future education for learning and training which AR can make educational environment interactive, simplicity and easy for providing learning and training experiences also AR promote the efficiency of learning and training in academic.
Chang et al. (2011)	Investigating Students' Perceived Satisfaction, Behavioral Intention, And Effectiveness Of English Learning Using Augmented Reality						*					*			The results of this study showed perceived satisfaction, perceived usefulness, and AR-learning effectiveness was a critical factor affected by system quality. Perceived satisfaction and perceived usefulness also affected by perceived self-efficacy and behavioral intention of learners was affected by perceived satisfaction and perceived usefulness of the AR-learning system.
Dunleavy et	Affordances							*	*	*					This study was about

al. (2009)	and limitations of immersive participatory augmented reality simulations for teaching and learning.														how students (participants) engaged in their learning using similar tools. The students found that the used of AR are motivated them in learning. The researcher predicts that the engagement will decrease as the students become familiar to this learning method.

As shown at Table 2.3, there are 13 researchers who implemented those AR measurements in their study to enhance motivation. There are top 5 measurements of AR attributes were applied as independent variables for this research. Ease of use which is utilized by 4 researchers (Gopalan et al., 2016; Martín-Gutiérrez et al., 2015; Mohd Jelani et al., 2018; Zulkifli et al., 2021). Followed by, Engagement (Di Serio et al., 2013; Gopalan et al., 2016a; Mohd jelani et al., 2018; Okimoto et al., 2015). Then, Learnability (Durairaj & Sagaya Aurelia, 2017; Hafsa et al., 2021; Zulkifli et al., 2021) After that, Satisfaction (Di Serio et al., 2013; Martín-Gutiérrez et al., 2015; Mohd jelani et al., 2018; Zulkifli et al., 2021) and finally Usefulness (Chang et al., 2011; Cheng, 2017; Mohd jelani et al., 2018).

Furthermore, based on Table 2.3, all the attributes that will use in this study were chosen from the variables that have been used from previous researchers in studies related to AR mobile-based learning in order to achieved the research objective number 1. So, the attributes such as ease of use, engagement, learnability, satisfaction and usefulness were chosen to be integrated in the design and development of the app. These attributes gave positive impacts to the learning environment based on the previous studies.

2.6.2.1 Ease of Use

The first independent variable in this study is ease of use. The ease of use means a user thinks utilizing a system would be effortless and able to navigate the app or system without anyone guidance (Davis, 1989). In the development of the MAWL prototype, the ease of use was considered in order to make the app simple for the student to use. where it must be comprehensive and easy to learn. The aim of the AR intervention in welding learning was to change the passive learning to active learning. Hence, the application should be easy to navigate so the student can use it without any guidance and engaging during their learning process.

2.6.2.2 Engagement

The second independent variable is engagement. According to the previous studies by researchers, AR can engage the students during learning by using the app. Engagement means when a user feels fully invested in their environment (Bierbaum et al., 2008) and they are not easily distracted when they are fully focused on their activity (Arnone et al., 2011). Hence, the student should focus and concentrate on their learning to get better performance in their studies. AR mobile-based app could give positive impact to the user (Baker et al., 2020). So, the MAWL prototype will integrate with AR where the student can learn interactively to enhance their engagement.

2.6.2.3 Learnability

The third independent variable is learnability. The past study by Hafsa et al. (2021) found that the usage AR give good impact and better learnability also great performance for learning. Learnability means when a user thinks that using the application will be simple to learn and improve his or her learning skills is known as learnability (Lin et al., 1997). Learnability will increase when the learner's interest was stimulated (Durairaj & Sagaya Aurelia, 2017). Hence, AR has a great scope and impact on student's learnability especially in the field of education. The MAWL prototype will be use by the mechanical engineering student so the content of the prototype consists of useful information about welding that student can learn.

2.6.2.4 Satisfaction

The fourth independent variable is satisfaction. The level of satisfaction is determined by how much the customer feels that using the system/service makes them happy, pleased, or fulfilled (Mohd Amin et al., 2021; Myhre, 2015). According to Hunt (1991), a user's emotional response and their level of experience between expectations and consumption are all referred to as satisfaction. User will use the system again willingly in the future when they feel satisfied and their high expectation towards the system are achieved. The successful in utilizing the AR technology able to gain user's satisfaction in using the MAWL prototype. Mechanical engineering student's satisfaction in using MAWL prototype is important in self-paced learning.

2.6.2.5 Usefulness

The fourth independent variable is usefulness. Usefulness is the degree to which a user believes that employing a piece of technology will increase their performance (Davis, 1989). In study by Alalwan et al. (2020) stated that AR technology could enhance usefulness and manipulated various forms of sensory feedback to enhance the learning experience of the students. The system was deemed useful is when it can assist users in achieving their goals and the system is effective, efficient, and simple to use which will make users are more likely to continue using it (Alalwan et al., 2020; Rubin & Chisnell, 2008). Hence, in this study the MAWL prototype has been developed which to increase student's motivation and enhance their learning performance in learning so that the prototype will be consider useful for the student to learn welding.

2.6.2.6 Motivation

The dependent variable in this study is motivation. Motivation is how strongly a person feels compelled to take an activity (Guay et al., 2010). Motivation also can be defined as when an individual has urge to start off and control the behavior for a certain task (Kaur et al., 2020). AR is able to enhance motivation of the student and be more interested in learning that were proven by the past studies (Cheng, 2017; Gopalan et al., 2016a). Motivation is an important factor to students to achieve their own goal. So, to motivate the student in welding learning, interactive contents are required. Thus, the student can use MAWL prototype integrating with AR environment for interactive learning which able to enhance their motivation in learning. Students have to academically motivated in order to achieve good grades and performance in welding and give effort towards the learning.

2.6.3 Previous studies related to welding learning used AR and VR

There is some of past studies on the AR and VR application for welding. Table 2.4 lists some of these previous studies. Based on the Table 2.4 there are some researchers using VR for real-time stimulation of welding training system that used motion capture and wearable glasses (Chambers et al., 2012).VR machine used for welder training and compared with traditional training (Stone et al., 2011). One of researcher use both AR and VR the technology used were Head-mounted Display and High-Dynamic-Range-CMOS cameras for quality improvement of manual welding (Tschirner & Graser, 2005). Furthermore, there are plenty of researchers using AR for welding learning and training. A study from Papakostas et al. (2022) used AR welding stimulator with 2D optical marker to analyses the use of AR for engineering training. Okimoto et al. (2015) used Head-mounted Display to investigate the user experience of AR technology in welding teaching. (Liu & Zhang, 2015) used motion sensor tracking to train welder using AR. A research on AR that uses a laptop's camera and webcam to show a technique of interaction and orientation that can be utilized in a welding simulator for basic welding training (Baskoro et al., 2014).

Table 2.4

Previous research works related to AR

Paper	Researcher	Objective	Technology Use	Results
User acceptance of augmented reality welding simulator in engineering training	Papakostas et al. (2022)	To examine the use of AR technology using an innovative approach and to comprehend the aspects affecting AR welding instruction.	2D Optical marker	The result shows the AR stimulator are easy to use and it is useful for the training and give satisfaction to the user.
User Experience in Augmented Reality applied to the Welding Education	Okimoto et al.,(2015)	To share user experiences with AR in welding instruction.	Head-mounted display (HMD)	The result shows the students are motivated to do pre-training and satisfied with the AR mediation teaching tools. Student also gave positive feedback where learning occurs fast, safe and more efficient.
Super Welder in Augmented Reality Welder Training System:A Predictive Control Approach	Liu & Zhang (2015)	To make a machine algorithm for unskilled welder which calculate the optimal welding speed in order for them to follow and to	Motion sensor tracking (Leap Motion)	The result of this system shows that control algorithm can be easily incorporated into the welding process in the real time control and also increase the

		improve their performance.		welding speed.
Development of Interaction and Orientation Method in Welding Simulator for Welding Training Using AR	Baskoro et al. (2014)	To demonstrate an interaction and orientation technique for basic welding instruction that will be apply in a welding simulator.	Laptop's webcam and marker	The experiment revealed that the actual and virtual distance values were different in 3D space, with large errors in the y- and z-axes affecting the precision of the real distance.
Real-time Simulation for a Virtual reality-based MIG welding training system	Chambers et al. (2012)	To build low-cost desktop VR based training system for stimulated Metal Inert Gas welding training system	Motion capture and wearable glasses	The result proved that the system provides good visual feedback and performance in real time for welding speeds also accuracy of size and shape of weld bead.
Virtual Reality Integrated Welder Training	Stone et al. (2011)	To compare the learning outcomes between virtual reality integrated training students and traditional training student	VR machine	The results of this study proved the students that using VR showed great training outcomes compared to traditionally trained students.
Virtual And Augmented Reality For Quality Improvement Of Manual Welds	Tschirner & Graser (2005)	To support the welder, develop a system for quality control in the welding process.	Head-mounted Display (HMD) and High-Dynamic-Range-CMOS cameras (HDRC)	The welder gains a completely new state of knowledge and is able to perform tasks with greater precision. As a result, the welding process is of higher and more consistent quality.

Based on Table 2.4, most of researchers were used head-mounted display and computer when using AR for welding learning and training but not many researchers do research about mobile AR and develop AR mobile-based app learning. AR mobile-based app is cost effective than using head-mounted display and most the students have their own smartphone so it is more convenient to develop AR mobile-based learning app. The student can do self-paced learning which they can easily access the app anytime and anywhere. Thus, this study will use AR technology using mobile phone to develop a MAWL app for the welding learning.

AR could engage the user in an immersive context with real experience (Dunleavy et al., 2009). Training using AR enables trainees to become more skillful before doing the real training with the real equipment. There are a lot of researches in welding training but most AR research prototype used robot or machine. Liu & Zhang (2015) studied the development of an innovative AR welder training system which helped to improve the unskilled welder for the pipe GTAW process. The training utilized a robot whereby the trainee could see what he/she was doing during the training process through the computer. The study proved that using AR for training could increase the trainee's welding speed. Chong et al. (2005) developed Robot Teaching in AR (RTAR) application for robot learning to perform in an AR environment on how to do arc welding task by teaching it. In the unstructured and unmodeled environment, RTAR enables the user to make a task for the robot quickly with the help from the visual feedback in the AR environment that has been provided. The application was able to raise the level of intuitiveness and provide the necessary flexibility in the welding training.

Another example of research that studied the welding training using machine tool is the Intelligent Welding Gun (Echtler et al., 2004). It helps welders to place the gun precisely at the planned stud positions and eventually increase the welding speed. There is also research using the AR helmet for welding training such as by Hillers et al. (2004). User can view the welding scene that has been enhanced through image processing and displayed on a head mounted display with video see-through. The welding parameters could be changed by the user without removing the helmet or changing the position while working through the on-screen remote control of the welding machine. Furthermore, a study by Vijay et al. (2016), captured and modelled the on-campus tutor knowledge into a virtual tutor in the AR environment. It is used for teaching and assessing engineering practical skills which is welding skills. The study proved that using AR environment was able to enhance the user's practical skills. Lastly, a study from Papakostas et al. (2022) evaluated the welding training using AR technology with an innovative model. The results reveal that the purpose the use of AR simulator is greatly influenced the intention to use because of quality of the system and perceived ease of use. However, there is a scarcity of research on AR in welding education (Papakostas et al., 2022).

2.6.4 Augmented Reality in learning

AR has many potentials in industrial and academic research. AR applications have been applied in several fields including education, training, medical visualization, maintenance and repair, advertising, and entertainment (Carmigniani et al., 2011; Zainuddin et al., 2012). AR is capable and qualified for use in educational settings and is evidenced by many applications that successfully apply AR to enhance learning, language learning, mechanical skills training, and spatial ability training (Diegmann et al., 2015).

AR has been experimentally used in education during the last two decades where the current technologies available nowadays are more powerful to deliver AR experiences to learning than before (Lee, 2012). AR allows students to be engaged and motivated in searching materials from a various of perspectives that may occur in the real world (Kerawalla et al., 2006). A study conducted on students showed that their learning performance could be enhanced through the use of the AR textbook (Gopalan et al., 2016a). The results from the same study proved positive and statistically significant relationship between engaging, enjoyment and fun, and motivation of the student for science learning (Gopalan et al., 2016a).

In providing a good learning environment, the trainee or lecturer must provide good training to the students. The usage of AR technology looks promising which it able to access to large amount of documentation which is a necessity for good learning or training (Benbelkacem et al., 2010). Much documentation is needed to provide students with better learning with the use of AR to enhance their knowledge and skills by using various interactive learning methods. In accordance with Lee (2012), several academics have hypothesized that virtual reality and augmented reality able to boost student motivation for learning and enhance their realism-based instructional strategies. In educational settings, the usage of AR can boost students' motivation, focus, satisfaction, and concentration (Diegmann et al., 2015). AR books are most popularly used in learning other than VR. Furthermore, (Wojciechowski & Cellary, 2013) studied learner's attitude towards the AR environment and the result from the study indicated that perceived usefulness and enjoyment have the same effect on learner's attitude in using the AR environments.

Furthermore, AR allows students to locate and use information from a range of real-world viewpoints that have never been used previously, and AR increases students' engagement and motivation (Lee, 2012). In addition, the AR book is also popularly used for learning whereby it could motivate student for learning. For Form II Secondary school, Gopalan et al. (2015) developed an AR-enhanced textbook for scientific learning (eSTAR). Students' motivation and performance can be enhanced by using eSTAR in science learning (Gopalan et al., 2016b).

The effectiveness of training can be seen when learners can implement what they have learnt before dealing with the real situation. Training through the use of AR is one of the good medium for training. AR has great potential to bring forth great contextual, learning experiences on site and unexpected exploration and discovery of the information's interrelated nature in the real world (Lee, 2012). Trainee can practice the training with the system on real equipment and able to perform real procedures without using simulation tools (Schwald & DeLaval, 2003). Training with AR enables learning process become more entertaining and intuitive where the industrial object interactively augments in real-time by user (Tamaazousti et al., 2016).

2.7 Welding

Welding is a process of joining together metal parts to form a strong joint using filler metal by melting a metal and the welding process produces metal fume and gas which is dangerous ("Controlling Hazardous Fume and Gases during Welding," 2013). There are two types of welding classification; fusion which is heat alone and pressure which is heat and pressure. Fusion welding consists of electric arc, gas and thermite and electric arc welding is the commonly used fusion welding where it applies an electric arc to melt the base and filler metals. Arc welding includes Flux Core Arc Welding

(FCAW), Shielded Metal Arc (SMAW), Gas Metal Arc (GMAW or MIG), Tungsten Inert Gas (GTAW or TIG) ("Controlling Hazardous Fume and Gases during Welding," 2013).

Welding fumes are harmful to people where it could cause lung damage and different types of cancer because of prolonged exposure to it (Brand et al., 2010; "Controlling Hazardous Fume and Gases during Welding," 2013). Besides that, they may cause irritation of the eyes, nose, and throat as well as nausea, dizziness, damage of kidney and nervous system. Manganese fume could cause symptoms of Parkinson's-like if exposed to it for a long time ("Controlling Hazardous Fume and Gases during Welding," 2013; Racette et al., 2012).

2.8 Augmented Reality (AR) in welding learning

AR is beneficial for learning and training situations where information is delivered in 'just-in-time' and 'just-in-place' where users are able to experience the real environment superimposed with virtual objects (Liu & Zhang, 2015; Okimoto et al., 2015). Students can experience the real training environment and can control the virtual tools used in real-time by using AR. The learning tools accessible for welding education and training, according to Okimoto et al. (2015), are welding equipment, AR systems used for welding, and VR. Normally during the welding training, consumables and specific equipment for each type of welding are utilized, along with safety requirements, personal protection equipment, and proper exhaust and ventilation systems (Okimoto et al., 2015). However, according to Okimoto et al. (2015), welding equipment training takes a lengthy time, with 70% of the time spent on material preparation and 30% on welding operations, including error and restart at all stages of the process. The error encountered during the training could waste time and money and also increase the maintenance task. In contrast, the AR system that is applied to welding could reduce the training time, cost, material consumption, future error, training in a safe environment and help accelerate the training process (Liu & Zhang, 2015; Okimoto et al., 2015; Schwald & DeLaval, 2003). The AR system allows trainee to experience the training using the system that have the same control without holding the real equipment whereby if the trainee makes an error while doing the work, he or she can delete the file and start the process over (Okimoto et al., 2015).

2.9 Theories related to learning

A theory is an explanation using the state-of-the-art research methods and information of the day which is scientifically proven by the researchers (Harasim, 2017). Theory of learning aids in understanding how people learn in a learning environment. According to Siemens (2005), there are three types of learning theories in instructional environment which are behaviorism, cognitivism, and constructivism. Behaviorism relies only on the objectively observable learning's aspects (Alzaghoul, 2012). There are several behaviorism theories about learning including observable behavior which is important rather than internal mental events. According to Siemens (2005) behavior should be studied in simple elements like specific stimuli and specific responses, and behavioral change is the process of learning. In addition, cognitivism is where learning is a process of inputs with the use of computer information processing model, short term memory was managed, and long-term recall was coded by a learner (Siemens, 2005). In other words, it is brain-based learning (Alzaghoul, 2012). Lastly, constructivism is a learning process where the learner can construct fresh ideas or concepts based on learner's previous active experience (Alzaghoul, 2012) and the knowledge nature and how human-beings learn (Ültanır, 2012). The theory that is applied in this research is Constructivist theory and Attention, Relevance, Confidence and Satisfaction (ARCS) Motivation Model.

2.9.1 Constructivist Theory

Learners can learn effectively with technology-based learning that was designed with broad principles of constructivist (Karaduman & Gültekin, 2007). Moreover, technology could give most powerful effect to learning and teaching process when the principles or theories are used (Sandholtz et al., 1997). According to Yusoff et al. (2012), constructivist theory includes problem solving, concept development and learner's critical thinking rather than simple delivery of factual knowledge.

2.9.2 Constructivist Approach in learning

According to Ornstein & Hunkins (2018), educators are role to shape the learning experience that will give positive learning outcomes to the students in a learning environment. Knowledge is based on learner's previous active experience (Alzaghoul, 2012). Learning is an active social process in which the student plays an active role in constructing knowledge, discovering relationships among the factual contents, developing frameworks to explain the interrelationship and exploring new arenas (Woodard, 2003). Moreover, according to Jonassen (1999) cited by Yusoff et al. (2012), the constructivist theory describes how student experiences and constructs ideas for factual information and then imposes symbolic representations. Essentially this theory suggests that student builds their knowledge through previous experiences and enhances positive outcomes in the learning process by promoting active learning.

2.9.3 Constructivist and AR

Constructionism (a branch of the constructivist theory) suggests that learner's knowledge and experiences can be constructed through physical interaction within a real world (Sánchez et al., 1997). In a learning process, AR covers the physical and perceptual interactions. AR can simulate the real world so that the users may learn and apply the learning in the real context. AR has the capabilities for constructivist learning. Table 2.5 explains previous studies which strengthen the use of constructivist theory. The previous studies show that by using AR that are designed with constructivist theory could increase student's engagement and learning environment is more enjoyable and interactive.

Table 2.5

AR capabilities for Constructivist Learning

Researcher	Description of AR Capabilities
Wojciechowski & Cellary, 2013	Positive attitudes feedback from the users: Increase the student's motivation because of novelty of AR technology.
Dunleavy & Dede, 2014	Literature Review about AR and Constructivist Theory: AR situate well with theory of constructivist learning. Using constructivist theory was able to engage the user with the AR application.
Rasalingam et al. 2014	Increasing of motivation level in learning by using AR technology. Student's engagement also increase with the interesting 3D animation using flash card during their learning.
Abdoli-Sejzi, 2015	Literature Review about AR and Constructivist Theory: AR that are designed with constructivist theory make environment of learning much more effective, enjoyable, and interactive.
Aaltola, 2020	AR is an immersive tools with immersive content and can positively support training

2.9.4 Implications of Constructivist to this study

The previous literature has presented the AR concepts and its possible impact on the learning process by using mobile phone. Constructivist theory could make variety of learning's applications. Besides, it could engage and motivate learners during the learning. The explanation implicates embedding AR technology in learning procedures could give positive effect to the learners by using MAWL application.

2.9.5 ARCS Motivation Model

Keller (1987) motivation model, known as the ARCS model, was used in this study. Attention, Relevance, Confidence, and Satisfaction are the factors that make up the ARCS model of motivation. The first factor is Attention, which relates to capturing the learner's attention, arousing curiosity, and retaining engagement (Keller, 2008). Relevance is the second factor, which encompasses concepts and strategies that connect the instructional environment, such as content, teaching strategies, and social organizations, with learner goals, learning styles, and previous experiences (Keller, 2008). Confidence is the third factor, which is linked to a student's sense of personal control and expectations of success (Keller, 2008). Finally, satisfaction is required for learners to have a positive attitude toward their learning experience and to establish a long-term learning motivation by rewarding or recognizing the learner so that they feel satisfied after they have achieved their goal (Keller, 2008). The ARCS Motivation model is primarily employed in the realm of education, where it has been applied to motivating design, development, and evaluation procedures in a range of computer-based teaching materials and systems (Gopalan et al., 2015).

There are researchers that have conducted studies using various learning platform to determine the effectiveness of the ARCS Motivation model. According to Gopalan et al. (2015), the ARCS Motivation theory improves students' motivation to learn science. Previous studies found that students achieved higher grade scores and got better academic performance after received ARCS instruction (K. Li & Keller, 2018) also improves the student's motivation level (Feng & Tuan, 2005). Besides, ARCS Motivation Teaching Mode can successfully promote learning motivation of students, modify learning attitudes, and gain teaching effects positively (Li & Ren, 2018). Student motivation levels reflect involvement and contribution to the learning environment (Gopalan et al., 2017). Hence, motivation and curiosity are very important for learner's engagement with a subject matter and increase their learning retention for the learning process (Feng & Tuan, 2005). So, ARCS motivation model will be implement in this study towards the use of the AR mobile-based welding learning app. Figure 2.8 shows the ARCS model factors and strategies to enhance level of student's motivation summarized by Gopalan et al. (2016b) which originally from Huang et al. (2006).

Factor	Description	Strategies
Attention	Student's attention and curiosity need to be aroused and sustained	***Perceptual Arousal***: Using novel, surprising, incongruous events to gain and maintain the student's attention level. ***Inquiry Arousal***: Stimulating information seeking by questioning the students. ***Variability***: Providing varieties in elements to maintain students' motivation.
Relevance	Accomplishing the goals of learning	**Familiarity**: Facilitate the language and provide related examples. ***Goal Orientation***: Provide statements or examples that are related to the objectives and goals. ***Motivational Strategies***: Arranging the learning strategies related to the student's motive.

Confidence	Students need to feel the confidence, enjoy and success after completing the tasks	***Learning Requirement***: Provide students the probability of success by presenting performance requirements or evaluations. ***Success Opportunities***: Provide challenge levels that allow meaningful success experience under both learning and performance conditions. ***Personal Control***: Provide feedbacks in supporting the success.
Satisfaction	Satisfaction comes when students are allowed to practice by using the new knowledge which then leads to positive outcomes to the attitudes.	***Natural Consequences***: Provide opportunities to use new knowledge. ***Positive Consequences***: Provide feedback and reinforcements that will sustain the desired behavior. ***Equity***: Maintaining the consistent standards and consequences for task accomplishment.

Figure 2.9. ARCS Model Factors and Strategies (Gopalan et al., 2016b)

2.10 Research Model

Figure 2.10 shows the research model used in this study. The model comprises of five independent variables and a dependent variable.

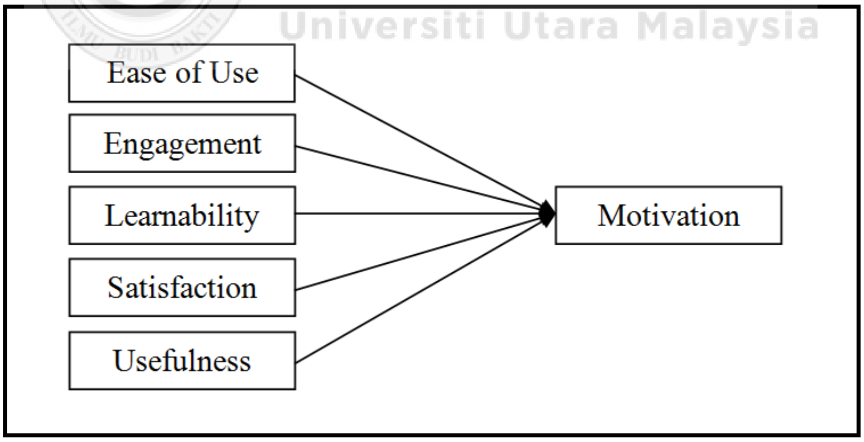

Figure 2.10. Research model

The independent variables include ease of use, engagement, learnability, satisfaction and usefulness while the dependent variable in this study is motivation. The research model will be used to develop the app and the attributes were chosen based on variables that have been used from previous researcher's studies related to AR mobile-based learning to achieve one of the research objective. These attributes had proven were giving the positive impact to the learning environment.

2.11 Evaluation

Evaluation is a process to determine the helpful feedback from the experts to make improvement and useful response from target users about the effectiveness of a solution that has been proposed through the research. According to Chen (2014), evaluation is the systematically process of collecting empirical data and contextual information regarding the intervention program with questions that will help in assessing the planning of program, implementation, and effectiveness of the program. The suitable guidelines were used in this study. There are several evaluations were conducted in this study include content and interface evaluation by expert and perception evaluation, pearson correlation analysis, regression analysis and learning performance evaluation by the target users.

2.12 Heuristic Evaluation

The usability evaluation technique used in the research namely heuristic evaluation. Heuristics are usability engineering process that intent to identify system's problem during its development and the interface review by the experts and potential users (Vieira et al., 2019). According to Vieira et al. (2019), heuristics evaluation can be applied during the app development or at the end of the app's development which it can be specific or general. Meanwhile according to Khajouei et al. (2018), heuristic evaluation is suitable for determining specific problems, such as determining and correcting errors, but in some areas like consistency and standards in the system design, it determines ineffective problems.

This evaluation method was created by Jakob Nielsen which derived from his experience in the field of teaching (Nielsen, 1995). The main objective of the heuristic evaluation is to determine the usability problems in prototype's design and validate content by the experts. Heuristic evaluation is one of the easiest and commonly used methods by experts to determining usability problem (Khajouei et al., 2018). The evaluation requires the experts in the field of a particular study (Davids et al., 2014). Therefore, the problems of the prototype can be identifying by evaluating its usability, then help to redesign it so that the users can use the prototype without any usability problem.

2.13 Summary

This chapter aims to improve understanding of research topics. The development of the MAWL app was based on research into multimedia technologies, augmented reality, theory and model. In addition, the research used Constructivist theory, ARCS motivation model and research model to develop the MAWL app. All of the theories were used to help design and construct the MAWL app, which will be used as a supplement to welding learning. The study proposes that the MAWL app be used as a supplement to welding learning, incorporating AR technologies via mobile phone.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This chapter covers the research methodology in developing the Mobile Arc Welding Learning (MAWL) app that incorporates Augmented Reality (AR). Thus, the methodology phase involves the planning strategy, how to achieve, approach, and plan together and become highly relevant (Saunders, 2009). It also consists of the design of research and its process to achieve the research objectives. The research activities were done in a systematic and orderly manner that is fundamental in knowing the findings are valid and credible.

3.2 Research Process

Research methodology is the numerous procedures, schemes, algorithms, and methods that are used in a research where samples and data are collected and search a solution to a problem (Rajasekar et al., 2006). Research methodology focuses on how to implement the design and carry out the research. This research adapted the general research methodology of design by Kuechler & Vaishnavi (2011). It consists of five phases namely; awareness of problems, suggestion, development, evaluation and conclusion as shown in Figure 3.1.

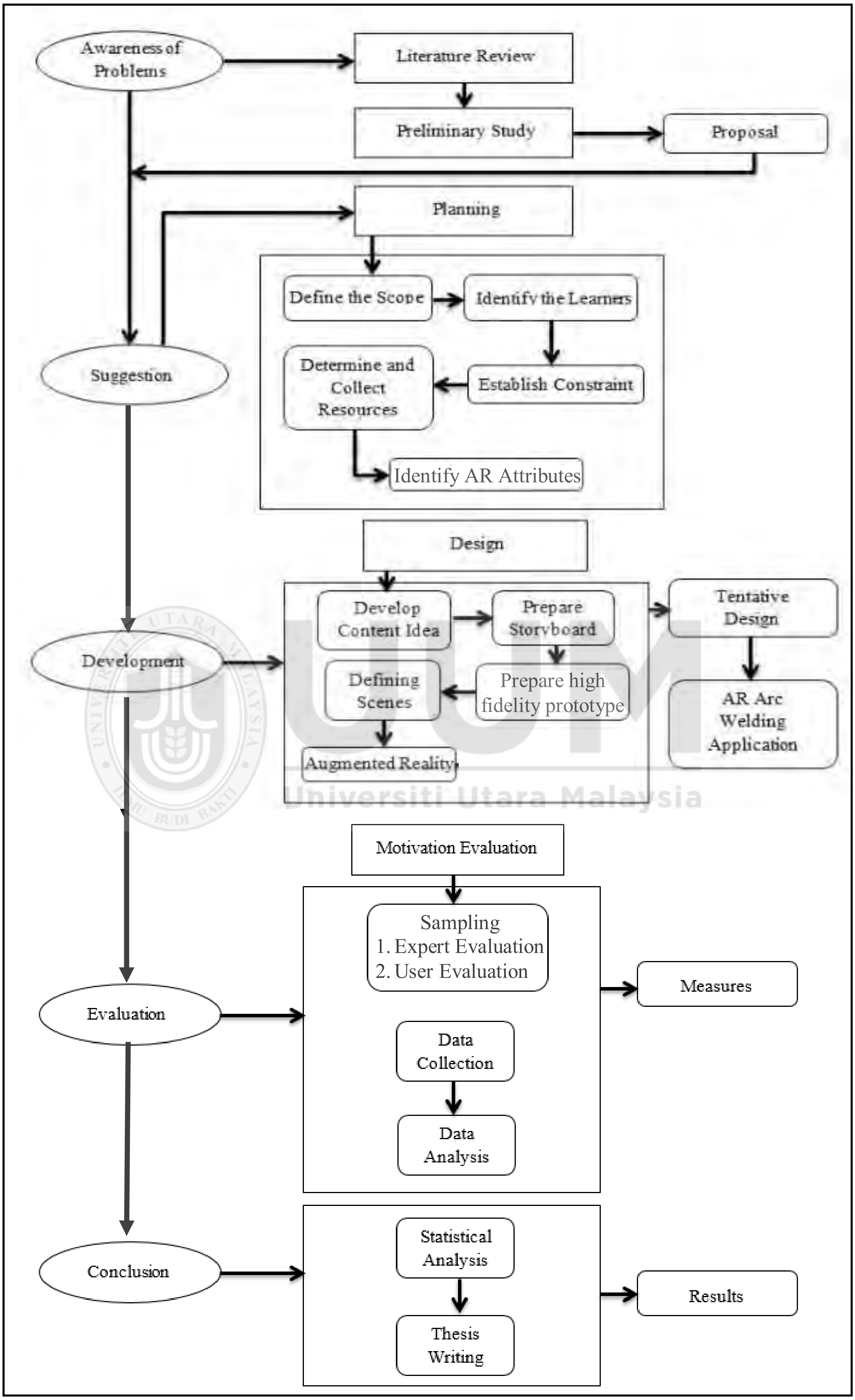

Figure 3.1. Research Methodology (Adapted from Kuechler & Vaishnavi (2011)

3.2.1 Awareness of Problem

The basis in identifying awareness of the problem in the current welding learning met hod would spearhead this research. It is the beginning to prove that the integration of mobile technology and AR can be a solution for this research. Based on the Figure 3.2, in order to know what problems faced by the students is through literature review and also preliminary study. In this case, the main issues are the lack of supplementary learning materials for welding and how to introduce a new approach to learning for welding.

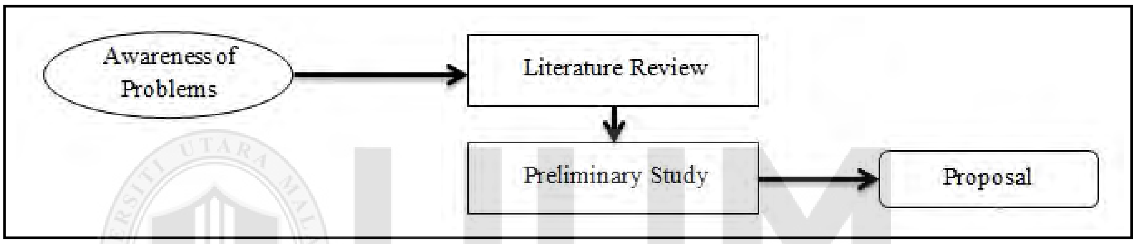

Figure 3.2. Awareness of Problems phase

To identify the current state of the research topic, a literature review was conducted. Furthermore, the literature review is necessary for the researcher to gain a greater understanding of the principles and theories that will be used in this study. The researcher can keep track of the study's progress with the help of a literature review. In addition, the researcher needs to be familiar with the students' current learning environment and any other resources they used to study welding. Thus, the literature review helps the researcher to understand the students’ learning situation and, in that way, the researcher can contribute something new to the students.

The preliminary study was conducted to identify the methods of learning for welding.

The results of the preliminary study assisted the researcher in determining the existing learning methods. In addition, the preliminary study also reinforced the problems to be investigated in this study. The preliminary study was carried out among 50 Mechanical Engineering students from Politeknik Tuanku Syed Sirajuddin (PTSS) regarding welding learning. The questions focused on two categories namely; demographic of the students and learning-related information using the welding. The preliminary study findings revealed that the students desired a change in the welding learning method. This is because the existing methods are based on “chalk and talk" and "paper-based" learning. The results of the preliminary study were used to produce the research proposal.

3.2.2 Suggestion

As shown in Figure 3.3, planning was created in this phase based on the results from the literature review and preliminary study. Planning includes defining the scope of research, identifying the target users, establishing the constraints for the research and finally determining and collecting the resources for conducting the research and in thesis writing.

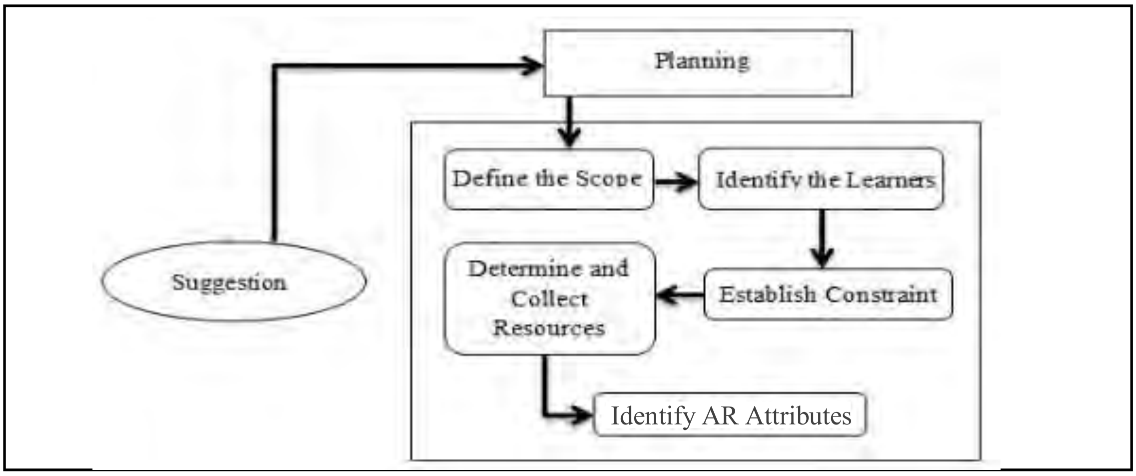

Figure 3.3. Suggestion phase

Further, this research needs to identify appropriate AR attributes in learning that can motivate students in welding learning that will be use for the development of the app. Previous study has proven that mobile app would attract more learners in learning and mobile AR app has the fullest potential that could deliver learning content effectively to the learners and by seeing virtual information shown in a real-world setting (Lee, 2012). Thus, AR elements that are applied to the app were identified in this phase. All the collected resources were used in the next phase which is the development phase.

3.2.3 Development

In the development phase as shown in Figure 3.4, all important information about welding suitable for a mobile app was gathered to complete the MAWL app incorporating with AR. The information was collected from the experts in welding by using their teaching and learning materials to be used to develop the content idea. Then, all the required information was used in the preparation of the storyboard for the app.

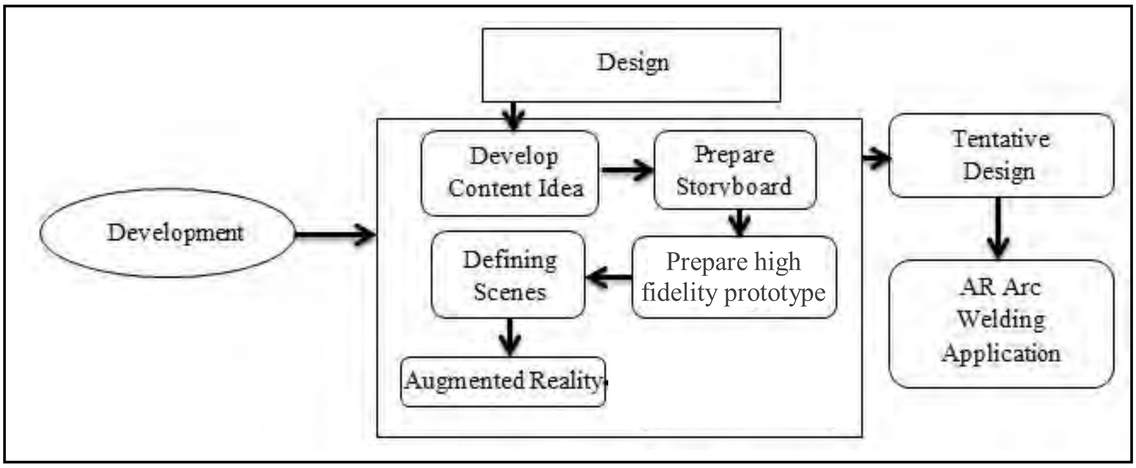

Figure 3.4. Development phase

In this research, since it involved the development of a mobile app, then a wireframe was developed for the storyboard. Wireframe is a blueprint of low fidelity presentation of the overall flow of a mobile application and important step in the development process of a mobile app (Chavda, 2022). In addition, wireframe gives simple approach to accept usefulness and ease of use of an app which allows users to imagine and explore the diverse segments (*Wireframe in Mobile App Development*, 2016). Figure 3.5 illustrates an example of wireframe used in the design of the app for this study. The wireframe includes all the tentative design of the MAWL app. In the development of the MAWL app, the researcher has to always refer to the wireframe to ensure that the app has been developed properly as planned.

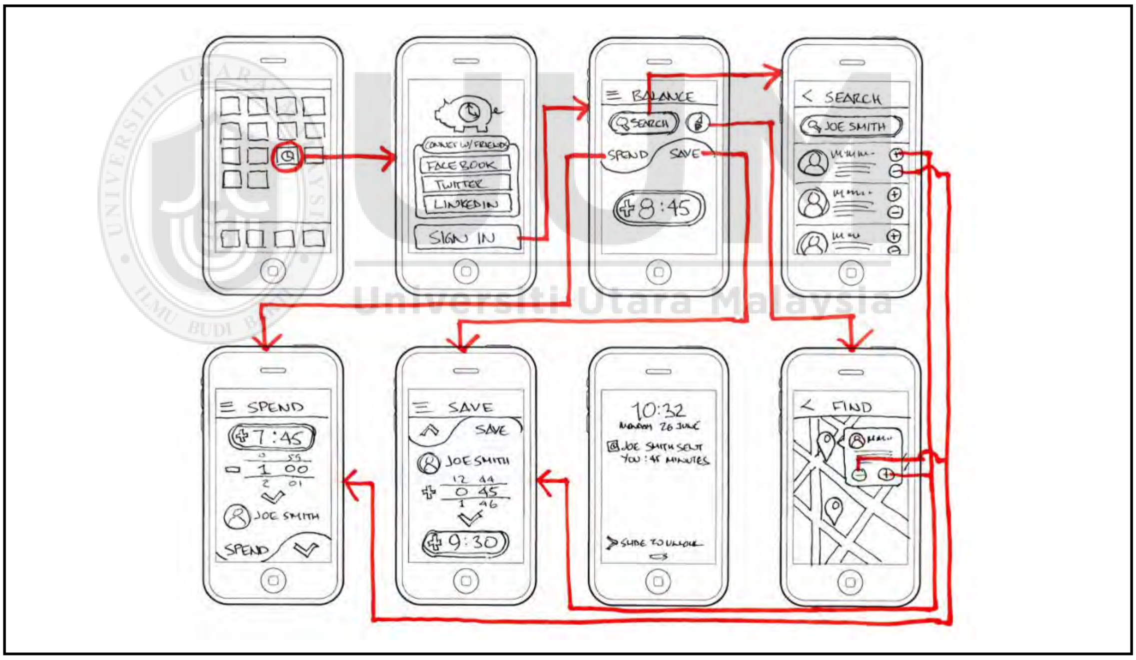

Figure 3.5. Example of Wireframe (*Wireframe in Mobile App Development*, 2016)

After creating a storyboard (in this study a wireframe) was done, the preparation for virtual prototype is the next step in this phase. The scenes from the storyboard were defined together with the scenes that incorporate with AR before implementing them into the software that are used for the MAWL app development.

3.2.3.1 Software

The MAWL app was created using a variety of software. The software includes; Adobe Photoshop CS6, Adobe Premiere CS6, and Unity3D integrated with Vuforia.

i. **Adobe Photoshop CS6**

It has been used for creating and editing of 2D graphics used in the app. Adobe Photoshop CS6 has some functions such as cropping, resizing, rotating, brushing, changing contrast, balancing, and combining. It could also save the images into multilayered composite (Shelly & Starks, 2009 as cited by Gopalan et al. (2015) and also save into different formats. With Adobe Photoshop CS6, all the 2D graphics were able to be edited to suit the requirements of the MAWL app.

ii. **Adobe Premiere CS6**

All the welding videos used in the MAWL app were recorded at PTSS and edited using Adobe Premiere CS6. This software was used to edit, manipulate, and export the videos. Besides, videos and still images could be edited together and can be added with filters along with the effect. It also can be used to import not only video but also audio and graphics.

iii. **Unity 3D Integrated with Vuforia**

MAWL app has been developed for the mobile platform. As such, in order to produce the AR interfaces, Unity3D with Vuforia has been used for the app development. Unity3D is a 3D real-time environment development platform than can be used to design and develop 3D model and virtual environment. It is also suitable to be used for AR development. Unity3D was used with Vuforia because the MAWL app is an application developed specifically for mobile platform as well as for developing AR applications. Vuforia supports AR app development for Android, iOS, and UWP devices (*Vuforia Engine Library*, n.d.). Developer can add advanced computer vision functionality to any app, allowing it to recognize images and objects, and interact with spaces in the real environment (*Vuforia Engine Library*, n.d.). Unity3D and Vuforia support a wide range of digital contents and formats such as two-dimensional (2D) images, videos, audios, three-dimensional (3D) static as well as animated models. Besides that, the AR interfaces require markers that will trigger the digital contents.

When all the editing processes have been completed, all these elements need to be integrated according to the three categories displayed in the app, namely; Safety in Welding, Component of Welding, and Steps in Welding.

3.2.4 Evaluation

Figure 3.6 shows the steps in the evaluation phase of this study. The evaluation includes expert evaluation and user evaluation. Heuristics evaluation has been done by the experts which to validate the content and identifying the usability problem includes functionality and interface of the MAWL app. The evaluation aimed to assess the potential and capability of the MAWL app to motivate students for welding learning. Then, the objective of the user evaluation is to evaluate the student's motivation by using MAWL app as a supplementary material of learning through the implementation of AR for welding learning. The evaluation design was created for the overall evaluation of the study as shown at Figure 3.7.

The experts and users were participated in the evaluation process. The experts consist of lecturers who have been teaching and have experience and knowledge about AR and welding, while the users were the students enrolled in the welding class at the Politeknik Tuanku Syed Sirajuddin. The results from the evaluation would be used to answer the research questions.

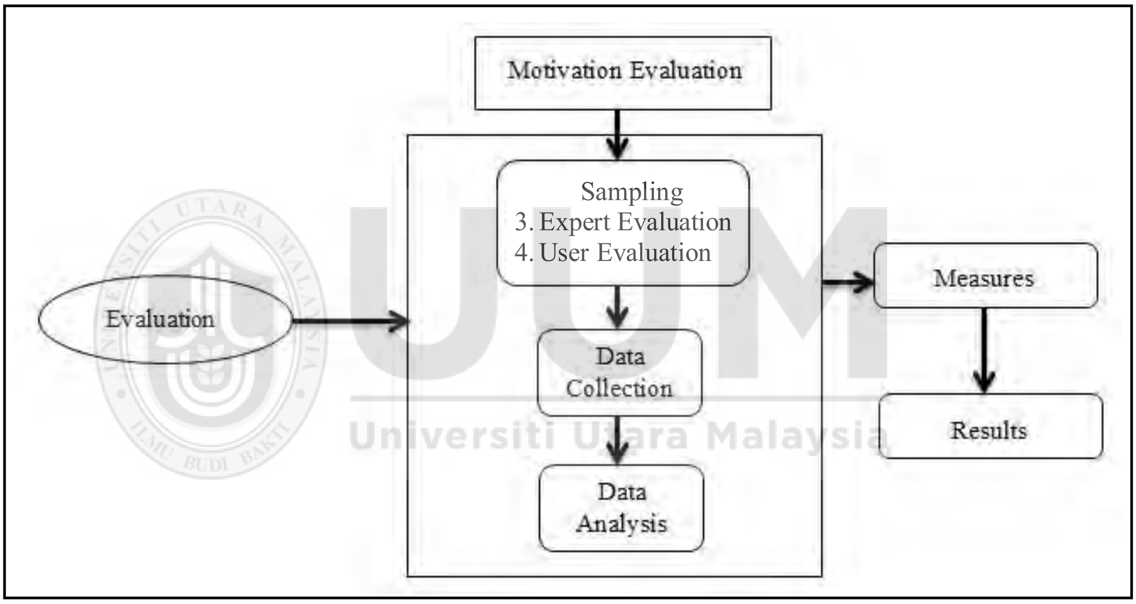

Figure 3.6. Evaluation phase

3.2.4.1 Evaluation Design

The processes employed in this study's evaluation design are depicted in Figure 3.7.

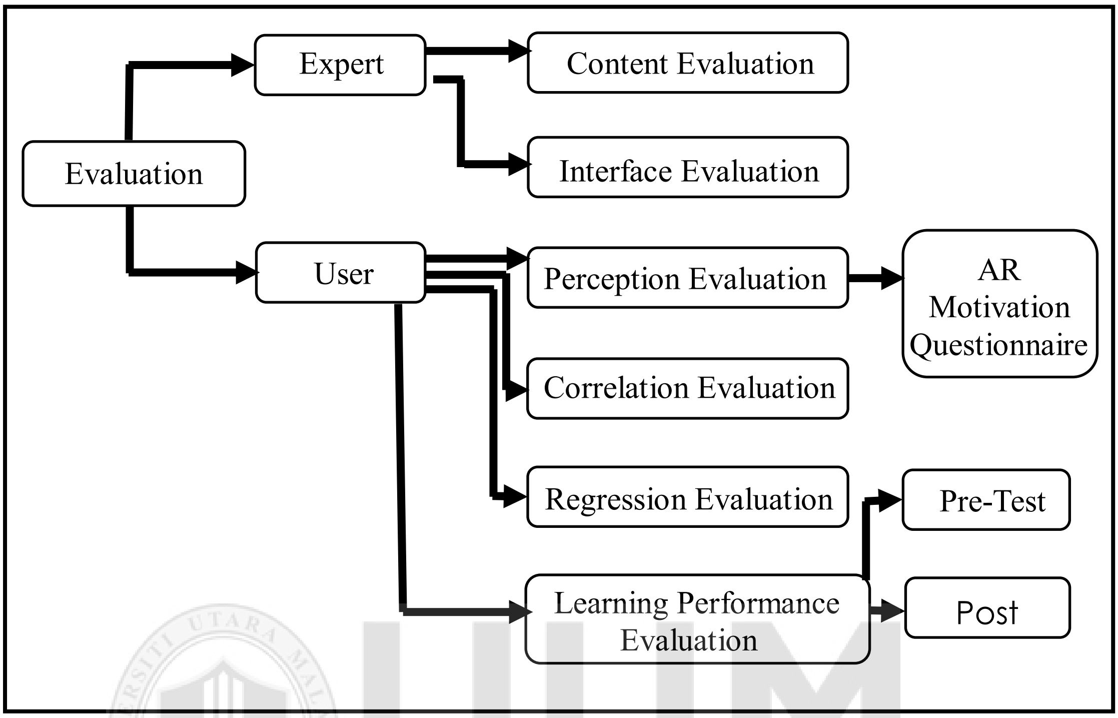

Figure 3.7. Evaluation design

Based on Figure 3.7, there are two type of evaluations which are expert evaluation and user evaluation that has been conducted for this study. There are two evaluations for expert evaluation which are content evaluation and interface evaluation. Moreover, there are four evaluations for the user evaluation included perception evaluation, correlation evaluation, regression evaluation and learning performance evaluation. The students were give AR motivation questionnaire for the perception evaluation. Furthermore, in order to evaluate the students learning performance evaluation, the pre-test and post-test has been conducted.

3.2.4.2 Expert Evaluation

The expert evaluation was conducted to make sure that the app's contents met the learning requirements of PTSS. The instrument was created to gather expert's feedback on functionality and interface of the MAWL app and their suggestion to improve the app. This evaluation involved altogether four experts; two content experts and two functionality and interface experts. The experts have at least 3 years' experience in their consecutive field. The experts provided comments and feedbacks based on their expertise and experience pertaining to the developed app.

3.2.4.3 Content Expert

Firstly, researcher met two PTSS lecturers who teach welding subject at mechanical engineering department's workshop to get permission to conduct the evaluation and briefing about the study. The workshop is where the lecturers train their students for welding training. Welding experts consisted of two lecturers who were involved in the welding learning at PTSS. The content experts have to validate the app's content in order to verify that the contents were suitable and valid for the PTSS students. Besides that, they need to ensure that the app was useful to the students.

The experts were given a complete storyboard of MAWL app which has every scenes and interfaces with welding information. Then, they have to evaluate the app by commenting about the content and suggesting what content that the researcher should added. They were given an evaluation paper consist of the list of the content in the app, a column to comment about the problem and a column for suggestion. The comments from the content experts can be refer at Appendix F and Appendix G. Corrections to any part of the contents were made based on the comments from experts.

3.2.4.4 Interface Expert

After the corrections were done based on the content expert's comments and the development of the MAWL prototype were completed, the researcher met another two experts but this time was interface experts. The functionality and interfaces experts consisted of two lecturers from Universiti Utara Malaysia who have knowledge and experience in mobile and AR apps development. Firstly, the researcher gets their permission to conduct the evaluation and briefing about the study. Then, the experts were given an evaluation paper consist of questions about interface, multimedia elements (image, video, text and 3D model) and interactivity and also the comment's column for the expert to comment. The experts evaluated the functionality and interfaces of the app before introducing the app to the students. Besides, they were also required to identify the app's fault and provide suggestions to improve the app. The comments from the interface experts can be refer at Appendix H and Appendix I. Corrections to any part of the interface's problem were made based on the comments from experts.

3.2.4.5 User Evaluation

User evaluation is necessary in ensuring and demonstrating whether any introduced solution has succeeded in achieving its goal or not. The user evaluation was conducted after expert evaluation. It involved perception study, correlation and regression analyses and learning performance study. For the user evaluation, a sample 67 semester 1 Mechanical Engineering students of PTSS were selected as respondents using purposive sampling technique. Purposive sampling is the characteristics were chosen for a purpose that is relevant to the study where researcher relies on own judgement (Andrade, 2021). The participant's age were ranged from 18 to 20 years old. Firstly, a set of questions were given to all the respondents for the research pre-test. The questions can be referred in Appendix B. It has 15 multiple-choice questions quiz about welding to test respondent's initial knowledge about welding. Then, all the respondents were given the MAWL app APK file so they could install in their mobile phone. All of the respondents had a week to become acquainted with the app. After a week, they were given the same 15 multiple-choice questions quiz for the research post-test in order to determine what the students have learned by using the MAWL app and whether they can answer all the same questions correctly. After that, a set of evaluation questionnaires for the app evaluation were given to them. In order to access the group's learning performance, paired-sample and independent sample t-tests were applied. The pre- and post-test scores were evaluated to determine whether the students' learning performance improves or not as a result of using the MAWL app. The questionnaires consist of all the attributes and items for Ease of Use, Engagement, Learnability, Satisfaction, Usefulness, and Motivation.

The motivation questionnaire is used in this research for the student's perception study, correlation and regression. The motivation questionnaire can be referred in Appendix C. Using a motivation questionnaire like the one provided in Table 3.1, the perception study aims to find out how users feel about the MAWL app when it comes to welding learning using a mobile app with AR. The correlation analysis was then used to evaluate whether there was a positive or negative link between all the independent variables and the dependent variable.

Data was collected and tabled in Excel prior to data analysis. SPSS version 22 was used to analyses the data. SPSS is a data management and statistical analysis tool. It is used to perform, among others, descriptive statistics, correlation, and regression analysis. Table 3.1 shows the measurements and items that have been used for the MAWL app user evaluation. The items for each measurement were adapted from the past study by various researchers which the reliability and validity of the measurements and items had been analyzed. The items for measurement ease of use, engagement and motivation was adapted from Gopalan et al. (2016b), then the items for measurement satisfaction and usefulness was adapted from Mohd jelani et al. (2018) and lastly the items for measurement learnability was adapted from Zulkifli et al. (2021). The measurements and items had proven that it can be used to determine the students' perception towards the app.

Table 3.1

Motivation Questionnaire: Measurements and Items used for App

Measurements	**Items**
Kemudahan penggunaan *(Ease of Use)*	MAWL senang digunakan secara individu
	MAWL sesuai digunakan untuk mempelajari kimpalan
	MAWL sesuai digunakan untuk mengulangkaji berkaitan kimpalan
	Teknologi Realiti Luasan Mudahalih sesuai digunakan secara sendirian
	Langkah dalam menggunakan MAWL mudah diingati
	Teknologi Realiti Luasan Mudahalih menyenangkan proses mengulangkaji berkaitan kimpalan
Keterlibatan *(Engagement)*	MAWL menarik minat saya untuk mempelajari kimplan untuk jangka masa yang lama
	MAWL membolehkan saya mengulangkaji kimpalan berulang kali

	MAWL membolehkan saya mengulangkaji kimpalan berulang kali
	MAWL menyebabkan saya mempelajari kimpalan untuk jangka masa yang lama
	Teknologi Realiti Luasan Mudahalih meningkatkan penglibatan saya dalam pembelajaran kimpalan
Keupayaan belajar *(Learnability)*	Ianya mudah untuk belajar menggunakan MAWL
	Informasi yang disediakan oleh MAWLmudah difahami
	Informasi yang disediakan oleh MAWL membantu saya dalam mempelajari kimpalan
	Menggunakan MAWL adalah munasabah untuk pembelajaran
Kepuasan *(Satisfaction)*	Saya berpuas hati menggunakan MAWL
	Saya berpuas hati dengan maklumat yang diperolehi dari MAWL
	Saya berpuas hati dengan kaedah pengajaran MAWL
	Saya berpuas hati dengan persekitaran pembelajaran yang terdapat pada MAWL
	Saya berpuas hati dengan keseluruhan keberkesanan pembelajaran
Kebergunaan *(Usefulness)*	Penggunaan MAWL membolehkan saya untuk menyudahkan tugasan dengan lebih cepat
	Penggunaan MAWL boleh meningkatkan prestasi pembelajaran saya
	Penggunaan MAWL dalam pembelajaran kimpalan boleh meningkatkan produktiviti saya
	Pengunaan MAWL boleh meningkatkan keberkesanan terhadap pembelajaran kimpalan
	Penggunaan MAWL membuatkan pembelajaran saya lebih mudah
	Saya suka belajar menggunakan MAWL
Motivasi *(Motivation)*	MAWLsenang digunakan
	MAWL meningkatkan penglibatan saya dalam pembelajaran kimpalan
	Saya seronok dengan pembelajaran kimpalan untuk jangka masa yang lama
	Pembelajaran kimpalan menjadi lebih seronok dengan menggunakan MAWL
	MAWL meningkatkan motivasi saya untuk mencapai tahap cemerlang dalam pembelajaran kimpalan
	MAWL mendorong saya untuk melanjutkan pengajian keperingkat tinggi dan kerjaya yang berkaitan dengan kimpalan pada masa hadapan

	MAWL mendorong saya untuk melanjutkan pengajian keperingkat tinggi dan kerjaya yang berkaitan dengan kimpalan pada masa hadapan

All of the items of the questionnaire were adapted from past studies were deemed valid for this study. Meanwhile, a reliability test was conducted to determine the usability and internal uniformity of the attributes by calculating the Cronbach Alpha value. Cronbach Alpha value should have a minimum value of 0.7 to consider its validity and reliability (Hair et al., 2006; Nunnally, 1978). The Cronbach Alpha values for all attributes can be referred to the Table 5.4.

3.2.6 Conclusion

The final phase is the conclusion phase as shown in Figure 3.7. This phase looks at ways to use a mobile app with augmented reality to increase motivation of the student to learn about welding. Then analyzed the collected data in SPSS using several statistical analyses namely; descriptive statistics, Pearson correlation, regression and paired samples t-test. The results of all these analyses were then elaborated in detail to draw conclusions for this study.

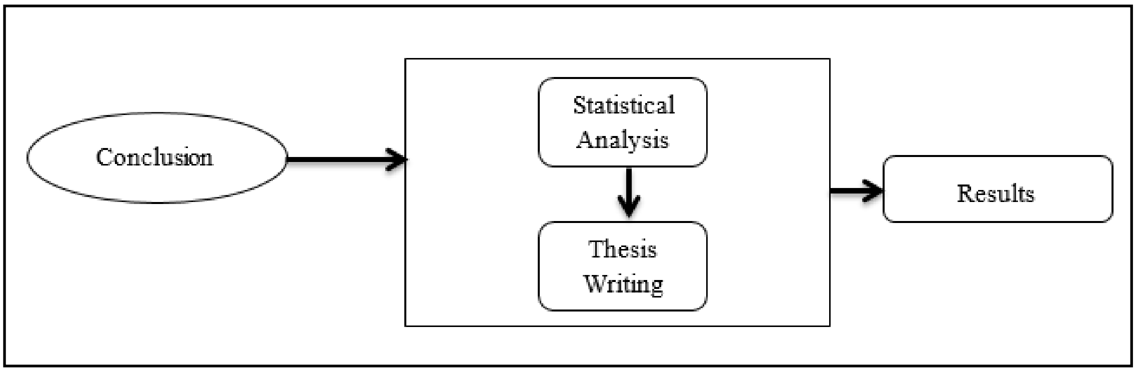

Figure 3.8. Conclusion phase

3.3 Summary

This chapter goes over all of the processes and methods that were used in this study. The research methodology as shown in Figure 3.1 was used for the whole process of this study. The methods proposed in this chapter contributed to the main outcome of this study that is the MAWL app. In addition, user evaluation involving perception study, correlation, and regression analyses, and learning performance study assists in explaining how the MAWL app can enhance students' learning performance and increase their motivation in welding learning using the app.

CHAPTER FOUR

DESIGN AND DEVELOPMENT

4.1 Overview

The design and development of the MAWL app are primarily covered in this chapter. It elaborates on all the process that were conducted pertaining to the design and development of the app based on the methodology discussed in Chapter three. Furthermore, it covers how the model's components and contents were used in the design and development of the MAWL app.

The architecture of the MAWL app, which includes the tools used in its design and development, is shown in Figure 4.1. MAWL is a mobile app and user can experience some AR features with the use of AR markers utilized via mobile device's camera. The MAWL app has been developed on a personal computer and further implemented on a mobile phone as depicted in the development tools section. Furthermore, Adobe Photoshop CS6, Adobe Premiere Pro CS6, Unity3D with Vuforia Development Kit (SDK) and 3DS Max were used the design and development of the app. Unity3D with Vuforia was used for the development of the app which was later saved as android package kit (APK) format before implemented on mobile device.

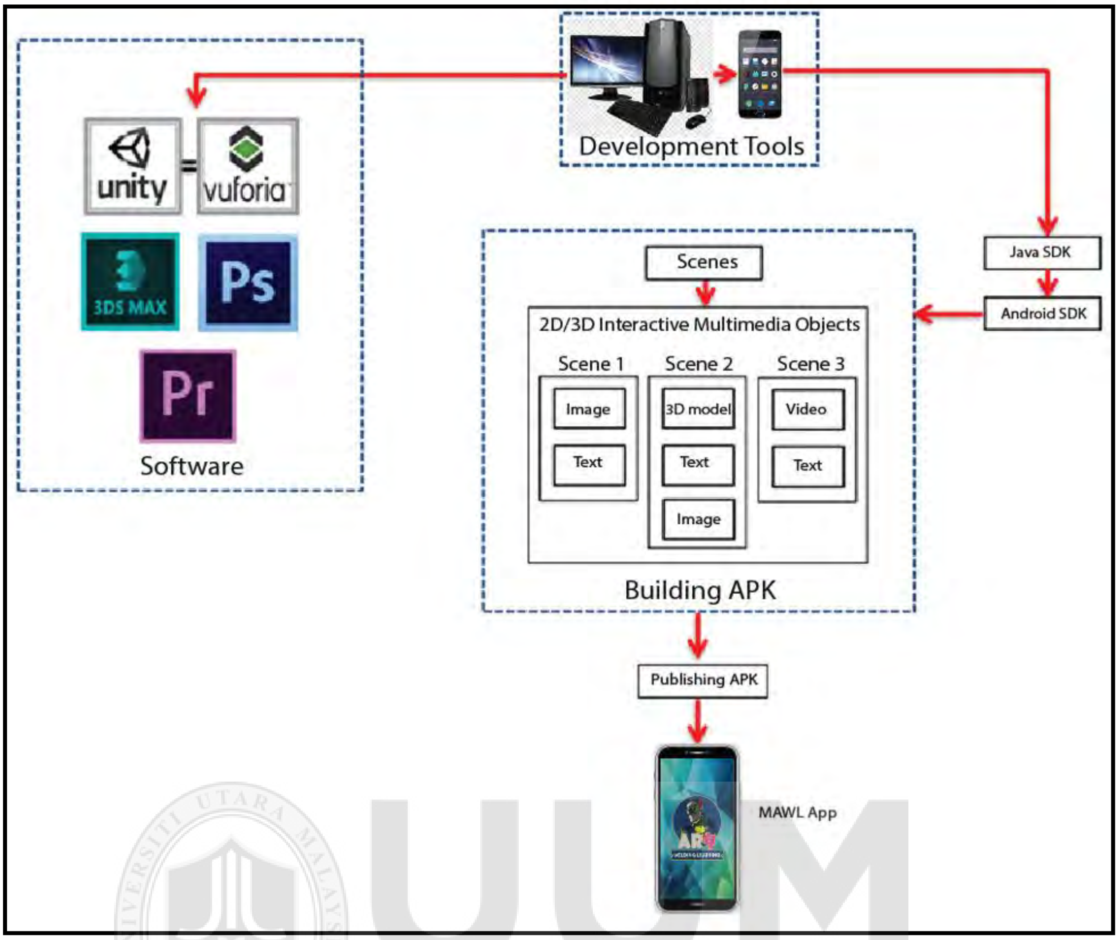

Figure 4.1. MAWL Architecture

4.2 MAWL App Development

The MAWL app was developed to provide supplementary learning materials for students who were learning welding through the use of mobile device. There are two main phases in the app development. The first phase involved the gathering and creation of contents while the second phase involved the development and integration of the app to the mobile device. As mentioned previously, the software that were used during development include; Adobe Premiere CS6 for video editing, Adobe Photoshop CS6 for image editing, 3DS Max 2012 for creating and modifying of 3D models, Unity3D for MAWL app's development and deployment to the android device, and Vuforia is the SDK for Android development. Since AR has been integrated into the MAWL app, Vuforia AR toolkit database was used to create the target marker. The image for the marker was edited using Adobe Photoshop so that it has customized dimensions prior to uploading to Vuforia database. The goal was to create a new target in the database. The authoring aspect of Unity3D was able to be activated as a result of this. The app can be installed on any Android mobile devices.

4.3 MAWL App Contents

The gathering and creation of contents to be put in the MAWL app took place in the first phase. App contents related to welding learning consisting of images, videos, text, and 3D models in formats that conform to smartphone specifications are collected. The contents were specifically selected to ensure that the developed app is more attractive, informational, fun and easy to use for learning. The contents were categorized into three sections namely; safety in welding, components of welding, and steps in welding.

MAWL app requires the use of AR markers. It is important to ensure that these markers function properly when implemented them into the app. Once a marker has been recognized, virtual (computer-generated) objects will be presented and superimposed on the screen of the mobile device, including 3D models and videos. Meanwhile, the marker was created by using Vuforia software marker manager. Vuforia online database create a device database and a new target has been determined and a name was given. The targets included in the MAWL app are 3D models and videos. In Vuforia, the markers then saved in JPEG format, as illustrated in Figure 4.2. Lastly, Unity3D was used to incorporate all the contents of the MAWL app and an APK file was created. The MAWL app can then be accessed by installing this APK on any mobile device.

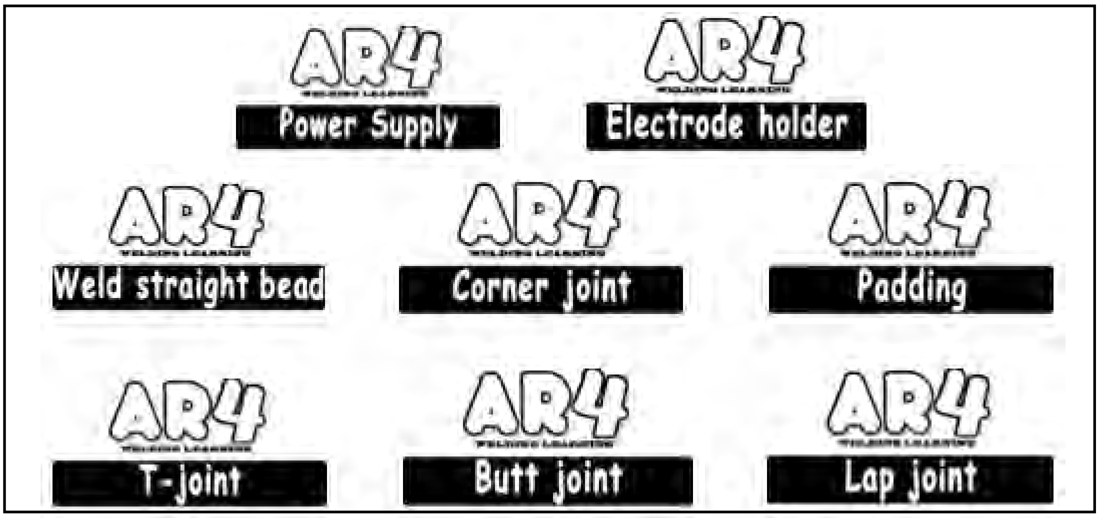

Figure 4.2. Markers for the MAWL app that are based on images

Figure 4.3 shows the users were using the installed MAWL app on a mobile phone while Figure 4.4 shows the users were trying with the marker to view the virtual content provided by the app.

Figure 4.3. Users using the MAWL app

Figure 4.4. Displaying the virtual content using a marker

4.4 Integration of MAWL on mobile device

For the MAWL app to be integrated into a mobile device, several features were set up in Vuforia, including 3D model and video targets, as well as a project file for the SDK for Android development. The target markers were uploaded as marker images prior to the project file being obtained from the Vuforia database. A Unity Editor file was utilized to conform to the Unity3D authoring development. Then, using the Vuforia SDK, the AR Unity project was created, saved, and downloaded for usage in Unity3D. This meant that the MAWL app's development would necessitate the integration of Vuforia and Unity3D. During the development period, the application also made use of the C++ programming language. The MAWL app's development, which included compilation, visual creation, interaction, content presentation, and mobile device distribution, was done fully in Unity3D.

Figure 4.5 illustrates the MAWL app's main interface, which includes three images that operate as buttons titled Safety in Welding, Component of Welding, and Steps in Welding. The Unity workspace contains these buttons. The MAWL app's background was created using a raw image that was added and saved in the Unity workspace. To enable the installed app on the mobile device to scan, a C++ script was developed. As a result, when a marker is scanned, the phone's screen displays the virtual content related to it. Figures 4.6 until Figure 4.9 present some screenshots of the interfaces for Unity3D, Adobe Premiere CS6, Adobe Photoshop CS6, and 3DS Max respectively.

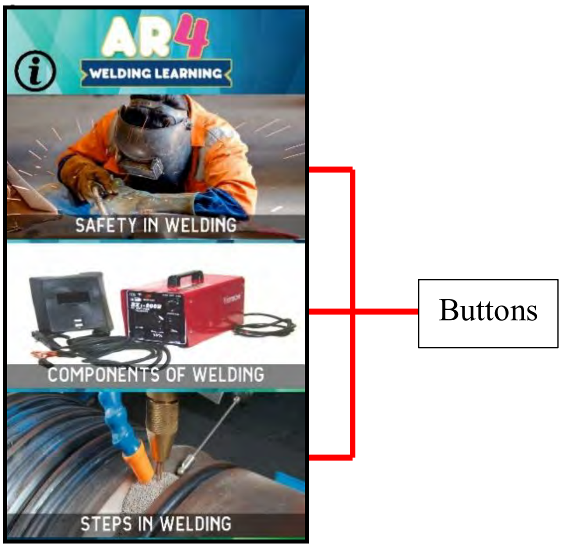

Figure 4.5. Main interface of MAWL prototype

Figure 4.6. Unity3D interface

Figure 4.7. Adobe Premiere CS6 interface

Figure 4.8. Adobe Photoshop CS6 interface

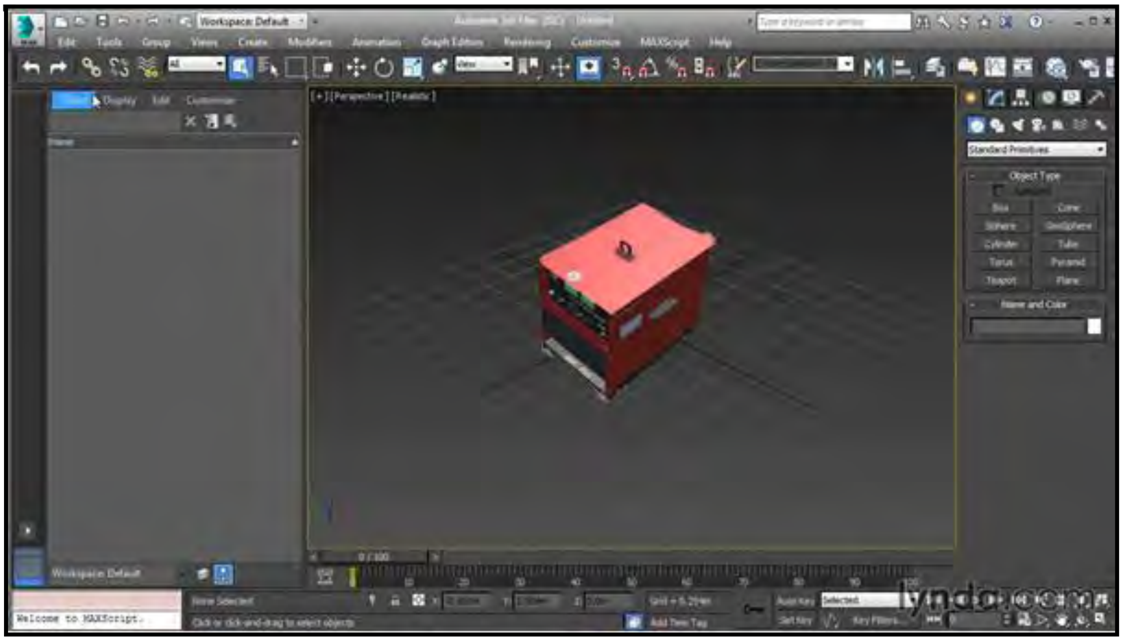

Figure 4.9. 3DS Max interface

4.5 MAWL App

The previous section discussed about the MAWL app until it can be installed on any Android device. All of the functional and technical requirements must be considered before the app is ready to be utilized. In the following section, the interfaces of the MAWL app will be discussed. The home page and the interaction function interface are the two types of interfaces.

4.5.1 Main page

The app starts with a colourful splash screen with picture and name of the app that lasts roughly 15 seconds before moving on to the main page. The splash screen consists of an image of a welder. The Main Menu appears after the splash screen has been displayed, and the user can interact with the app further by pressing the buttons. There are 3 images that act as buttons entitled Safety in Welding, Components of Welding, and Steps in Welding as shown in Figure 4.5. The buttons will navigate user to the following page. The splash screen, the Main Menu, and the Info screen are all shown in Figure 4.10.

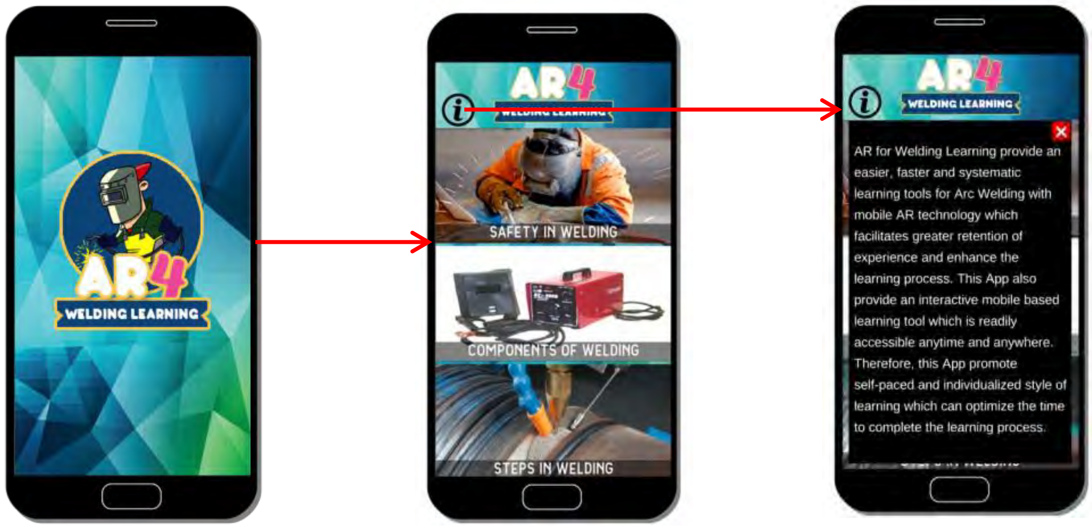

Figure 4.10. Splash Screen, Main Menu and Info

4.5.2 Interaction function interface

The Main Menu has info button as seen on the left in Figure 4.10. The info button provides background information about the app while the exit button on the right of the info box is to exit from the info page. The Safety in Welding button navigates the user to the page which provides information regarding the safety guidelines that welder should follow before, while and after doing the welding works. It also shows the images of equipment normally used while welding. Information provided by this button is classified into five themes namely; personal protective equipment, pre-operational safety checks, operational safety checks, ending operation and cleaning, and potential hazards. In order to see the additional information for each theme, the user needs to click the next button as shown in Figure 4.11. For example, if the user clicks at the next button for personal protective equipment, the page displays a picture of personal protective equipment used by welders to protect themselves. Every interface in safety learning has home button which displays on the top left to let the user to go to the home page and back button at the bottom left to go back to the previous page.

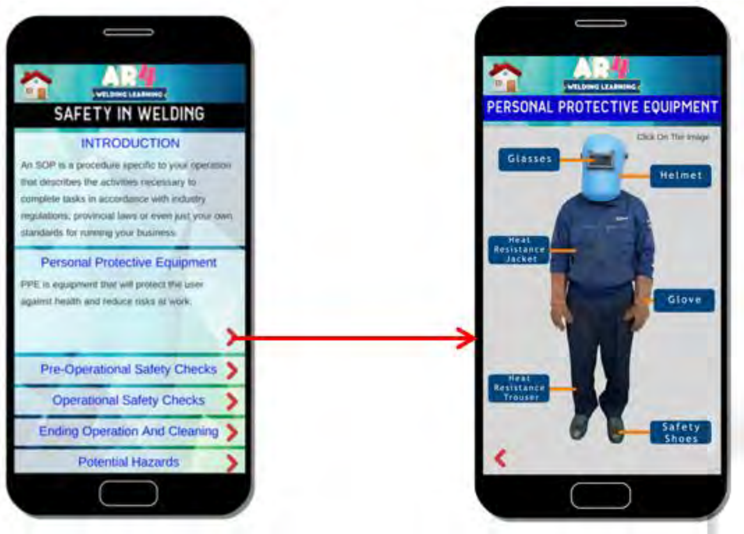

Figure 4.11. Personal Protective Equipment

Figure 4.12 shows the Pre-Operational Safety Checks where the page provides information pertaining to the guidelines the welders should follow before starting their welding works.

Figure 4.12. Pre-Operational Safety Checks

Figure 4.13 displays the Operational Safety Checks page which provides the guidelines what the welders should do while doing the welding works.

Figure 4.13. Operational Safety Checks

The Ending Operation and Cleaning navigates to the Ending Operation and Cleaning page which provides some guidelines of what the welders should do after they have finished their welding works as in Figure 4.14.

Figure 4.14. Ending Operation and Cleaning

The Potential Hazard interface provides information on the hazards that welders may face if they do not follow safety guidelines during welding as shown in Figure 4.15.

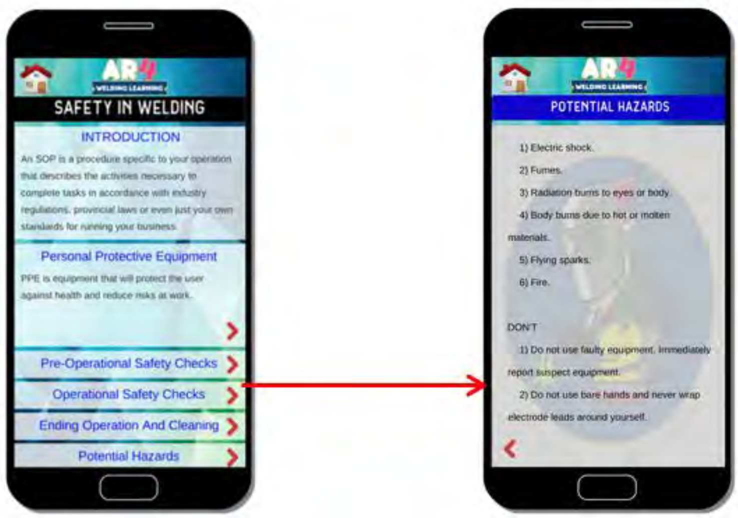

Figure 4.15. Potential Hazards

Furthermore, the Components of Welding in the main page navigates the user to a page containing components used in welding such as power supply, electrode holder and cables, welder protection, and tools as depicted in Figure 4.16. The image also acts as button where user can click to navigate to the Component in Welding page. Every interface in Component of Welding has button which is displayed on the top left enabling user to go to the home interface and back button at the bottom left to go back to the previous page. Figure 4.16 shows whenever the user clicks the Power Supply AC/DC button, a brief information about the power supply and its use will be displayed.

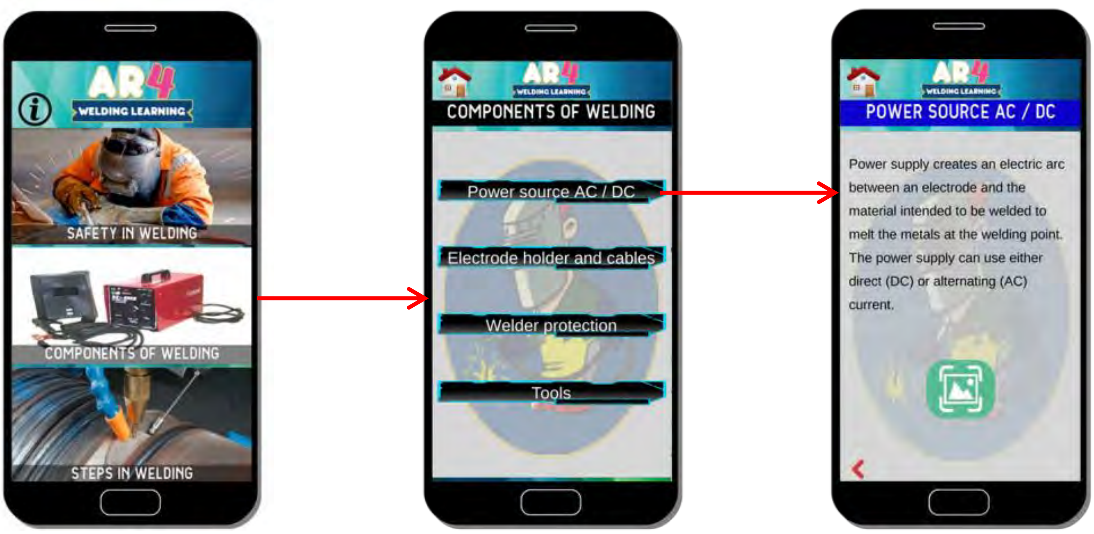

Figure 4.16. Components of Welding

Furthermore, the scan button allows the user to utilize the mobile phone camera to scan the specified marker and display the 3D item on the screen, as illustrated in Figure 4.17. By tilting and rotating the marker, the user can change the angle of view of the 3D object. This is one of the AR features that is implemented in the MAWL app.

Figure 4.17. AR feature in MAWL App

Meanwhile Figure 4.18 shows the interface for Steps in Welding. When the user clicks on this interface, it will open the Steps in Welding page consisting of 3 main buttons. The buttons include; Steps to be taken before start the welding, Steps in starting arc welding, and Welding Defect. When the 'Steps to be taken before start welding' is clicked, it opens the 'Steps to be taken before start' page which provides the steps that welders should follow before starting the welding work. The back button goes back to the Steps in Welding page and the image button shows the example of the image. The close button closes the picture and back button goes to the previous page.

Figure 4.18. Steps in Welding

Figure 4.19 shows steps in welding by showing various types of welding videos. Users have to click the green button to view then the video. Here users can experience the AR feature provided by the app for video viewing.

Figure 4.19. Types of Welding

If the user clicks on the Welding Defect's button as shown in Figure 4.20, the Welding Defects page will open which provides information of the common mistakes made by welders. Users can click the green button to display the image of the welding defect.

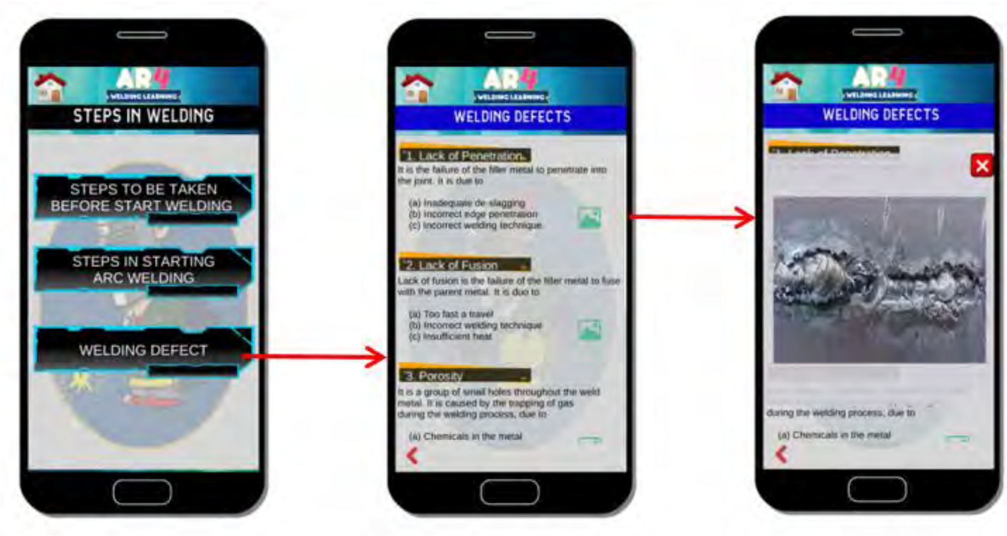

Figure 4.20. Steps in Welding pages

Lastly, Figure 4.21 shows the wireframe of the MAWL app. It depicts all of the app's interfaces and procedures for viewing the app's material, such as images, text, 3D models, and videos related to the welding process. It's also crucial to highlight the connections between the ARCS motivation model's elements (Attention, Relevance, Confidence, and Satisfaction), which were used to develop the MAWL app. As a result, the elements that were integrated in the MAWL app are discussed in the following section.

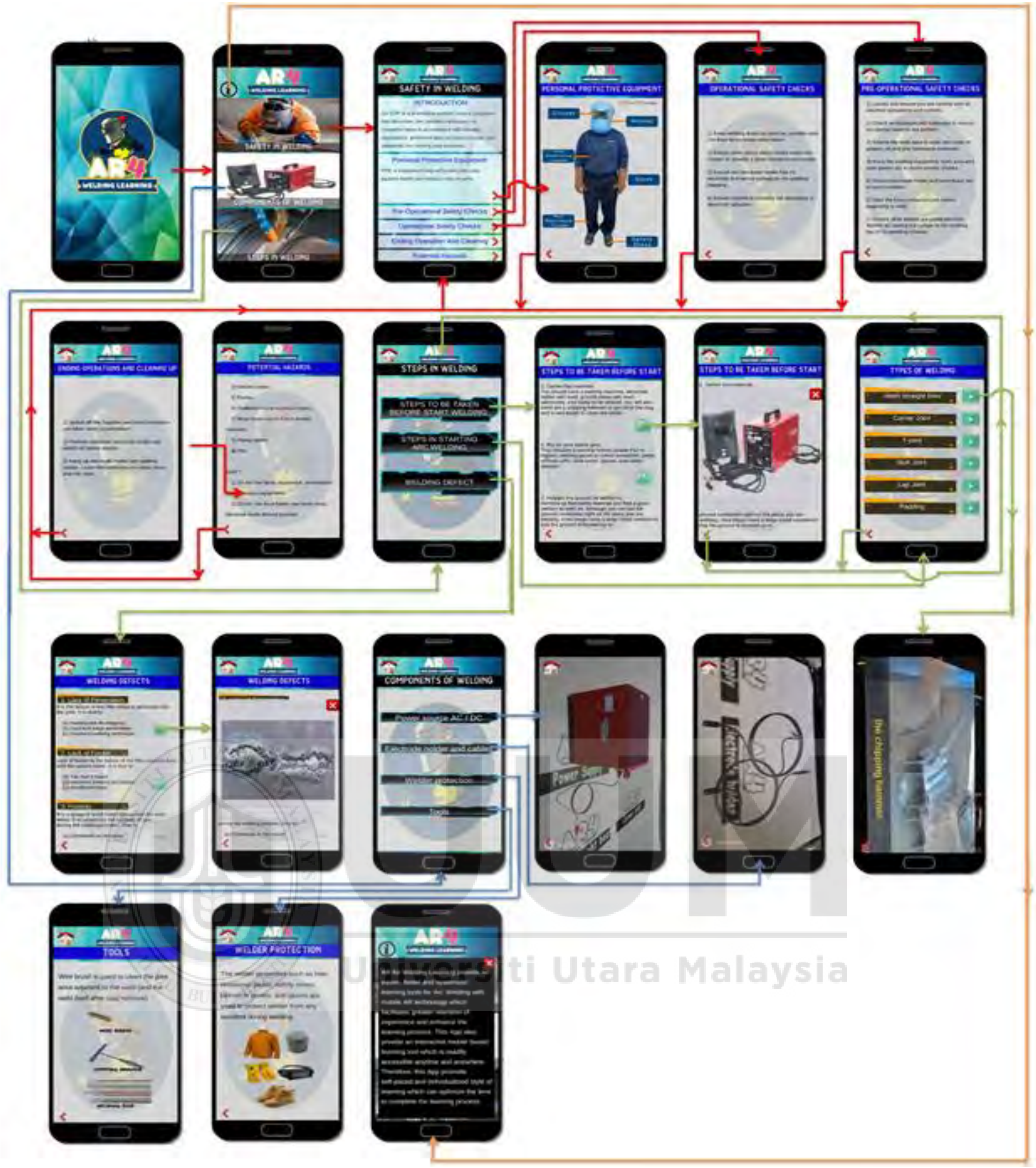

Figure 4.21. Full wireframe of MAWL app

4.6 Embedded elements in MAWL App

During the implementation phase, the MAWL app was designed to include all of the aspects necessary for welding learning. The constructivist theory and the attributes of the ARCS motivation model were also included into the app during development process.

4.6.1 Constructivist theory in MAWL App

Constructivist theory was used for the development of the MAWL app. By using this theory, learners can learn effectively with technology based learning (Karaduman & Gültekin, 2007). The students build their knowledge through the app and enhance positive outcomes in learning process by promoting active learning. Constructionism which a branch of Constructivist theory suggest that learner's knowledge and experience can be constructed through physical interaction within a real world which AR covers the physical and perceptual interactions also AR has the capabilities for constructivist learning (Sánchez et al., 1997). Hence, by using AR that are designed with constructivist theory could increase student's engagement and learning environment is more enjoyable and interactive. So, the AR mobile-based welding learning app which is MAWL app was developed in this study to enhance student learning performance. Furthermore, the MAWL app give positive effect to the learners during the learning process by using mobile app integrated with AR.

4.6.2 ARCS Motivation Model in MAWL App

The MAWL app contains virtual contents namely; texts, images, videos and 3D models. 3D models and video were coded into the AR marker where the users can view the content by using the mobile device's camera. The ARCS Model is a motivational strategy consisting of four factor namely; Attention (A), Relevance (R), Confidence (C) and Satisfaction (S). The ARCS Model was introduced by John Keller based on the theory of motivation (Keller, 1987). The ARCS Model is a formula to improve the motivational appeal of instructional materials. Thus, the ARCS Model has been incorporated into the MAWL app to increase the motivation of the student in welding learning. Each of the attributes is discussed in detail in the sub-sections that follow.

4.6.2.1 Attention

Attention is the first factor of the ARCS motivation model. According to Keller (2000), a lesson must attain attention from learners in order to engage their deeper level of curiosity by mentally stimulating problems. In attracting user's attention towards the app, a splash screen consisting of 2D animation and colorful background has been applied whenever the user starts the app as shown in Figure 4.22. Further, on the main page of the app, images were used for buttons to draw the attention of the user to the welding learning process.

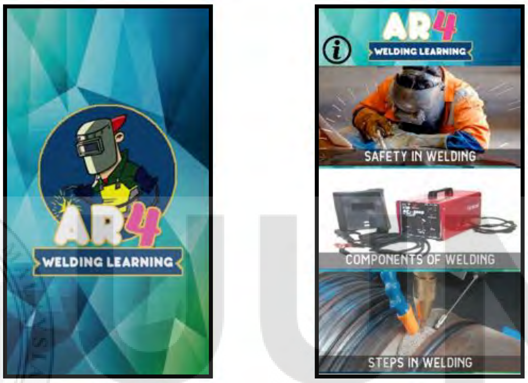

Figure 4.22. Attention factor applied in the design

4.6.2.2 Relevance

The second factor is Relevance. It is required to attain motivation so the content must have perceived value to the learners by keeping their curiosity aroused, and it is important to link instructional content to the learners' academic needs in order to maintain their interest (Keller, 2000). In the current study, the users were Mechanical Engineering students studying welding, so the content of the app is about welding learning where the welding subject is one of their core subjects. Figure 4.23 depicts Relevance in the MAWL app where it provided an active learning environment by maintaining the interactivity between user and the app. The user can choose any button of Components of Welding in order to continue with the learning. Component of

Welding page has AR function where the user able to view the 3D model of Power Source AC/DC, and Electrode holder and Cable. Moreover, the user can view the 3D model interactively by tilting and rotating the marker. On top of that, the user can also view the 2D image of Personal Protective Equipment and Tools.

Figure 4.23. Relevance factor applied in the design

4.6.2.3 Confidence

Confidence is the third factor of the ARCS motivation model. Confidence is needed to enable user to intrinsically motivate and acts independently without guidance from anyone (Gopalan et al., 2016a). Students who have little understanding of what they expect often have low confidence so in order to gain the confidence is by helping them to initiate positive expectancies for success (Keller, 2000). Welding learning using the MAWL app integrated with AR is intended to help students to be engaged and attentive throughout the learning process. Moreover, users can conduct self-learning independently without guidance from others through demonstrations shown in videos available in the app as shown in Figure 4.24. This type of learning, intrinsically motivates the students to learn and act independently during learning with confidence. Students are able to display strong performance in welding learning thanks to the experience and knowledge gained via the usage of the MAWL app, which may also aid to enhance their confidence and motivation.

Figure 4.24. Confidence factor applied in the design

4.6.2.4 Satisfaction

Lastly, Satisfaction is the fourth attribute of motivation required for learners to become intrinsically motivated to learn when they are attentive and interested in the learning content (Keller, 2000). Satisfaction is the good feeling about people's accomplishments and experience of learning (Keller, 2000). The level of satisfaction gained from using the MAWL app will encourage and intrinsically motivate users through the learning process by using the app several times until they get what they expected from learning. The knowledge gained through welding learning using the app could increase their learning performance which has been proven after the students took a welding quiz after using the app. Figures 4.24 shows the students taking a welding quiz one week after using MAWL app.

Figure 4.25(a) and Figure 4.25(b) Students taking a welding quiz

4.7 Summary

This chapter goes through the details of the MAWL app's development and how the ARCS attributes were used in the app. Additionally covered are the model components, theories, and contents that went into the creation of the MAWL app. Moreover, in order to provide an overview on how the app was implemented, the detail explanations of the MAWL app implementation have also been discussed.

CHAPTER FIVE

DATA ANALYSIS AND RESULTS

5.1 Overview

This chapter details all of the evaluation that was done with a group of Politeknik Tuanku Syed Sirajuddin (PTSS) semester 1 Mechanical Engineering students who were classed as an experimental group for this study, as well as experts. This study's evaluation is grouped into two: heuristic and user. With the use of the collected data, it was possible to determine how the students felt about using the MAWL app to learn welding as well as the link between the independent variables and the dependent variable. In this study the independent variables are Ease of Use, Engagement, Learnability, Satisfaction, and Usefulness, while Motivation is the dependent variable. The student's learning performance was assessed after they had used the MAWL app for welding learning.

The reliability of the questionnaire used in this study was determined through the Cronbach Alpha values of the attributes. Hypotheses were constructed and evaluated using regression analysis in order to discover the correlations between the independent and the dependent variables. The developed MAWL app was evaluated by experts through heuristic evaluation in order to minimize error within the app. Furthermore, descriptive statistics, correlation and regression analyses, and paired samples t-test were conducted. Statistical Package for Social Science (SPSS) version 22 was used to conducted the analysis. Lastly, at the end of this chapter, the summary of the data findings is presented.

5.2 Expert Evaluation

The researcher met the Head of Department of the Mechanical Engineering Department of PTSS in his office to brief about the research, the objective, as well as data collection intention. The researcher was then introduced to some lecturers, whom were content experts, to discuss the MAWL app's content. The lecturers were very corporative and very enthusiastic when it comes using mobile technology for welding learning. Furthermore, experts have been categorized into two; content expert and interface expert. Two PTSS Mechanical Engineering lecturers with experience teaching welding serve as content experts and they had examined the content of the MAWL app and were involved in this study from an early stage. While interface experts are two UUM lecturers with experience teaching and conducting research in the fields of augmented reality and multimedia. All of the experts have been teaching in their respective areas of specialization for at least three years. Before designing and developing the app and presenting it to the target users, content experts verified the suitability and validity of the contents. Meanwhile, the evaluation of the functionality and interface of the MAWL app were evaluated by the interface experts. In order to make sure that the application is error-free and functioning as it should, the feedback from expert is required to correct the errors. Table 5.1 shows the comments from two content experts and suggestions during the evaluation phase were combined in the table.

Table 5.1

Comments from content experts

No.	Content	Expert Comments	
		Problem	**Suggestion**
1.	Safety in Welding ▪ Types of Personal Protective Equipment (PPE)	▪ The arrangement of information just like from the book (not interesting for the app). ▪ No clear information of SOP (Safety Operation Procedure).	▪ Idea: Pictures and details is more appropriate with minimum text. ▪ Put SOP I. Pre-Operational II. Operational III. Post Operational ▪ Full picture or video of PPE outfit.
2.	Component of Arc Welding ▪ Power Source AC/DC ▪ Electrode Holder and Cables ▪ Welder Protection ▪ Tools	▪ The arrangement of information needs to be improved. ▪ Welder protection can be put on SOP only. ▪ Component's labelling and details can be improved.	▪ Schematic diagrams for welding machines can also be used as a clear picture to the user. ▪ Brief introduction to arc welding components.
3.	Steps in Arc Welding ▪ Steps to be taken before start welding ▪ Steps in starting welding ▪ Video	▪ Must put information about welding defect. ▪ App's user will get information about the quality of welding produced. ▪ The video is not clear and need to focus on arc welding technique.	▪ Just enough by putting the main type of defects while doing welding works. ▪ Cause of welding defect I. Current to high/low II. Arc length III. Speed of action

Table 5.2 shows the comments from the interface experts during the evaluation of the MAWL app. According to the experts, the elements are suitable for the MAWL app interface design.

Table 5.2

Evaluation of the MAWL App's interface

Interface (IN)		**Pick one**		**Comment**
		Yes	**No**	
IN1	The interface is clear, simple and easy to understand.	✓		Ok
IN2	The design's interface is attractive and interesting	✓		
IN3	The MAWL application is easy to use.	✓		Easy
IN4	The interface's colour scheme used is appropriate.	✓		
IN5	The interface's screen design has attractive display.	✓		
IN6	Appropriate image used for interface.	✓		Suitable homepage icon
IN7	Readable texts are used for the interface	✓		Suitable font and size
Multimedia (Image, Video, Text, and 3D model) (MM)		**Pick one**		**Comment**
		Yes	**No**	
MM1	Each multimedia elements used serves a clear purpose.	✓		Clear
MM2	The use of multimedia elements is suitable with the content.	✓		
MM3	The presentation of multimedia elements is well managed.	✓		
MM4	The use of multimedia elements supports meaningfully the information provided.	✓		Ok
MM5	The use of multimedia element's quality is good.	✓		
MM6	The use of multimedia elements intensifies the content presentation.	✓		
Interactivity (IV)		**Pick one**		**Comment**
		Yes	**No**	
IV1	The interactivity is easy to understand.	✓		
IV2	The interactivity is not misleading.	✓		Clear
IV3	The interactivity of MAWL is fun	✓		How to define fun?

Based on Table 5.1, there were some problems from the app which the experts pointed out in each contents of the MAWL app. The suggestions also were given by the experts for the improvement of the app. There were some improvements that have been made before conducted the app interface evaluation. The improvements that has been done based on the problems stated from the experts as their suggestion. The arrangement of the information for the contents was arranged with proper pictures and details with minimum text also make it more interesting to attract user in using the MAWL app. Then, the SOP of the welding was added under the content of Safety in Welding includes Pre-operational, Operational and Post- Operational of the welding were put on also the full picture of PPE outfit. Furthermore, at the Component of Arc Welding content, the component's labelling and details have been improved by putting the proper name or label to the 3D model of the component of welding. The user can view 3D model of welding's component interactively by tilting and rotating the marker and can read the brief introduction to arc welding components. In the Step in Arc Welding's content, the information includes the main type of welding defect, what cause of the welding defect and the quality of welding produced without defect was added in the MAWL app. Besides, the blurry video was changed to high quality video which focus on arc welding technique was added and the user can use the marker to play the video in the MAWL app. The improvements that has been made for the app is to provide better information for the student to learn efficiently and the MAWL app can be a useful supplementary tool for welding learning. After the conducted the content user evaluation, the expert evaluation was next as shown in Table 5.2. Before using the MAWL app during the user evaluation, relevant improvements to the app were made based on expert's feedback.

5.3 User Evaluation

For user evaluation, 67 semester 1 Mechanical Engineering students were chosen for this study. Since the researcher was unable to gather all of the students at one time for evaluation, the pre- and post-test had to be completed in accordance with the students' welding timetables, which took two weeks to finish the pre-test alone. The pre-test was the first to be conducted by providing the students a quiz consisting of 15 questions (see in Appendix B). The goal of the pre-test was to find out about the students' welding knowledge. Next, the developed app installation (APK) file was distributed among the students. They had one week to use the app after being instructed to install it on their smartphone. The students gathered to take the post-test, which was a 15-question quiz with the identical questions as the pre-test, after a week. The intention was to determine whether using the MAWL app for welding education improved students' learning outcomes.

5.3.1 Sample

There are about 67 students of semester 1 were chosen as the participant for this study. According to Coakes & Steed (2001), the number satisfies the minimal threshold for sample size, which is at least 30. The user evaluation for this study has been conducted in Politeknik Tuanku Syed Sirajuddin, Pauh, Perlis. The demographic data of the respondents is shown in Table 5.3. Males made up 31 of the respondents, while females made up 36. There were 64 Malays (95.5%), 1 Chinese (1.5%), and 2 Indians (3.0%) among the respondents. Only 3 (4.5%) respondents did not have mobile phone while 64 (95.5%) have mobile phone. With regard to knowledge about Augmented Reality (AR), 37 (55.2%) of the respondents know about AR while 30 (44.8%) did not know at all about AR. There are 33 (49.3%) of respondents used AR mobile application before while 34 (50.7%) did not have any experience with AR mobile application. Lastly, 58.2% of respondents which is 39 students had used mobile app about welding while 28 (41.8%) respondents did not.

Table 5.3

Demographic data of respondents

Respondent		Frequency	Percentage (%)
Gender			
1.	Male	31	46.3
2.	Female	36	53.7
Age			
1.	18	63	94.0
2.	19	3	4.5
3.	20	1	1.5
Race			
1.	Malay	64	95.5
2.	Chinese	1	3.0
3.	Indian	2	1.5
Availability of Mobile Phone			
1.	Yes	64	95.5
2.	No	3	4.5
Knowledge about AR			
1.	Yes	37	55.2
2.	No	30	44.8
Experience using AR Mobile			
1.	Yes	33	49.3
2.	No	34	50.7
Experience Learning Welding using Mobile			
1.	Yes	39	58.2
2.	No	28	41.8

5.3.2 The Questionnaire's Validity and Reliability

A 5-point Likert scale was applied for this study. The Likert scale was marked ranging from 1(strongly disagree) to 5(strongly agree). The questionnaire is made up of 6 attributes, namely; Ease of use, Engagement, Learnability, Satisfaction, Usefulness, and Motivation. To avoid bias and distortion, it is imperative to guarantee the questionnaire's reliability and validity. In this study, only content validity defined as how precisely the items' content captures the entirety of all pertinent objects under investigation was considered (Blumberg et al., 2014). This is because all of the items of the questionnaire were adapted from previous studies and deemed valid. Meanwhile, a reliability test was conducted to determine the usability and internal uniformity of the attributes. Cronbach Alpha should have a minimum value of 0.7. (Hair et al., 2006;

Nunnally, 1978). The Cronbach alpha values were determined using SPSS 22 to examine the association between several attributes. The Cronbach alpha values for all attributes from the reliability evaluation among 67 respondents are shown in Table 5.4.

Table 5.4

Cronbach Alpha values for all attributes

Attribute	**Number of Items**	**Cronbach Alpha ±**
Ease of Use	6	0.853
Engagement	4	0.829
Learnability	4	0.852
Satisfaction	5	0.898
Usefulness	6	0.872
Motivation	6	0.877

All of the attributes and items are strongly interconnected and reliable, whereby the values of Cronbach alpha are between 0.8 to 0.9 and larger than 0.7 (Nunnally, 1978). The Cronbach alpha for Motivation is 0.877, ease of use is 0.853, engagement is 0.829, learnability is 0.852, satisfaction is 0.898 and usefulness is 0.872. In conclusion, all the attributes are reliable and strongly interconnected.

5.3.3 Descriptive Statistics

The mean and standard deviation for each attribute were derived using descriptive statistics. The purpose is to understand the perceptions of users and in this case the students toward the use of the MAWL app. Table 5.6 shows the descriptive statistics for all the attributes and items.

Table 5.5

Descriptive Statistics for all attributes

Attributes and Items	Mean	SD
Ease of Use	**4.03**	
MAWL was easy to use individually	4.09	0.596
MAWL was suitable for learning about welding	4.13	0.600
MAWL was suitable as a revision tool for welding	4.10	0.606
Augmented Reality was suitable for personal use	3.87	0.694
Steps in using MAWL were easy to remember	3.93	0.611
Augmented Reality has made revision for welding easy	4.06	0.672
Engagement	**3.93**	
MAWL attracted me to study welding for a long time	3.96	0.706
MAWL allowed me to review the welding repeatedly	4.09	0.668
MAWL made me to study welding for a long time	3.73	0.898
Mobile Augmented Reality increased my involvement in welding learning	3.93	0.681
I was satisfied with the overall effectiveness of learning	3.94	0.672
Usefulness	4.03	
The use of MAWL allowed me to finish welding learning faster	4.01	0.663
The use of MAWL could improve my learning performance	4.01	0.590
The use of MAWL in welding learning could increase my productivity	4.07	0.586
The use of MAWL could improve the effectiveness of welding learning	4.00	0.651
The use of MAWL made my learning easier	3.99	0.663
I like to learn welding using MAWL	4.09	0.543
Motivation	**4.01**	
MAWL was easy to use	4.09	0.596
MAWL enhanced my involvement in welding learning	4.10	0.554
I enjoyed the welding learning for a long time	3.93	0.659
Welding learning becomes more fun by using MAWL	3.96	0.684
MAWL enhanced my motivation to achieve excellence in welding learning	4.00	0.674
MAWL encouraged me to pursue higher education and careers related to welding in the future	4.01	0.685

The means for each attribute and item were calculated using a 5-point Likert scale as a base. Nevertheless, as proposed by Qasim et al. (2018), numerical scales are typically employed in place of the Likert scale to gauge users' levels of agreement or disagreement with the statements that are being presented. A numerical scale is based on calculating the distance between a set of positions, with each position having to fall into one of four directional categories—strongly disagree, disagree, strongly agree, and agree—instead of a neutral position. As a result, by solving the mathematical equation as follows, the interval range of Likert scales was determined.

RS = (m - n) / b

Whereby;

RS = Score range

m = highest score on scale

n = lowest score on scale

b = number of classifications

RS = (5-1)/4 = 1

As stated in Table 5.7, a numerical scale with the following anchors was used: 1 to 1.99 for strongly disagree, 2 to 2.99 for disagree, 3 to 3.99 for agree, and 4 to 5 for strongly agree. According to the results of the descriptive statistics analysis, the mean score for ease of use is 4.03 (strongly agree), engagement is 3.93 (agree), learnability is 4.07 (strongly agree), satisfaction is 4.05 (strongly agree), usefulness is 4.03 (strongly agree), and motivation is 4.01 (strongly agree) based on numerical scale. The results revealed that the participants only agreed on engagement, but they strongly agreed on learnability, satisfaction, usefulness, and motivation. The mean score for learnability is 4.07, while the mean score for engagement is 3.93.

Table 5.6

Category of Rating for Numerical Scale

Category	Rating Scale
Strongly Disagree	1 – 1.99
Disagree	2 – 2.99
Agree	3 – 3.99
Strongly Agree	4 – 5

5.4 Correlation Study

Correlation analysis was applied to ascertain how the independent and dependent variables are related. Correlation analysis was conducted using SPSS Version 22. (Pallant, 2013) distinguishes between two types of correlation: bivariate and partial. Bivariate offers the mean of two variables, while partial provides a link between two variables while controlling another variable. For this study, Pearson correlation analysis was used to determine the relationship and strength of the variables. Pearson correlation coefficients ranging from -1 to +1 are ideal values (Pallant, 2013). A linear relationship's strength is determined by the correlation coefficient as depicted in Table 5.8.

Table 5.7

Correlation Coefficient vs Strength of Linear Relationship

Correlation Coefficient	Strength of Linear Relationship
0.70 and above	Very Strong
0.50 – 0.69	Strong
0.30 – 0.49	Medium
0.10 – 0.29	Weak
0.01 – 0.09	Not Exist

The Pearson correlation coefficient (r) for all variables are shown in Table 5.9. First and foremost, the dependent variable and the independent variables are significantly and positively correlated. The correlation for Ease of use is .648, Engagement is .688, Learnability is .687, Satisfaction is .767 and Usefulness is .822. Each variable's correlations are significant at the 0.01 level, showing that they are all highly correlated to Motivation. Ease of use is significantly and positively correlated with Engagement, Learnability, Satisfaction, and Usefulness, with correlation values of .677, .779, .645, and .729 respectively. Learnability, Satisfaction, and Usefulness all have positive correlations with Engagement and Usefulness, with correlation values of .652, .649, and .662, respectively, and are significant at the 0.01 level. Learnability has positive correlations with Satisfaction and Usefulness, with correlation values of .743 and .739, respectively, and are significant at the 0.01 level. Finally, Usefulness is positively correlated to Satisfaction, with a correlation value of .777 and significance at the 0.01 level.

Table 5.8

Pearson Correlation Coefficient

Variables	**Motivation**	**Ease of use**	**Engagement**	**Learnability**	**Satisfaction**	**Usefulness**
Motivation	1					
Ease of use	.648**	1				
Engagement	.688**	.677**	1			
Learnability	.687**	.779**	.652**	1		
Satisfaction	.767**	.645**	.649**	.743**	1	
Usefulness	.822**	.729**	.662**	.739**	.777*	1

5.5 Regression Analysis

The study's independent and dependent variables are compared in order to assess the relationships between them, and hypotheses are tested as a result of this analysis (Gopalan et al., 2015). The results of the regression analysis are shown in Table 5.10. As a result of the MAWL app's intervention, students' motivation to learn welding has changed, as indicated by the R^2 value of 0.738. The independent variables in this study are the predictors in the analysis which include Ease of Use, Engagement, Learnability, Satisfaction and Usefulness. In verifying the hypotheses, a one-tailed test was employed to determine the association between the variables. According to Cohen (2008), the t-value must be greater than 1.645 and the p-value must be less than 0.05 or 0.01 in order to be considered significant. The F-ration in the ANOVA table is used to determine if the entire regression model fits the data or not. The regression model was found to fit the data since F (5.61) = 34.279 which indicates that the dependent variable was statistically significantly predicted by the independent variables.

Table 5.9

Regression Analysis

Variable	Beta	Std. Error	t-value	Sig (p-value)
Ease of Use	0.037	0.123	0.300	0.766
Engagement	0.167	0.082	2.043	0.045*
Learnability	0.031	0.129	0.243	0.809
Satisfaction	0.241	0.112	2.153	0.035*
Usefulness	0.525	0.127	4.135	0.00**

**Significance level; $p < 0.01$

* Significance level; $p < 0.05$

Dependent Variable: Motivation

N=67; R Square, 0.738; Adjusted R Square, 0.716; F (5.61) 34.279

As the results based on Table 5.10 shown that Engagement, Satisfaction and Usefulness are significant with Motivation which the p-value for Engagement and Satisfaction were less than 0.05 while Usefulness was less than 0.01 and all their t-values were greater than 1.645. However, Ease of use and Learnability are not significant with Motivation because the p-values were higher than 0.05 and the t-values also lower than 1.645.

5.6 Learning performance study

The MAWL app for welding learning was used to conduct a pre- and post-test to assess the student's learning performance. Pre-test was conducted prior to the students being introduced to the MAWL app in order to test their background knowledge pertaining to welding. The students were given a quiz consisting of 15 multiple-choice questions (see Appendix B) and allowed 20 minutes to answer the questions. The MAWL app was then given to the students to use for a week. Then, the same set of 15 multiple-choice questions for the post-test was given out to the students after a week for the post-test. Students' performance in answering quiz questions before and after the intervention was assessed. Interpretation related to the pre- and post-test differences must be made with caution as the researcher need to ensure that the differences are only related to the MAWL app intervention. Altogether, 67 students were participated in the both tests. The snapshot of both tests is listed in Appendix D. A paired sample t-test was used to evaluate the group's learning performance. Students are all from semester one and in the same course which is Mechanical Engineering. All the students were learning welding in the class and workshop.

Table 5.10

Pre- and Post-test Learning Performance

Evaluation Type	Mean	Number of Respondents	Std. dev.	Std. Error Mean
Pre-Test	9.07	67	1.550	.189
Post-Test	9.76	67	1.508	.184

Tables 5.11 show the results of students' learning performances for pre- and post-test. Pre-test mean represents the mean score during pre-test whereby background knowledge of students was assessed. While post-test mean represents the mean score during post-test whereby knowledge of students was assessed after using the MAWL app. The mean score for the pre-test was 9.07, increase to 9.76 for the post-test. As a result, the pre- and post-test learning performance mean scores were significantly different which is mean there is differences between the student's learning performance.

Table 5.11

Pre- and Post-test Paired sample t-test

Learning Evaluation	Paired Difference					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Dev.	Std. Error Mean
				Lower	Upper			
Pre-test and Post-test	-.687	1.777	.217	-1.120	-.253	-3.162	66	.002

The results of the paired sample t-test for the pre- and post-tests of the learning performance study are shown in Table 5.12. The mean of both pre-test and post-test is

0.687 with t-value's mean is 3.162 and the significance value is 0.02 which is significant at 0.05 and 0.01. Hence, the results of the pre-test and post-test proved that the use of the MAWL app for welding learning was able to increase student's motivation and improve the learning performance of the student.

5.7 Testing of Hypotheses

The finding of the analyses of null hypotheses and alternative hypotheses are presented in this section. The null hypothesis and alternative hypotheses as stated in Chapter 1 as follows:

Hypothesis$_{01}$: There is no significant positive relationship between ease of use and motivation.

Hypothesis$_{a1}$: There is a significant positive relationship between ease of use and motivation.

Hypothesis$_{02}$: There is no significant positive relationship between engagement and motivation.

Hypothesis$_{a2}$: There is a significant positive relationship between engagement and motivation.

Hypothesis$_{03}$: There is no significant positive relationship between learnability and motivation.

Hypothesis$_{a3}$: There is a significant positive relationship between learnability and motivation.

Hypothesis$_{04}$: There is no significant positive relationship between satisfaction and motivation.

Hypothesis$_{a4}$: There is a significant positive relationship between satisfaction and motivation.

Hypothesis$_{05}$: There is no significant positive relationship between usefulness and motivation.

Hypothesis$_{a5}$: There is a significant positive relationship between usefulness and motivation.

Hypothesis$_{06}$: There is no substantial difference in the students' learning performance.

Hypothesis$_{a6}$: There is a substantial difference in the students' learning performance.

5.7.1 Testing Hypothesis$_1$

Hypothesis$_{01}$: There is no significant positive relationship between ease of use and Motivation.

Hypothesis$_{a1}$: There is a significant positive relationship between ease of use and motivation.

Since the significance value is higher than 0.05, the study fails to reject the null hypothesis (H_0). Therefore, the H_0 is accepted. As a result, there is no significant relationship between the MAWL app's ease of use and motivation.

5.7.2 Testing $Hypothesis_2$

Hypothesis$_{02}$: There is no significant positive relationship between engagement and motivation.

Hypothesis$_{a2}$: There is a significant positive relationship between engagement and motivation.

Since the significance value is less than 0.05, the study succeeds in rejecting the null hypothesis (H_0). Therefore, the H_0 is not accepted. As a result, there is a significant relationship between the MAWL app's engagement and motivation.

5.7.3 Testing $Hypothesis_3$

Hypothesis$_{03}$: There is no significant positive relationship between learnability and motivation.

Hypothesis$_{a3}$: There is a significant positive relationship between learnability and motivation.

Since the significance value is higher than 0.05, the study fails to reject the null hypothesis (H_0). Therefore, the H_0 is accepted. As a result, there is no significant relationship between the MAWL app's learnability and motivation.

5.7.4 Testing $Hypothesis_4$

Hypothesis$_{04}$: There is no significant positive relationship between satisfaction and motivation.

Hypothesis$_{a4}$: There is a significant positive relationship between satisfaction and motivation.

Since the significance value is less than 0.05, the study succeeds in rejecting the null hypothesis (H_0). Therefore, the H_0 is not accepted. As a result, there is a significant relationship between the MAWL app's satisfaction and motivation.

5.7.5 Testing Hypothesis$_5$

Hypothesis$_{05}$: There is no significant positive relationship between usefulness and motivation.

Hypothesis$_{a5}$: There is a significant positive relationship between usefulness and motivation.

Since the significance value is less than 0.05, the study succeeds in rejecting the null hypothesis (H_0). Therefore, the H_0 is not accepted. As a result, there is a significant relationship between the MAWL app's usefulness and motivation.

5.7.6 Testing Hypothesis$_6$

Hypothesis$_{06}$: There is no substantial difference in the students' learning performance.

Hypothesis$_{a6}$: There is a substantial difference in the students' learning performance.

Since the significance value is less than 0.05, the study succeeds in rejecting the null hypothesis (H_0). Therefore, the H_0 is not accepted. As a result, there is a substantial difference in the students' learning performance. Table 5.13 summarizes the results of the hypotheses testing.

Table 5.12

Summary of Hypotheses testing results

Hypotheses	Variable	Results
H_{01}	There is no significant positive relationship between Ease of use and motivation in the MAWL prototype.	Null hypothesis is accepted
H_{02}	There is no significant positive relationship between Engagement and motivation in the MAWL prototype.	Null hypothesis is not accepted
H_{03}	There is no significant positive relationship between Learnability and motivation in the MAWL prototype.	Null hypothesis is accepted
H_{04}	There is no significant positive relationship between Satisfaction and motivation in the MAWL prototype.	Null hypothesis is not accepted
H_{05}	There is no significant positive relationship between Usefulness and motivation in the MAWL prototype.	Null hypothesis is not accepted
H_{06}	There is no substantial difference in the students' learning performance between the pre- and post-test mean scores.	Null hypothesis is not accepted

5.8 Comparison between previous findings and findings of this study

There are five attributes used in this study that are able to influence students' motivation in welding learning namely; ease of use, engagement, learnability, satisfaction and usefulness. Experts in the respective fields proposed and evaluated the attributes. The results provide support for engagement, satisfaction and usefulness which are positively and statistically significant to motivation. Ease of use and learnability, on the other hand, do not correlate with motivation in a statistically meaningful way.

Based on previous evaluation results, these findings are consistent with Fabian et al. (2016) where mobile learning promotes learning and was able to increase students' engagement while their task engagement also increases when they can control their learning activities (Ciampa, 2014; Poitras et al., 2013). Pribeanu (2014) proved mobile learning that incorporates with AR was able to provide engagement to students that contribute to their motivation. Furthermore, AR combined with multimedia-based learning was able to keep students engaged (Gopalan et al., 2016b; Pribeanu, 2014; Rasalingam et al., 2014). Mobile learning promotes successful learning and enhance student's satisfaction with positive attitudes (Alqahtani & Mohammad, 2015) and increase their motivation using mobile learning application incorporates with AR (Chen, 2019; Chiang et al., 2014; Khan et al., 2019). In addition, students learning by using mobile application was able to help students to achieve learning benefits (Jou et al., 2016) and ready to adopt it in their learning when the mobile learning is useful (Nikou & Economides, 2016). Mobile AR facilitates learning is highly useful in higher education contexts (Chen, 2019; Mejías Borrero & Andújar Márquez, 2012). It is also proven that usefulness of the mobile AR could motivate student in mobile learning (Pribeanu, 2012). Meanwhile, using mobile applications that feature AR may not be as easy to use as it appears, because novice AR users must adjust to a new learning environment and become familiar with it (Balog & Pribeanu, 2010; Gopalan et al., 2016a; Pribeanu, 2012). The user needs more times to understand the learning task and develop epistemic skills to employ AR in a way to achieved the learning goals (Alalwan et al., 2020). Previous studies by Chen et al. (2017) and Ahmad Zaki et al. (2018) found that students give positive response to learnability of mobile AR but for this study learnability is not significant with motivation. This most likely results from some technical issues with the software and hardware that the students were experiencing. The issues include; slow internet connection and data connection and also compatibility of the students' mobile phone for installing the MAWL app that contribute to the lack of learnability in using AR-based mobile learning.

5.9 Summary

The evaluation aims to ensure that the proposed MAWL app could improve students' welding learning performance and motivation. Several statistical analyses were performed to verify the study statistically, including descriptive statistics, Pearson correlation, regression, and paired sample t-test. The results statistically demonstrate that the MAWL app may motivate students and enhance their performance in welding learning. This study found that the MAWL app can be used as a supplement to the traditional welding learning methods in motivating and improving the student's learning performance. The study's objectives were achieved as a result of the findings.

CHAPTER SIX

CONCLUSION

6.1 Overview

Chapter 6 summarizes the general conclusions of this study. It elaborates on the objectives that have been achieved, the contribution to the body of knowledge, some useful insights towards welding learning, limitations and recommendations for future development of AR mobile-based welding learning app in particular and other relevant subjects in general. The following sub-sections go over the entire study in detail.

6.2 Research Discussion

The main aim of this study is to design and develop an AR-enabled mobile app for welding learning. This app was developed for PTSS Mechanical Engineering students with the purpose of providing supplementary learning materials aimed at motivating the students. The development process was followed by the evaluation which utilizes analyses which include; descriptive statistics, Pearson correlation, regression, and paired sample t-test. This study proposed an app consisting of motivation theory and components that can motivate students in welding learning. Descriptive statistics determined the students' perceptions based on all the attributes used in this study. Each independent variable's relationship to the dependent variable was established using Pearson correlation. While to test the hypotheses, regression analysis was used. Finally, paired sample t-test was applied to determine the significant difference between pre-test and post-test mean scores in the learning performance study. The results for descriptive statistics, Pearson correlation, regression, and paired sample t-test are available in Chapter Five.

The following objectives were set forth for this study.

i. What are the AR attributes for learning for the AR mobile-based welding learning app?

ii. How should the AR attributes for learning be applied in the AR mobile-based welding learning app?

iii. What is the relationship between the AR attributes for learning and motivation in using the AR mobile-based welding learning app among the students?

iv. What is the learning performance of the students in relation to the intervention of the Mobile Arc Welding Learning (MAWL) app for welding learning?

In order to achieve those objectives, four research questions were developed as shown below.

i. To identify the AR attributes for learning for the AR mobile-based welding learning app.

ii. To design and construct the AR mobile-based welding learning app.

iii. To determine the relationship between the attributes of AR for learning and motivation among the students.

iv. To assess students' learning performance when using the AR mobile-based welding learning app.

This study was proposed based on ARCS motivation model and constructivist learning theory, as well as the construction of the MAWL app that combines AR, as presented in Chapter 1. All those components were applied in the design and development of the MAWL app. Furthermore, to determine the students' response towards the use of MAWL app in welding learning, a perception study was conducted. Then the relationships between each of the attributes of AR and motivation were determined through Pearson correlation. Next, regression analysis was applied to determine the significant of the relationships for the purpose of hypotheses testing. Finally, paired sample t-test was conducted to determine the significant difference between pre-test and post-test mean scores for the leaning performance study.

6.2.1 Identifying AR Attributes

Literature review on previous studies related to AR was conducted in identifying the AR attributes. Table 2.4 shows the previous research works related to AR that have been reviewed and Table 2.3 shows the attributes of AR that have been reviewed. Based on this information, the researcher has selected Ease of Use, Engagement, Learnability, Satisfaction and Usefulness (independent variables) and Motivation (dependent variable) as attributes used during the evaluation phase. The definition of each of these attributes can be referred to in sub-section 2.6.2 of Chapter 2. Once all the attributes of AR have been identified, the first objective of this research has been fulfilled.

6.2.2 Designing and Developing the MAWL App

From the results of the preliminary study, supplementary material for welding learning is needed by the students. Consequently, the study suggested the MAWL app as a supplementary learning tool for welding which incorporates with AR technology. There are two phases in the app development, gathering and creation of contents and development and integration of the app to the mobile device. The software used in the development process include; Adobe Premiere CS6, Adobe Photoshop CS6, 3DS Max 2012, Vuforia, and Unity3D. Furthermore, Constructivist theory are used by using AR technology to develop the MAWL app which can enhance student's learning performance and increase their motivation in welding learning. All attributes of the ARCS motivation model namely; Attention (A), Relevance (R), Confidence (C) and Satisfaction (S) were also included into the app since this model is a motivational strategy to improve the motivational appeal of instructional materials so that the students could be motivated in welding learning. For more information on MAWL app development can be referred to Chapter 4. By successfully developing the MAWL app, the second objective of this research has been fulfilled.

6.2.3 Evaluation of MAWL App

The evaluation was conducted aim to achieve the third and fourth objectives of the research. The evaluation phase started with the heuristic evaluation. There were two types of experts involved: content and interface. The consistency of the MAWL app's content was overseen by two content experts. Two lecturers from PTSS who are knowledgeable with teaching and training in the field of welding make up the study's content experts. Meanwhile two interface experts comprising of UUM lecturers were responsible to evaluated the functionality and interface of the app before introducing to the users. They were also responsible in ensuring that the MAWL app's interfaces function as intended. Next, user evaluation was conducted among 67 semester 1 Mechanical Engineering students of PTSS. The age of the participants ranged from 18 to 20 years old. The selection of the samples in this study was based on purposive sampling technique. Before introducing the students to the app, pre-test was conducted whereby the students had to answer a 15 multiple-choice questions quiz. The pre-test is intended to ascertain the students' understanding of welding. The students were then given the MAWL app's APK file so they could install it and use it to learn welding on their individual smartphones for a week. After a week, students were given the same 15 multiple-choice questions quiz for the post-test. All of the students were given a set of questionnaires to fill out in order to assess their perceptions about using the MAWL app. The questionnaires consist of all the attributes and items for Ease of Use, Engagement, Learnability, Satisfaction, Usefulness, and Motivation. Furthermore, the reasons why giving the students the same quiz questions was because to prevent them from remembering quiz questions so that their learning performance can be assessed. Once all the data has been gathered and tabulated, reliability, descriptive statistics, Pearson correlation, regression, and paired sample t-test analyses were conducted using SPSS version 22. The reliability test is intended to determine the attributes' internal consistency. The Cronbach alpha values for Motivation is 0.877 while Ease of Use (0.853), Engagement (0.829), Learnability (0.852), Satisfaction (0.898) and Usefulness (0.872). All of the attributes were regarded as reliable because their Cronbach Alpha values were greater than 0.7. The mean and standard deviation for each attribute and item were determined using descriptive statistics. According to the results, the students only agreed on engagement, but they strongly agreed on other variables such as learnability, satisfaction, usefulness, and motivation. The mean score for learnability is the highest at 4.07, while the mean score for engagement is the lowest at 3.93.

In achieving the third objective, Pearson correlation and regression analyses were conducted. The correlation coefficient for Ease of use is .648, Engagement is .69,88 Learnability is .687, Satisfaction is .767 and Usefulness is .822. Each variable's correlations are significant at the.01 level, showing that they are all highly correlated with Motivation. The variables have a positive relationship with motivation where the significant levels ($p < 0.01$ and $p < 0.05$). The table of Pearson Correlation Coefficient analysis can be referred to Table 5.9.

The regression analysis was used to estimate the associations between the independent and dependent variables by testing the hypotheses to determine whether they should be accepted or rejected. For the regression analysis, as referred to Table 5.10 shows the regression analysis results where Engagement, Satisfaction and Usefulness have significant values of less than 0.05. However, Ease of use and Learnability have significant values of greater than 0.05. There is no significant correlation between Ease of use and motivation and this is similar to the findings by Pribeanu (2012) and Gopalan et al., (2016a). Pribeanu (2012) stated that AR concept may cause some usability problems because of its standalone application. The usability problems from the app such as ease of use, how to learn through it, and exhaustion (Pribeanu, 2012). Learnability is also not significant to motivation because there are some technical issues faced by the students in terms of software and hardware. The issues include; slow internet connection and data connection and also compatibility of the students' mobile phone for installing the MAWL app that contribute to the lack of learnability in using AR-based mobile learning.

For the learning performance study, the same 15 multiple-choice questions quiz was utilized during the Pre- and Post-test. Pre-test was intended to test students' background knowledge pertaining to welding and Post-test was intended to test students' welding knowledge gained after using the app. Pre-test mean was 9.07 and post-test mean was 9.76 indicating that there was a slight increase in mean. To test whether the difference was significant or not, paired sample t-test was performed and the results as shown in Table 5.12 show that the significant value is 0.02 which is smaller than 0.05. As a result, there is a significant difference in the pre- and post-test learning performance thus, achieving the fourth research objective. The use of MAWL app for welding learning can improve students' learning performance.

The hypotheses testing results are shown in Table 5.13 whereby four of the null hypotheses (H_{02}, H_{04}, H_{05}, and H_{06}) were not supported and two of the null hypotheses (H_{01} and H_{03}) were supported. There were significant relationships between engagement, satisfaction and usefulness and motivation in using the MAWL app. The difference in the students' pre- and post-test mean scores of the learning performance is also significant. Ease of use, and learnability no significant relationships with motivation.

6.3 Research Contributions

This study contributes to the body of knowledge mentioned in the next sections.

6.3.1 Mobile Arc Welding Learning (MAWL) App

The MAWL app is the study's key contribution. The app was developed using Unity3D and Vuforia. As mentioned, the purpose of the MAWL app is to motivate students in welding learning. Based on the results of the evaluation, this app could help in improving learning performance of the student and motivate them in welding learning. The MAWL app is a useful supplementary learning tool for mechanical engineering students, especially for welding subjects. In conclusion, the MAWL app has proven to be a helpful learning tool and effective for welding learning and is suitable for use as a supplementary learning tool other than the conventional learning method.

6.3.2 Results from students' motivation on using MAWL App

The second contributions to the body of knowledge are the findings from the user evaluation, which include; user perception study, correlation, regression, and learning performance study. The results of the perception study indicate that the students strongly agreed on ease of use, learnability, satisfaction, usefulness and motivation and only agreed on engagement of the MAWL app. The results of the regression indicate that the relationships between engagement, satisfaction and usefulness and motivation are significant and there are no significant relationships between ease of use and learnability and motivation in using the MAWL app. Finally, there is a significant difference in the pre- and post-test mean scores of the learning performance which means that by using the MAWL app, the students were able to increase their learning performance. Refer to Appendix E for the MAWL app screenshots.

6.4 Research Limitations

While conducting this research, there are some limitations that need to be overcome by the researcher and they are explained briefly as follows:

i. Although there are many different types of welding, the information provided in the MAWL app is only about arc welding. For arc welding only, the information that needs to be provided is quite a lot and it was obtained through the internet, books, and also from experts.

ii. The MAWL app was developed for the Android mobile platform. The constraint that arose was that some of the students involved in this study could not access the app because they were using mobile phones that were not the Android platform. In addition, the MAWL app needs to be installed on a high-capacity mobile phone for it to function properly and smoothly.

iii. Another problem faced by the students was related to the internet connection being too slow for the WiFi and also data. Moreover, some students did not use their mobile data to download the MAWL app because the APK file is large. Furthermore, the researcher was unable to provide students with access to the app via USB because the evaluation venue was in their workshop where computers and laptops were not permissible.

iv. The main problem faced during the evaluation process was the difficulty to gather all the students at one time. So, the evaluation had to be conducted following the students' welding class schedule which took two weeks to complete the pre-test and another two weeks for the post-test. In addition, the evaluation could only be conducted in the workshop where the welding training was done.

6.5 Future Recommendations

Several issues were highlighted in this study. It is recommended that user evaluation be extended so that students can resolve problems that they encountered while installing the APK file to their mobile devices. More time is recommended so that students can better understand the app as a new learning tool for welding. Since mobile learning is relatively new for students, giving more time for them hopefully this app is easy to use for students and enhances their learnability. Finally, future research needs to develop MAWL app for other platforms such as iOS, Symbian, and Windows phone OS. This is to enable more users to be able to use the MAWL app. In addition, to achieve better results, a conducive, suitable, and comfortable place should be considered for conducting user evaluation.

6.6 Summary of the Discussion and Conclusion

In achieving the objectives as stated in Chapter 1, this study was conducted. The MAWL app was designed and developed to supplement students' welding learning. In addition, the app can motivate students and help them enhance their welding learning performance. Through this research, the MAWL app was developed using theories related to motivation and learning. Overall, the results of the evaluation from the user in this study indicated that the students strongly agreed on ease of use, learnability, satisfaction, usefulness and motivation and only agreed on engagement. Based on the findings, the relationships between engagement, satisfaction and usefulness with motivation are significant in using the MAWL app. However, Ease of Use and Learnability have no significant relationships with motivation in using the MAWL app. In addition, it has also been proven that the use of MAWL app could improve the students' learning performance in welding learning.

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APPENDIX A

Preliminary Study Questionnaires

UNIVERSITI UTARA MALAYSIA

KOLEJ SASTERA DAN SAINS

06010 SINTOK KEDAH DARUL AMAN

PENYELIDIKAN

Penggunaan Pembelajaran Kimpalan Arka Mudah Alih (MAWL)
Mobile Arc Welding Learning (MAWL)

Assalamualaikum dan salam sejahtera pelajar yang saya hormati,
Saya adalah pelajar Universiti Utara Malaysia dan kini sedang melanjutkan pengajian di peringkat Sarjana Sains (Pengajian Multimedia) melalui Penyelidikan. Saya dikehendaki menjalankan kajian awal di kalangan pelajar Kejuruteraan Mekanikal dari Politeknik Tunku Syed Sirajuddin untuk mengenal pasti isu-isu yang berkaitan dengan pendekatan pembelajaran kimpalan sedia ada di PTSS. Semua maklumat dari kajian ini akan digunakan hanya untuk tujuan akademik semata-mata. Kerjasama anda amat dihargai.

Terima kasih.
Farhatun Najwa Binti Rusli (821854)

BAHAGIAN A:

MAKLUMAT PERIBADI

Jawab soalan berikut dengan menandakan (√) didalam kotak dan juga menulis jawapan diruang yang disediakan.

1. Jantina: ☐ Lelaki
   ☐ Perempuan

2. Umur: ____ tahun

3. Bangsa:
   ☐ Melayu ☐ Cina
   ☐ India ☐ Lain-lain

4. Semester: _____

BAHAGIAN B:

MAKLUMAT BERKAITAN PEMBELAJARAN KIMPALAN

Jawab soalan berikut dengan menandakan (√) didalam kotak yang disediakan.

5. Adakah anda memerlukan sumber yang lain untuk memahami tentang kimpalan?	☐ Ya ☐ Tidak
6. Adakah anda menghadapi masalah dalam mencari bahan untuk mengulangkaji berkaitan dengan penerangan dan penggunaan mesin kimpalan?	☐ Ya ☐ Tidak
7. Tandakan (√) didalam kotak bagi kaedah pembelajaran lain yang boleh digunakan untuk anda memahami dengan lebih mendalam berkaitan dengan kimpalan	☐ Animasi 3d ☐ Video ☐ Gambar ☐ Buku ☐ Lain-lain
8. Adakah anda inginkan perubahan dalam kaedah pembelajaran anda?	☐ Ya ☐ Tidak

9. Adakah latihan berbentuk simulasi dengan bantuan video, animasi 3D, gambar dan teks dapat membantu anda dalam pembelajaran kimpalan?	☐ Ya ☐ Tidak
10. Secara keseluruhan, adakah anda memahami kesemua penerangan tentang kimpalan?	☐ Ya ☐ Tidak

APPENDIX B

Learning Evaluation (Pre test and Post test) Questionnaires

UNIVERSITI UTARA MALAYSIA

KOLEJ SASTERA DAN SAINS

06010 SINTOK KEDAH DARUL AMAN

Tuan/Puan yang dihormati,

Soal selidik ini dijalankan untuk mendapatkan maklumat berkaitan pemahaman anda tentang kandungan pembelajaran kimpalan arka dengan intervensi teknologi "Realiti Luasan Mudahalih"

.

Oleh itu, saya amat berbesar hati sekiranya Tuan/Puan dapat menjawab **SEMUA** soalan pada ruangan yang disediakan. Segala maklumat yang diberikan hanyalah untuk tujuan akademik.

Kerjasama Tuan/Puan amatlah dihargai. Terima kasih.

SILA BULATKAN PADA JAWAPAN YANG BERKENAAN.

NO.	SOALAN
1.	Apakah definisi Prosedur Operasi Piawai (SOP)? A) SOP adalah penerangan berkaitan keselamatan yang perlu dilakukan oleh penyelia sebelum pekerja memulakan kerja supaya lebih selamat B) SOP adalah prosedur yang khusus untuk operasi anda dimana ia menerangkan aktiviti-aktiviti yang diperlukan untuk menyelesaikan tugas bersesuaian dengan peraturan industri, dan undang-undang provinsi C) SOP adalah peralatan keselamatan yang digunakan untuk perlindungan daripada bahaya semasa melakukan kerja yang berisiko ditempat kerja. D) SOP adalah prosedur operasi dimana ia menerangkan pengunaan alatan ditempat kerja dengan betul
2.	Apakah peralatan keselamatan yang tidak sesuai digunakan untuk peralatan perlindungan diri (PPE)? A) Tshirt berkolar B) Sarung tangan C) But keselamatan D) Topeng muka
3.	Peralatan PPE yang manakah melindungi muka daripada percikan api ketika mengimpal? A) Sarung tangan B) Perlindung pernafasan C) Topeng kimpalan D) Cermin mata
4.	Apakah yang perlu dilakukan semasa pra-operasi semakan keselamatan (pre-operational safety check)? A) Memastikan kawasan kerja bersih dan bebas daripada gris, minyak dan sebarang bahan yang mudah terbakar B) Pastikan kerja kabel bumi membuat hubungan kukuh untuk menyediakan sambungan elektrik yang baik C) Memastikan arus ditetapkan dengan betul mengikut pemilihan elektrod D) Alihkan tiang elektrod (electrode stub) daripada pemegang dan matikan sumber kuasa

5.	Apakah potensi risiko yang membahayakan kesihatan ketika melakukan kimpalan? A) Tekanan kerja yang banyak B) Ruang kerja yang bising C) Peralatan tidak kemas D) D) Percikan api
6.	Apa yang perlu dilakukan jika peralatan kimpalan rosak? A) Report peralatan rosak kepada " " dengan segera B) Membaiki sendiri peralatan yang rosak C) Membeli dan menukar peralatan yang rosak D) Terus menggunakannya sehingga peralatan betul-betul rosak
7.	Apa yang perlu dilakukan selepas selesai melakukan kimpalan?Pilih jawapan yang paling tepat. A) Kemas kawasan kerja dalam keadaan selamat, kemas dan bersih B) Matikan mesin dan *fume extraction*, menggantung semua kabel dan bersihkan kawasan kerja C) Pastikan pemegang elektrod tiada elektrod sebelum memasang mesin kimpalan D) Pastikan peralatan kimpalan bersih dan cuci daripada gris, minyak dan bahan yang mudah terbakar
8.	Yang manakah bukan alat yang digunakan untuk kimpalan arka?? A) Tukul penyerpih B) Berus dawai C) Pemegang sumpitan (gun) D) Tiada jawapan
9.	Apakah kegunaan mesin kimpalan arka? A) Ia berfungsi menghantar dawai elektrod, gas pelindung dan arus ke kawasan kimpalan B) Mengalirkan gas lengai ke kawasan kimpalan yang dilaras bersama panel kawalan, pengatur dan meter aliran C) Bekalan kuasa yang menghasilkan arka elektrik di antara elektrod dan bahan untuk dikimpal dengan mencairkan logam pada titik kimpalan

	D) Ia berfunsi sebagai pengatur tekanan gas yang digunakan di dalam pengelasan gas dan menunjukkan tekanan gas serta besarnya aliran gas pelindung
10.	Apakah perbezaan pemegang elektrod dengan kabel bumi? A) Pemegang elektrod menghubungkan kabel kimpalan ke bekalan kuasa manakala kabel bumi digunakan untuk menjadikan penyambungan elektrikal ke *workpiece* stabil B) Pemegang elektrod digunakan untuk menjadikan penyambungan elektrikal ke *workpiece* stabil manakala menghubungkan kabel kimpalan ke bekalan kuasa C) Pemegang elektrod menghubungkan kabel kimpalan ke bekalan kuasa manakala kabel bumi digunakan bersama rod untuk mengimpal D) Pemegang elektrod digunakan bersama rod untuk mengimpal manakala kabel bumi digunakan untuk menghubungkan kabel kimpalan ke bekalan kuasa
11.	Susun langkah-langkah sebelum memulakan kimpalan. i. Mengumpul semua alatan ii. Memakai peralatan keselamatan iii. Membersihkan metal sebelum kimpalan iv. Menyediakan tempat welding dan mesin A) i, ii, iii, iv B) i, ii, iv, iii C) ii, i, iii, iv D) iii, i, iv, ii
12.	*Amperage* bekalan kuasa selalunya adalah diantara 90-120 amps, tetapi perlu di *adjust* bersesuaian dengan? A) Ketebalan metal dan panjang elektrod B) Ketebalan metal dan diameter elektrod C) Ketinggian metal dan diameter elektrod D) Saiz metal dan jenis elektrod
13.	Yang mana satukah jenis kimpalan? A) Weld corner bead B) Corner Joint C) L-Joint D) Pedding

14.	Yang manakah bukan jenis-jenis kecacatan kimpalan? A) Lack of penetration. B) Undercuts C) Porosity D) Tiada jawapan
15.	Apakah yang menyebabkan berlakunya 'excessive penetration'? A) Penyediaan hujung yang salah (incorrect edge preparation) B) Kepekatan haba terlalu besar (too big a heat concentration) C) Terlalu lambat mengimpal (too slow travel) D) Semua jawapan diatas.

APPENDIX C
Motivation Questionnaires

UNIVERSITI UTARA MALAYSIA

KOLEJ SASTERA DAN SAINS

06010 SINTOK KEDAH DARUL AMAN

PENYELIDIKAN

Penggunaan Realiti Luasan Mudahalih untuk Meningkatkan Motivasi Intrinsik Dalam Pembelajaran Kimpalan Arka

Assalamualaikum dan salam sejahtera pelajar yang saya hormati,

Saya adalah pelajar Universiti Utara Malaysia dan kini sedang melanjutkan pengajian di peringkat Sarjana Sains (Pengajian Multimedia) melalui Penyelidikan. Sebagai sebahagian daripada penyelidikan, saya dikehendaki menjalankan kajian di kalangan pelajar Kejuruteraan Mekanikal dari Politeknik Tunku Syed Sirajuddin mengenai motivasi intrinsik pelajar dalam pembelajaran kimpalan arka dengan intervensi teknologi "Realiti Luasan Mudahalih" menggunakan aplikasi MAWL. Semua maklumat dari kajian ini akan digunakan hanya untuk tujuan akademik semata-mata. Kerjasama anda amat dihargai.

Terima kasih.

Farhatun Najwa Binti Rusli (821854)

<u>**Bahagian A: Profil Demografik**</u>

Bahagian ini bertujuan untuk mendapatkan maklumat mengenai latar belakang demografik responden. Sila isikan ruang kosong dan tandakan "√" dalam kotak yang sesuai.

11. Jantina:

☐ Lelaki ☐ Perempuan

12. Umur: ______ tahun

13. Bangsa:

☐ Melayu ☐ Cina

☐ India ☐ Lain-lain

14. Adakah anda mempunyai peranti mudahalih?

☐ Ya ☐ Tidak

15. Adakah anda mengetahui berkaitan Teknologi Realiti Luasan?

☐ Ya ☐ Tidak

16. Adakah anda pernah menggunakan aplikasi Teknologi Realiti Luasan melalui peranti mudahalih?

☐ Ya ☐ Tidak

17. Adakah anda pernah menggunakan sebarang aplikasi mudahalih untuk mempelajari kimpalan arka?

☐ Ya ☐ Tidak

Persepsi pelajar: Sila baca setiap pernyataan berikut dan bulatkan item yang anda pilih.

Sangat tidak setuju	Tidak setuju	Tidak pasti	Setuju	Sangat setuju
1	2	3	4	5

BIL	KENYATAAN	SKALA				
KEMUDAHAN PENGGUNAAN						
1	MAWL senang digunakan secara individu	1	2	3	4	5
2	MAWL sesuai digunakan untuk mempelajari kimpalan	1	2	3	4	5
3	MAWL sesuai digunakan untuk mengulangkaji berkaitan kimpalan	1	2	3	4	5
4	Teknologi Realiti Luasan Mudahalih sesuai digunakan secara sendirian	1	2	3	4	5
5	Langkah dalam menggunakan MAWL mudah diingati	1	2	3	4	5
6	Teknologi Realiti Luasan Mudahalih menyenangkan proses mengulangkaji berkaitan kimpalan	1	2	3	4	5
PENGLIBATAN						
1	MAWL menarik minat saya untuk mempelajari kimpalan untuk jangka masa yang lama	1	2	3	4	5
2	MAWL membolehkan saya mengulangkaji kimpalan berulang kali	1	2	3	4	5
3	MAWL menyebabkan saya mempelajari kimpalan untuk jangka masa yang lama	1	2	3	4	5
4	Teknologi Realiti Luasan Mudahalih meningkatkan penglibatan saya dalam pembelajaran kimpalan	1	2	3	4	5
KEUPAYAAN BELAJAR						
1	Ianya mudah untuk belajar menggunakan MAWL	1	2	3	4	5
2	Informasi yang disediakan oleh MAWL mudah difahami	1	2	3	4	5
3	Informasi yang disediakan oleh MAWL membantu saya dalam mempelajari kimpalan	1	2	3	4	5
4	Menggunakan MAWL adalah munasabah untuk pembelajaran	1	2	3	4	5
KEPUASAN						

1	Saya berpuas hati menggunakan MAWL	1	2	3	4	5
2	Saya berpuas hati dengan maklumat yang diperolehi dari MAWL	1	2	3	4	5
3	Saya berpuas hati dengan kaedah pengajaran MAWL	1	2	3	4	5
4	Saya berpuas hati dengan persekitaran pembelajaran yang terdapat pada MAWL	1	2	3	4	5
5.	Saya berpuas hati dengan keseluruhan keberkesanan pembelajaran	1	2	3	4	5
MOTIVASI						
1	MAWL senang digunakan	1	2	3	4	5
2	MAWL meningkatkan penglibatan saya dalam pembelajaran kimpalan	1	2	3	4	5
3	Saya seronok dengan pembelajaran kimpalan untuk jangka masa yang lama	1	2	3	4	5
4	Pembelajaran kimpalan menjadi lebih seronok dengan menggunakan MAWL	1	2	3	4	5
5	MAWL meningkatkan motivasi saya untuk mencapai tahap cemerlang dalam pembelajaran kimpalan	1	2	3	4	5
6	MAWL mendorong saya untuk melanjutkan pengajian keperingkat tinggi dan kerjaya yang berkaitan dengan kimpalan pada masa hadapan	1	2	3	4	5
KEBOLEHGUNAAN						
1	Penggunaan MAWL membolehkan saya untuk menyudahkan tugasan dengan lebih cepat	1	2	3	4	5
2	Penggunaan MAWL boleh meningkatkan prestasi pembelajaran kimpalan saya	1	2	3	4	5
3	Penggunaan MAWL dalam pembelajaran kimpalan boleh meningkatkan produktiviti saya	1	2	3	4	5
4	Pengunaan MAWL boleh meningkatkan keberkesanan dalam pembelajaran kimpalan saya	1	2	3	4	5
5	Penggunaan MAWL akan memudahkan tugasan saya	1	2	3	4	5
6	Saya suka belajar menggunakan MAWL	1	2	3	4	5

Terima kasih di atas kerjasama anda

Appendix D

Snapshots (Pre-test and Post-test)



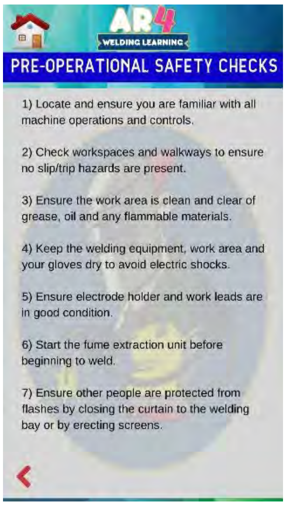


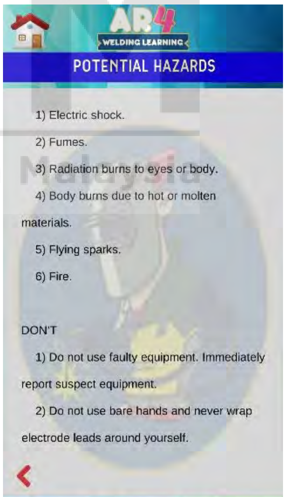



Appendix E

Snapshots of MAWL App

Safety in Welding





Components of Welding

Steps in Welding

APPENDIX F

Experts Reviews 1

Content Evaluation

Content Evaluation

No	Content	Problem	Suggestion
1	**Safety in Welding:** ➢ Types of Personal Protective Equipment (PPE) ➢ Pre-Operational Safety Checks ➢ Operational Safety Checks ➢ Ending Operation and Cleaning ➢ Potential Hazards		1) ~~Video of~~ Gambar @ Video yg lengkap berpakaian dgn PPE.
2	**Component of Arc welding:** ➢ Power source AC/DC ➢ Electrode Holder and Cables ➢ Welder Protection ➢ Tools		1) Brief introduction to Arc welding components.
3	**Steps in Arc welding:** ➢ Steps to be taken before start welding ➢ Steps in starting arc welding ➢ Welding Defect	1) Video kurang jelas, perlu fokus pd. teknik arc welding.	Tambahan 1) How to stop an arc welding. 2) Cause of welding defect - current to high/low - Arc length. - Speed of motion

APPENDIX G

Experts Reviews 2

Content Evaluation

Content Evaluation

No	Content	Problem	Suggestion
1	**Safety in Welding:** ➢ Types of Personal Protective Equipment (PPE)	- Susunan atur info lebih kepada susunan buku (Kurang menarik untuk App). - Tiada maklumat S.O.P (Safety (Standard operation procedure) yang jelas.	- Idea : gambar & penerangan lebih sesuai dengan teks yang minimum. - Masukkan S.O.P → Pre-operational → operational → post-operational → Housekeeping
2	**Component of Arc welding:** ➢ Power source AC/DC ➢ Electrode Holder and Cables ➢ Welder Protection ➢ Tools	— Susun atur maklumat perlu di perbaiki ⊕ Welder protection dimasukkan di dalam S.O.P shj. - ~~Labeling~~ Labelling kepada komponen dan penjelasan komponen boleh diperbaiki	— Gambarajah skematik untuk mesin kimpalan boleh juga digunakan sebagai gambaran yang jelas kepada pengguna.
3	**Steps in Arc welding:** ➢ Steps to be taken before start welding ➢ Steps in starting arc welding ➢ Video	- Perlu masukkan maklumat berkaitan "welding defect". - Pengguna App akan dapat maklumat kepada mutu/kualiti kimpalan yang dihasilkan.	— Memadai untuk masukkan 5 jenis "defects" yang utama semasa mengimpal.

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19/02/2018

APPENDIX H

Experts Reviews 3

Interface Evaluation

Interface Expert Evaluation Form

I hereby certify that the MAWL application has been produced by Farhatun Najwa Binti Rusli from the SMMTC, College of Arts and Sciences, Universiti Utara Malaysia. It has been checked by me in terms of the validity of the interface and the general comments are as follows:

Heuristic and Sub heuristics				
Interface (IN)		Pick one		Comment
		Yes	No	
IN1	The interface is clear, simple and easy to understand.	✓		
IN2	The design's interface is attractive and interesting	✓		
IN3	The MAWL application is easy to use.	✓		
IN4	The interface's colour scheme used is appropriate.	✓		
IN5	The interface's screen design has attractive display.	✓		
IN6	Appropriate image used for interface.	✓		Home page icon → ✓
IN7	Readable text are used for interface	✓		
Multimedia (Image, Video, Text, and 3D model) (MM)		Pick one		Comment
		Yes	No	
MM1	Each multimedia elements used serves a clear purpose.	✓		
MM2	The use of multimedia elements is suitable with the content.	✓		
MM3	The presentation of multimedia elements is well managed.	✓		
MM4	The use of multimedia elements supports meaningfully the information provided.	✓		ok.
MM5	The use of multimedia element's quality is good.	✓		
MM6	The use of multimedia elements intensifies the content presentation.	✓		
Interactivity (IV)		Pick one		Comment
		Yes	No	
IV1	The interactivity is easy to understand.	✓		
IV2	The interactivity is not misleading.	✓		
IV3	The interactivity of MAWL is fun	✓		How to define fun?

Other(s) - should include evaluation item on AR' element.

Name: [signature]

Date: 27/1/2020.

Stamp: PROF. MADYA Ts. DR. SOBIHATUN NUR ABDUL SA
Dekan
Pusat Pengajian Teknologi Multimedia dan Komunikasi
UUM College of Arts and Sciences
Universiti Utara Malaysia

APPENDIX I

Experts Reviews 4

Interface Evaluation

Interface Expert Evaluation Form

I hereby certify that the MAWL application has been produced by Farhatun Najwa Binti Rusli from the SMMTC, College of Arts and Sciences, Universiti Utara Malaysia. It has been checked by me in terms of the validity of the interface and the general comments are as follows:

Heuristic and Sub heuristics		Pick one		Comment
Interface (IN)		Yes	No	
IN1	The interface is clear, simple and easy to understand.	✓		ok.
IN2	The design's interface is attractive and interesting	✓		
IN3	The MAWL application is easy to use.	✓		Easy.
IN4	The interface's colour scheme used is appropriate.	✓		
IN5	The interface's screen design has attractive display.	✓		
IN6	Appropriate image used for interface.	✓		
IN7	Readable text are used for interface	✓		Suitable font/size.
Multimedia (Image, Video, Text, and 3D model) (MM)		Yes	No	Comment
MM1	Each multimedia elements used serves a clear purpose.	✓		Clear.
MM2	The use of multimedia elements is suitable with the content.	✓		
MM3	The presentation of multimedia elements is well managed.	✓		
MM4	The use of multimedia elements supports meaningfully the information provided.	✓		
MM5	The use of multimedia element's quality is good.	✓		Ok.
MM6	The use of multimedia elements intensifies the content presentation.	✓		
Interactivity (IV)		Yes	No	Comment
IV1	The interactivity is easy to understand.	✓		
IV2	The interactivity is not misleading.	✓		Clear.
IV3	The interactivity of MAWL is fun	✓		

Name: MOHD FITRI YUSOFF

Stamp: MOHD FITRI YUSOFF
Lecturer
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Date: 27/1/2020.