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ARC WELDING EDUCATION: MOBILE ARC WELDING LEARNING APP TO IMPROVE STUDENTS' MOTIVATION

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ABSTRACT

All Mechanical Engineering students studying in Malaysian polytechnics have to take welding as a core subject. They will learn the basic theory in the classroom and proceed with instruction-based training in the workshop. With limited learning time in the classroom, students find it difficult to follow and understand everything that has been taught. Furthermore, welding is dangerous for beginners and the environment is hazardous to health. If students are not well prepared before going to the workshop, this might jeopardize themselves as well as the welding equipment. To help students be better prepared, a supplementary learning method is needed and the Mobile Arc Welding app has been introduced to them. A study has been conducted to determine whether the app contributes to the students' learning process. The study was carried out among 67 mechanical engineering students of a polytechnic. The analysis involved Pearson Correlation and Regression in determining the impact of engagement, ease of use, learnability, satisfaction and usefulness on students' motivation through the use of a welding app. The findings show that there are empirically positive and substantial correlations between motivation and engagement, satisfaction, and usefulness. However, there was no evidence of a positive and significant relationship between ease of use and learnability and welding learning motivation.

Keywords: Mobile Augmented Reality, ARC Welding Education, Correlation, Regression.

INTRODUCTION

All Mechanical Engineering students at Polytechnics in Malaysia must take courses related to welding. Normally, students will begin learning gas and arc welding and as they progress, they will learn metal inert gas (MIG) and Tungsten Inert Gas (TIG) welding. Welding learning involves a variety of theoretical and practical concepts that are typically presented to students in the classroom through the conventional methods and instruction-based training (IBT) in the workshop. The instruction in the classroom typically is based on text and images and is difficult to explain various dynamic and complex concepts and processes of welding. In the current classroom learning environment, face-to-face teaching does not seem to be favourable among the students (Lee & Oh, 2015; Oh et al., 2015; Shin et al., 2015). In a limited amount of time, students find it difficult to follow and understand everything that is taught (Mahamad et al., 2010). Welding normally takes place in an injurious and health-hazardous environment with arc light, ultraviolet ray, sparks, and fumes (Wang et al., 2006). Students need to understand and be able to observe all the welding steps to avoid endangering the process and their safety. For beginners, welding training is dangerous because it takes time to reach the required level of competency, needs the right tools, equipment, materials, and lack of skills (Hashimoto, 2015). Students need to have sufficient knowledge before proceeding with practical activities in the workshop. Therefore, students need to find other methods to understand and follow all the welding steps themselves. Learning resources for welding come in various forms and among the popular ones are books, websites, and videos. The students require an innovative approach to learning which include step-by-step instructions which enable them to operate the welding equipment effectively. According to Oz et al. (2012), students must have the knowledge, skills, training, and experience in welding joints. In addition, students need a comprehensive learning approach in channeling knowledge based on the curriculum needs and also to facilitate the students during revision.

Mobile learning is gaining attention, and can therefore expand the scope of opportunities in education (Al-Emran et al., 2016). Compared to conventional classroom learning, mobile learning can be conducted anytime and anywhere, thus enabling learning while on the move and enhancing students' learning efficiency (Shudong et al., 2005). Mobile learning has been well received without limitations of place and time and provides student-centered educational environment (Al-Emran et al., 2016). Mobile learning is useful for students as well as lecturers in improving learning efficiency due to limitations on conventional learning methods (Kukulska-Hulme et al., 2009). In education, mobile learning has been widely applied (Yahya, et al., 2018; Shamsuddin et al., 2018; Sanusi et al., 2018) and is used in various areas of learning which include; science (Gopalan et al., 2020; Liu et al., 2021; Khery et al., 2020; Baharom et al., 2020), mathematics (Yosiana et al., 2021; Amasha et al., 2021; Malik et al., 2020), and finance (Mueangpud et al., 2019; Teymurova et al., 2020; Zakaria et al., 2020).

MOBILE ARC WELDING LEARNING (MAWL) APP

Recognizing the importance and benefits of mobile learning, the Mobile Arc Welding Learning (MAWL) app was developed. Augmented Reality (AR) is incorporated into the app to provide unique experience to mobile learning. The app is a supplement to the current classroom learning prior to Instruction-based Training (IBT). It is intended to help students review their classroom learning before they go to the workshop to perform practical welding works. AR is a technology that superimposes virtual objects on the real world. AR expands the real world by adding layers of digital information to it. In contrast to virtual reality (VR) technology, AR does not create an entirely artificial environment to replace reality. AR is based on mediated reality that uses images, audio, text, video, 3D object, and GPS. Besides that, AR can be used to reproduce real-world scenes and situations with conventional simulation environments, real-time contexts, and semantics. In education, AR enables teachers/instructors to teach the computer/internet savvy generation in a format that can be read, understood, and remembered; which is fundamental for developing a strong interest in learning. AR was chosen to be applied in this study due to the need in overcoming the issue of engaging the students in learning about complex topics in welding which have prompted the researchers to use this technology as a tool to deliver the learning materials. In addition to AR, mobile technology is one of the essential elements for most people especially youngsters in their daily lives. It is not only used for communication purposes only, but its use is increasing as the number of applications developed specifically for it increases. Mobile-based AR is widely applied in learning (Rohendi & Wihardi, 2020; Gopalan et al., 2020; Rusli et al. 2019), cultural heritage (Baker et al., 2020; Kim & Yu, 2021; Phithak & Kamollimsakul, 2020), advertising (Choi & Choi, 2020; Idris et al., 2018) and more.

MAWL ARCHITECTURE

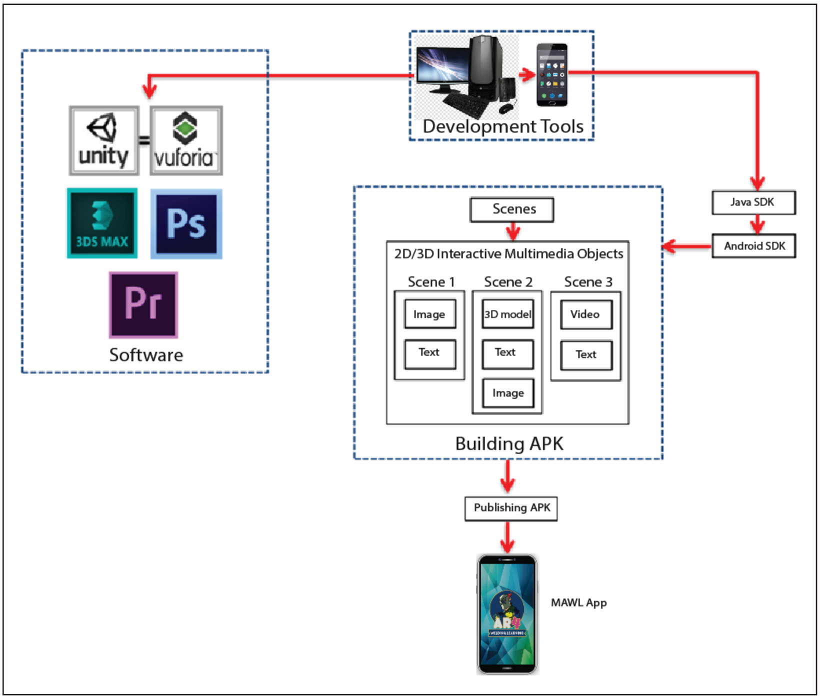
Figure 1 shows the architecture of the MAWL app along with the tools for the design and development of the app. MAWL app is a mobile based and user can experience some AR functions with the use of AR markers that utilize the mobile device's camera. The MAWL app has been developed using personal computer and further implemented on a mobile phone. Furthermore, the design and development of the app utilised Adobe Photoshop CS6, Adobe Premiere Pro CS6, Unity 3D with Vuforia Software Development Kit (SDK) and 3DS Max. Once the app development in Unity is completed, it has been saved as android package kit (APK) before being implemented on a mobile device.

MAWL DEVELOPMENT

The MAWL app has been developed as a supplementary learning tool through the use of mobile devices for Polytechnic students who are taking welding subject. There are two main phases involved in the development of the app. The first phase is the gathering and creation of contents while the second phase is the development and integration of the app on mobile device. MAWL app has also built-in AR function where Vuforia AR toolkit database was used to create target marker. Images were edited using Adobe Photoshop so that they have customized dimensions to be uploaded into Vuforia database. It was to add targets to the database which allows the activation of the authoring parts in the Unity 3D software. The MAWL app has been developed for Android devices only.

Figure 1

The MAWL Architecture



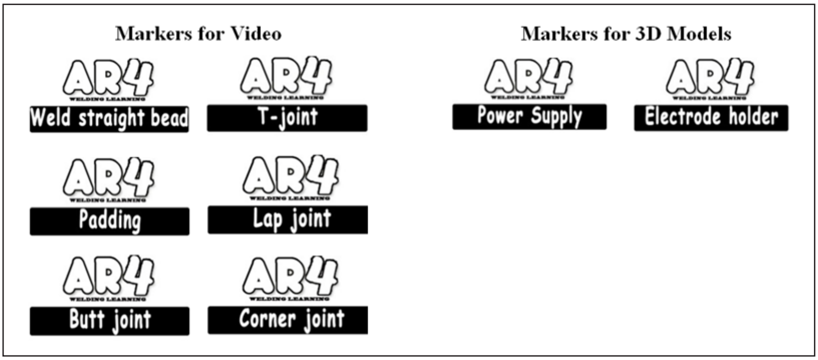
MAWL APP CONTENTS

The first phase constitutes the gathering and creation of contents whereby it involves the gathering of relevant information to be included in the app. The contents of the MAWL app include images, videos, text and 3D models in suitable smartphone formats pertaining to welding learning and training. They are required to make the app more informative, attractive, easy and fun for welding learning. The contents of MAWL also include information pertaining to welding safety, components, and steps.

In using the MAWL app, AR markers are required and to ensure that the markers function properly, they have to be implemented with the installed app. Moreover, computer-generated objects such as 3D models and videos will be displayed and superimposed onto the mobile device screen in the MAWL app once a marker has been recognized. Meanwhile, the markers were created using Vuforia software marker manager as shown in Figure 2. A device database was created using the Vuforia online database and a new target has been identified and given a name. The targets included in the MAWL app are 3D models and videos. The target image size was modified as required and then the file was uploaded to the Vuforia database. The marker can be saved as JPEG or PNG format in Vuforia. All the markers used in the MAWL app were saved in JPEG format. Lastly, Unity 3D software was used to combine all the contents of the MAWL app using the Vuforia SDK. In order to install the app to the mobile devices, an APK file for android was created.

Figure 2

Image-based Markers for the MAWL App



INTEGRATION OF MAWL APP ON MOBILE DEVICE

Several features comprising of 3D model targets and video targets and the SDK project file for the Android development were set in Vuforia for the integration of the MAWL app on mobile devices. The marker images were uploaded as target markers before the project file was downloaded from the Vuforia database. A Unity editor file was selected to match the authoring development of the Unity 3D software. Then the augmented reality unity project was set up with Vuforia SDK, saved and downloaded for further development in the Unity 3D software. This implied that, the development of the MAWL app requires the merging of Vuforia and Unity 3D software. The application also used C++ language during the development phase. The whole development of the MAWL app including compilation, visual development, interaction, content presentation and deployment to mobile device, employed the use of Unity 3D.

Figure 3 shows the main interface of the app which comprises of three images which act as buttons for safety in welding, components of welding and steps in welding. These buttons are stored in the Unity workspace. For the MAWL app, a raw image was inserted and saved in the Unity workspace to function as the background of the app. A script written in C++ was created in order to enable the installed app in the mobile device to be able to scan. Thus, the virtual content that is attached to the marker will appear on the mobile screen whenever a marker is scanned.

Figure 3

Main Interface of the MAWL App

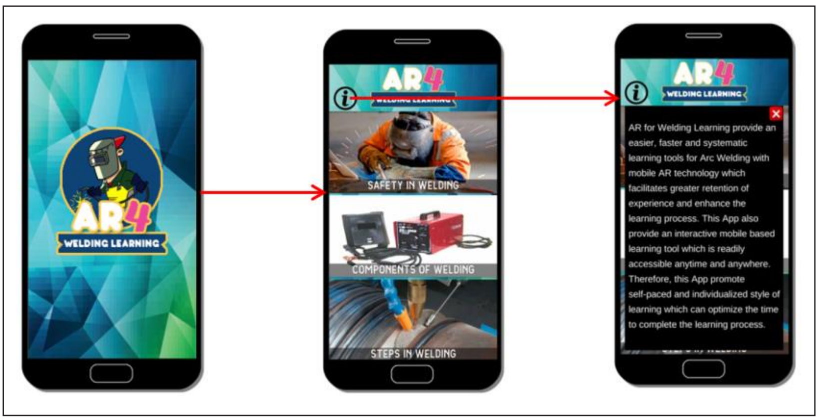
Before the app is ready to be used, all the functional and technical requirements have to be taken into consideration. In the following sections, the interfaces of the MAWL app were discussed. These interfaces are grouped into two; the home page and the interaction function interface.

MAIN PAGE

The app starts with a splash screen for about 15 seconds and then displays the main page. The splash screen consists of an image of a welder. After the splash screen is displayed, the Main Menu appears and the user can further interact with the app by clicking the buttons. There are 3 images that act as buttons representing Safety in Welding, Components of Welding, and Steps in Welding. The buttons will navigate user to the following page. Figure 4 shows the interfaces of the splash screen, the Main Menu, and the Info screen.

Figure 4

Splash Screen, Main Menu and Info



INTERACTION FUNCTION INTERFACE

The Main Menu has info button as seen on the left of Figure 4. 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 5. 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 allow the user to go to the home page and back button at the bottom left to go back to the previous page.

Figure 5

Personal Protective Equipment

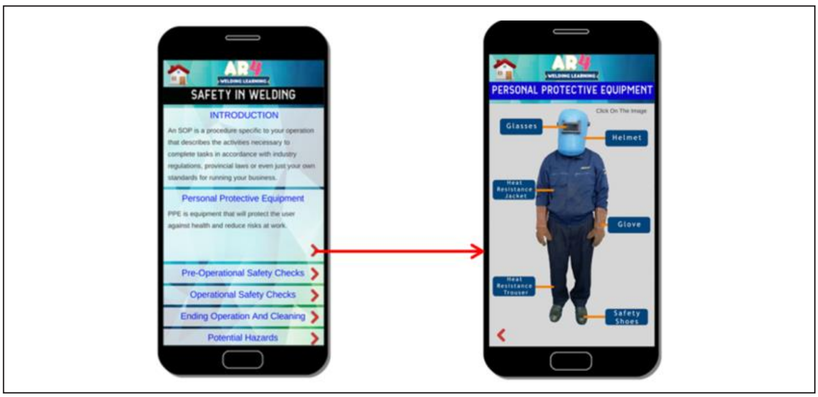


Figure 6 shows the Pre-Operational Safety Checks where the page provides information pertaining to the guidelines the welders should follow before starting their welding works. Figure 7 shows the Operational Safety Checks page which provides the guidelines what the welders should do while doing the welding works.

Figure 6

Pre-Operational Safety Checks

Figure 7

Operational Safety Checks

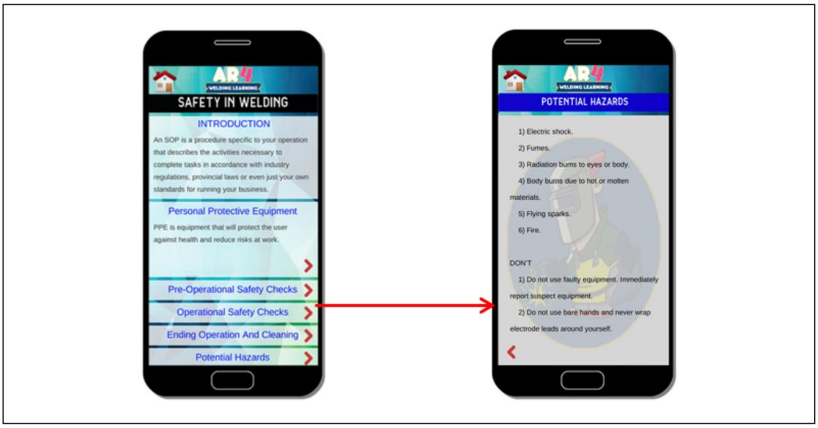
The Ending Operation and Cleaning navigates to the Ending Operation and Cleaning page which provides some guidelines of what the welders should do after they have finished their welding works as shown in Figure 8. The Potential Hazard interface provides information on the hazards that welders may face if they do not follow safety guidelines during welding as shown in Figure 9.

Figure 8

Ending Operation and Cleaning

Figure 9

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 shown in Figure 10. The images also act as buttons whenever the user clicks to navigate to the Component in Welding page. Every interface in the Component of Welding has button which is displayed on the top left enabling the user to go to the home interface and back button at the bottom left to go back to the previous page. Figure 11 shows whenever the user clicks the Power Supply AC/DC button, a brief information pertaining to the power supply and its use will be displayed. Moreover, the scan button allows the user to scan the provided marker using the mobile phone camera to display the virtual 3D object onto the screen as shown in Figure 11. User can manipulate the angle of view of the 3D object by tilting and rotating the marker. This is one of the AR features that is implemented in the MAWL app.

Figure 10

Components of Welding

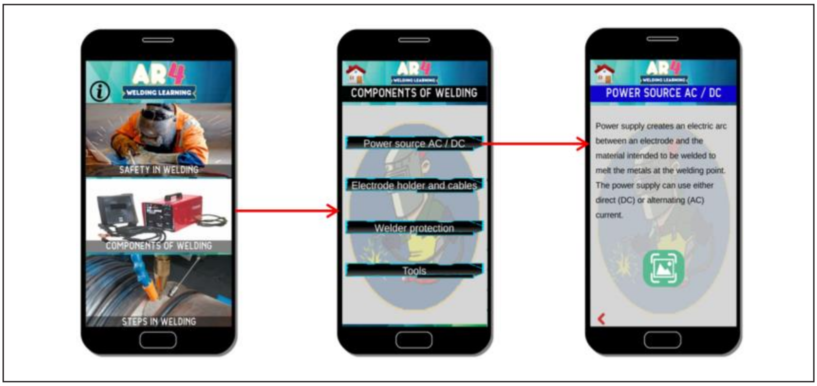
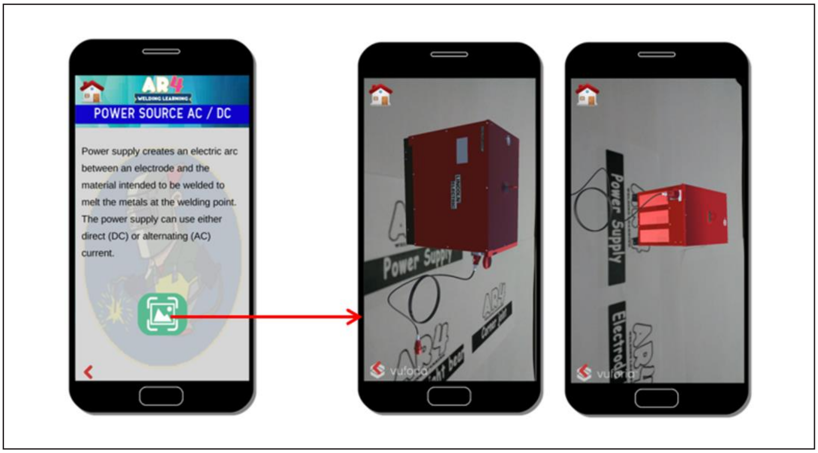


Figure 11

Power Source AC/DC



Meanwhile Figure 12 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 12

Steps in Welding

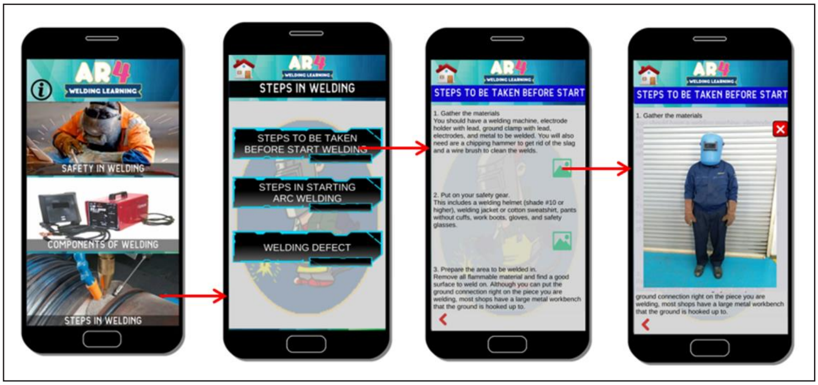
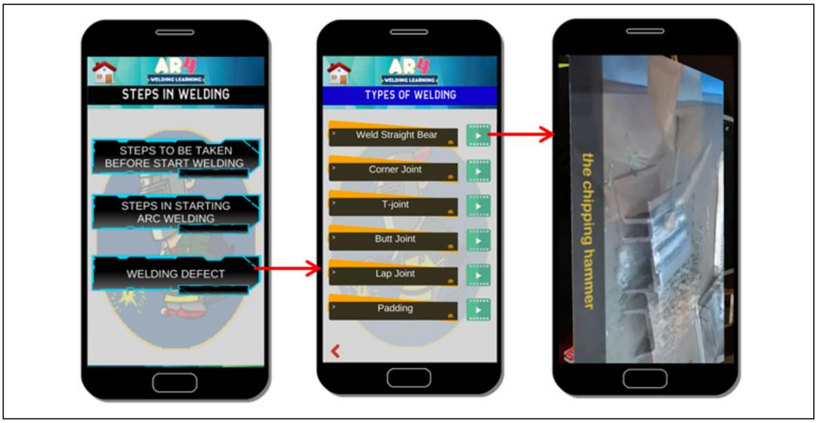


Figure 13 shows steps in welding by showing various types of welding videos. Users have to click the green button to view the video. Here users can experience the AR feature provided by the app for video viewing.

Figure 13

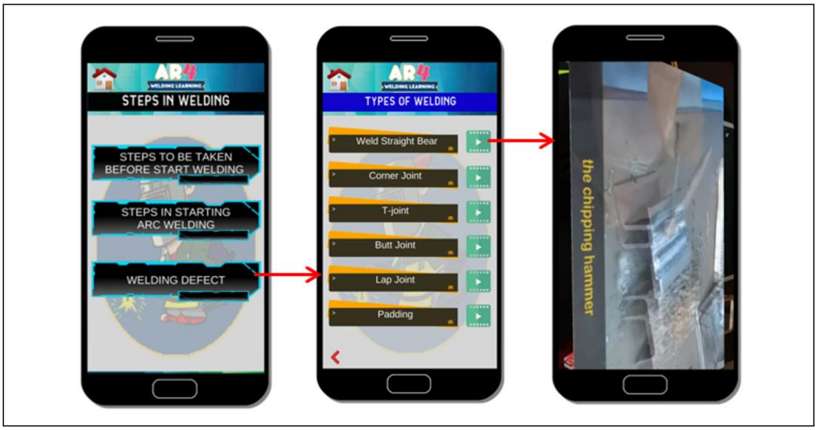
Types in Welding



When the user clicks on the Welding Defect's button as shown in Figure 14, 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 14

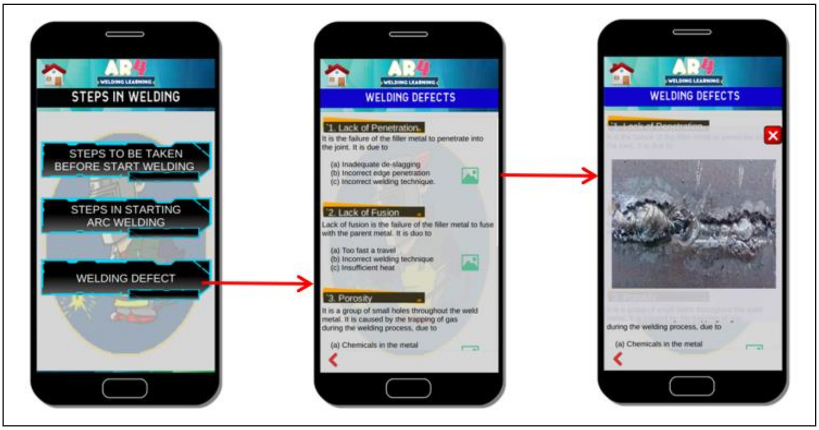
Steps in Welding Pages



Lastly, Figure 15 shows the wireframe of the MAWL app. It represents all the interfaces and steps to view the content of the app such as image, text, 3D model and video pertaining to the welding process. This paper describes our study that investigated whether the MAWL app intervention contributes to students' welding learning process. The following sections discuss briefly the method, results, hypothesis testing and the conclusion is in the last section.

Figure 15

Wireframe of the MAWL App



METHOD

Participants

Purposive sampling was used to select a sample of 67 first semester polytechnic students for this study. The number has met the minimum requirement for sample size which is at least 30 as recommended by Coakes and Steed (2003) and Hair et al. (2018). The user evaluation for this study has been conducted at the Tunku Syed Sirajuddin Polytechnic which is located in Perlis. 31 (46.3%) respondents were male and 36 (53.7%) respondents were female.

Measurements

In this study, Motivation (M) is the dependent variable. Motivation can be defined as pursuing toward a positively evaluated goal state by activating orientation of current life (Rheinberg & Engeser, 2018). The positively evaluated goal state means desired goal or achievement in doing something. According to Rheinberg and Engeser (2018), the performance of an activity with positive incentives makes the individuals engross in an activity just for the enjoyment of it. Furthermore, motivation provides a source of energy that is responsible for why learners decide to try, how long they are willing to sustain an activity, how hard they are going to pursue it, and how connected they feel to the activity (Rost, 2006). Previous studies have proven that digital learning through mobile app and computer able to motivate and enhance the students learning performance. In addition, the integration of AR in mobile app helps the students academically motivated to engage in learning to achieve good grades (Gopalan et al, 2015). The independent variables (IVs) used in this study are ease of use (EOU), engagement (E), learnability (L), satisfaction (S) and usefulness (U). EOU is one believes that using an application will free him/her from physical and mental effort (Davis, 1993). Meanwhile, E is a person feeling motivated to learn because the experience is enjoyable and fully commited to learn more (Arnone et al., 2011). According to Gopalan et al. (2015), previous studies related to AR-based projects indicate the engagement variable is the most studied by researchers. Engagement enables students to fully focused on the learning process without easily distracted. Meanwhile, L is one believe that using an application will facilitate learning and enhance a person learning ability with a well-designed and well-organized interface (Lin, Choong, & Salvendy, 1997). S refers to when a person achieves his/her goals by using the system comfortably (Alqahtani & Mohammad, 2015) and feels positive when experiences success (Hui et al., 2008). Lastly, U is a person believe using an application would enhance his/her job performance (Asenjo, 2011).

Instrument

For the user evaluation, the instrument was handed to the respondents. It was drawn from validated instrument from a previous study (Gopalan et al., 2015) and later adapted to suit mobile and AR learning. The measurements included are; Motivation, Ease of use, Engagement, Learnability, Satisfaction and Usefulness. The instrument was divided into two components; respondents demographic and respondents perception. A five-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree and 5 = Strongly Agree) was used in the instrument.

Procedure

The respondents were briefed on the goal of the evaluation and how to use the app before the user evaluation began. They were given the APK file, which they needed to install the app on their devices. To make sure that the respondents are able to use the app satisfactorily, a week was given so that they were able to familiarize themselves with the use of the app. Prior to the evaluation, the respondents were briefed pertaining to the evaluation. Next, instruments were distributed and they have to answer all the questions pertaining to their perceptions towards the use of the MAWL app for welding learning within forty-five minutes.

RESULTS

Demographic data

Table 1 shows the demographic characteristics of the respondents, with 31 male and 36 female respondents.

Table 1

Demographic Data

Gender	Frequency	Percentage
Male	31	46.3
Female	36	53.7

Validity and Reliability

Measurements and items for the instrument have been adapted from a previous study (Gopalan et al., 2015), thus they are considered valid. SPSS version 22.0 was used for reliability analysis in ensuring the instrument's internal consistency. Table 2 presents the Cronbach Alpha values for all the measurements. All the measurements and items are reliable and interrelated since the Cronbach Alpha values are greater than 0.7 (Hair et. al, 2018).

Table 2

Conbach Alpha

Measurement	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

Descriptive Statistics

The means and standard deviations for all measurements and items are shown in Table 3. The results show that the means are 4.03 for EOU, 3.93 for E, 4.08 for L, 4.05 for S, 4.03 or U and 4.02 for M. The Likert scale used in this study's instrument is an ordinal scale.

Table 3

Descriptive Statistics

Measurement/Item	Mean	Std. Deviation
Ease of use	**4.03**	
EOU1	4.09	0.596
EOU2	4.13	0.600
EOU3	4.10	0.606
EOU4	3.87	0.694
EOU5	3.93	0.611
EOU6	4.06	0.672
Engagement	**3.93**	
E1	3.96	0.706
E2	4.09	0.668
E3	3.73	0.898
E4	3.93	0.681
Learnability	**4.08**	
L1	4.12	0.537
L2	4.12	0.508
L3	4.12	0.537
L4	3.94	0.715

(continued)

Measurement/Item	Mean	Std. Deviation
Satisfaction	**4.05**	
S1	4.03	0.651
S2	4.13	0.600
S3	4.09	0.596
S4	4.04	0.589
S5	3.94	0.672
Usefulness	**4.03**	
U1	4.01	0.663
U2	4.01	0.590
U3	4.07	0.586
U4	4.00	0.651
U5	3.99	0.663
U6	4.09	0.543
Motivation	**4.02**	
M1	4.09	0.596
M2	4.10	0.554
M3	3.93	0.659
M4	3.96	0.584
M5	4.00	0.674
M6	4.01	0.685

When interpreting the means, the ordinal scale needs to be converted to numerical scale and recategorized into strongly disagree with mean 1 – 1.99, disagree with mean 2 – 2.99, agree with mean 3 – 3.99 and strongly agree with mean 4 – 5 as suggested by Qasim et al. (2018). Therefore, based on the numerical scale, EOU has mean of 4.03 (strongly agree), E has mean of 3.93 (agree), L has mean of 4.08 (strongly agree), S has mean of 4.05 (strongly agree), U has mean of 4.03 (strongly agree), and M has mean of 4.02 (strongly agree).

Correlation

In order to determine the relationship between the independent (EOU, E, L, S, and U) and the dependent (M) variables, correlation analysis was applied. The results are presented in Table 4 indicating that the correlations between independent and dependent variables are positive. Correlation value for EOU is .648, E is .688, L is .687, S is .767 and U is .822. Since all the values are greater than 0, the correlations are positive (Pallant, 2020).

Table 4

Pearson Correlation

Variables	M	EOU	E	L	S	U
M	1					
EOU	.648**	1				
E	.688**	.677**	1			
L	.687**	.779**	.652**	1		
S	.767**	.645**	.649**	.743**	1	
U	.822**	.729**	.662**	.739**	.777*	1

Note: Correlation is significant at the 0.01 level (1-tailed) **

Regression

Regression analysis was used to determine the relationship between the independent and dependent variables and subsequently to test the hypotheses. The predictors in the analysis are the IVs. R^2 depicts the students' motivation related to welding learning using the MAWL app. The R^2 value of 0.738 indicates that 74% of variation in the dependent variable is associated to the variation in the dependent variables, while the rest is unexplained.

Table 5

Regression

Variable	Beta	Std. Error	t-value	Sig (p-value)
EOU	0.037	0.123	0.300	0.766
E	0.167	0.082	2.043	0.045
L	0.031	0.129	0.243	0.809
S	0.241	0.112	2.153	0.035
U	0.525	0.127	4.135	0.000

**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

Hypothesis Testing

It was conducted to determine the relationship between the independent and the dependent variables. Thus, the hypotheses are as follows.

$Hypothesis_1$: There is a relationship between EOU and M.
$Hypothesis_2$: There is a relationship between E and M.
$Hypothesis_3$: There is a relationship between L and M.
$Hypothesis_4$: There is a relationship between S and M.
$Hypothesis_5$: There is a relationship between U and M.

According to Cohen (2014), in verifying the hypotheses, the t-value > 1.645 and p-value < 0.05. Referring to the results in Table 5, for H_1, the t-value is 0.300 and the p-value is .766 which indicate that the hypothesis is rejected. For H_2, the t-value is 2.043 and the p-value is .045 which indicate that the hypothesis is supported. For $H_{3,}$ the t-value is 0.243 and the p-value is .809 which indicate that the hypothesis is also rejected. For $H_{4,}$ the t-value is 2.153 and the p-value is .035 which indicate that the hypothesis is also supported. For $H_{5,}$ the t-value is 4.135 and the p-value is .000 which indicate that the hypothesis is also supported. The results indicate that EOU and L are not significant to M in the used of the MAWL app. Even though they are not significant, both EOU and L have positive correlation to M as indicated in Table 4.

CONCLUSION

Welding is one of the core subjects for every Mechanical Engineering program at Malaysian polytechnics. Students learn welding theories in class and proceed with IBT in the workshop. Students faced difficulty in following and understanding all the instructions within a limited amount of time in class. Welding can be dangerous and detrimental to others if it is done by an unprepared beginner. In addition, the welding environment is hazardous and can endanger health without proper safety consideration. Students need to understand all the steps in welding before going to the workshop. Therefore, students need a learning tool that is trendy, convenient, and available anywhere and anytime. This paper introduces MAWL app, a mobile app enhanced with AR for arc welding learning. It also reports the students' perceptions whereby they strongly agreed on EOU, L, S, U and M while agreed on E. It also describes the relationship between the IVs and M, whereby; there are statistically significant relationships between E, S, and U with M. Whereas for EOU and L, there are no significant relationships with M. It also gives insights into MAWL app's attributes namely; Ease of use, Engagement, Learnability, Satisfaction and Usefulness towards welding learning motivation among semester 1 Mechanical

Engineering students. The results empirically support positive and significant relationship between Engagement, Satisfaction and Usefulness. However, Ease of use and Learnability have no positive and significant relationship with motivation.

Based on the previous evaluation results, these findings are consistent with Fabian et al (2018) where mobile learning was able to increase students' engagement and their task engagement increases when they can control their learning activities. (Ciampa, 2014; Poitras et al., 2013). Pribeanu (2014) proved that mobile learning incorporating AR was able to provide engagement to students that contribute to their motivation. Moreover, AR with multimedia-based learning was able to engage student (Gopalan, 2016; Pribeanu, 2014; Rasalingam, 2014). Mobile learning promotes successful learning and enhance student's satisfaction with positive attitudes (Alqahtani & Mohammad, 2015) and increases their motivation using mobile learning application incorporating AR (Khan et al., 2018; Chiang et al., 2014). Furthermore, employing a mobile app to learn aids students in achieving learning benefits (Jou et al., 2015) and ready to adopt it in their learning when the mobile learning is useful (Nikou & Economides, 2016). Mobile AR facilitates learning in the context of higher education (Chen, 2019; Borrero & Márquez, 2012). It also proves that usefulness of the mobile AR could motivate students in mobile learning (Pribeanu, 2012; Balog & Pribeanu, 2010). Meanwhile, using a learning application incorporating AR may not be easy to new users because they have to get used to and be comfortable with the new learning environment (Gopalan et al., 2016; Pribeanu, 2012; Balog & Pribeanu, 2010). Previous studies by Chen et al. (2017) and Zaki et al. (2019) found that students give positive response to learnability of mobile AR. However, for this study learnability is not significant with motivation. This probably is due to some technical issues faced by the students pertaining to the software and hardware. Slow internet and data connections, as well as the students' mobile phone's compatibility for installing the MAWL app, all contribute to the lack of learnability in adopting AR-based mobile learning.

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