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Research paper



Design and Development of Augmented Reality Teaching Kit: In TVET Learning Context

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Abstract

Due to the recent development of computer power and information technology, augmented reality (AR) is commonly found to be one of the interactive experience of a real-world environment refers to the objects are augmented by computer generated information. Previously, there is a number of studies have discussed the importance of AR technologies in various domain, engineering, design. However, it is less focused on integrated the development of AR as a teaching aid kit for specific engineering subjects (Welding Technology). This study proposes a development of AR teaching kit using ADDIE models, which aimed to exhibit required skills for the specific welding technology task. An expert survey is conducted to evaluate the usability of the teaching kit based on the given score. Based on finding shows the positive usability score obtained from the expert validation. This AR teaching kit may facilitate teachers throughout the teaching and learning process.

Keywords: *Teaching kits, Augmented Reality, ADDIE Model, Expert Evaluation, Usability Testing*

1. Introduction

Augmented reality (AR) refers to technologies those bridging virtual and real words, which create reality that it is enhanced and augmented [1]. The application and implementation of AR system have been discussed in various fields, and its show the importance and benefit of using it such as business, environmental, marketing and including in education. In the context of education, the main advantages of AR application commonly found to be essential in activity of students, cost and safety [2]. During learning session, AR can help in allowing content to be well-presented in comprehensive and meaningful ways including training of practical skills in technical and vocational courses.

Besides, AR technologies help students to engage and explore the virtual object (e.g. text, videos, graphics) whereby they can conduct and observe the real world practically [3]. Secondly, the use of AR technologies can extend to the integration of real-world and digital learning resources. It is can be cost reduction by replacing real expensive resources, for example laboratory equipment and supplies, with their virtual counterparts. Students are able to learn and understand the theory taught in class easier compared to 2D images or videos. In addition, AR application also can be significant for safety issue. Learning and training new machining kits sometimes too dangerous to novice or unskilled learners as the first place, therefore AR environment can helps students to explore the new machine or kits (e.g. how it's works, potential failure and function). However, Bronack (2011) [1] stated that AR technologies required high-end electronics device and experienced kits, which is not suitable for educators, and new-skilled students, but it is shall be emphasized on the how technologies support and provide comprehensive learning.

Furthermore, a new set of skills that can be essential in engineering based practice which AR learning environment can be promoted. For example, cognitive skills that highlighted on visual and cognitive ability. Thus, in this paper researchers wish to develop an AR teaching kit for engineering subjects, that emphasized on potential failure in welding course. The remainder of this paper is structured as follows. Section 2 presents a research background review focused on the Argument reality. Section 3 presents development of AR teaching kit, Section 4 presents experimental results are presented and discussion and lastly, Section 5 concluded of overall paper.

2. Related Studies

2.1. Augmented Reality in Education

The use of new technologies in the teaching and learning process, as the case of devices with the use of Augmented Reality (AR), captures student and teacher's attention, creating the expectation that its use can provide the participants with new ways of interacting, new possibilities for collaboration and potentially an increase in motivation for learning [4,5]. Previously, there are number of studies have

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been discussed on instructional and learning design of AR learning situation, such as gamed learning [6], role playing, studio-based pedagogy [7], participatory simulations[8]. For example, Mathews and James [7], have proposed a studio-based curriculum intervention aimed at engaging students in the design of place-based mobile games and interactive stories using geo-locative technologies, in particular collaboratively designing an AR simulation and explores how the embedded design practices align with a socio-cultural view of literacy.

Based on literature survey, there are the main issues that gain attention among academician society: (i) technologies used – On how various of AR kits can be optimally used in teaching and learning process, (ii) pedagogical issue – discuss on implementation of AR system in classroom, teaching and learning limitation, (iii) Learning issue – A wealth of data and information given to students, may lead to the large cognitive load and complex tasks.

As mentioned, one of the main issues is AR technologies used and the implementation in teaching and learning process which is large and expensive design. For example, head-mounted display and/or an additional backpack with computer equipment used that can cause discomfort and poor depth perception [9]. However, current developments and rapid development, Klopfer & Squire [8] have developed a portable technologies that helps in enhancing a immersion and presence by integrated a multiple hardware and software devices.

Besides, issue on pedagogical strategies during its implementation in classrooms. Learning activities associated with AR usually involve innovative approaches such as participatory simulations and studio based pedagogy required educator to shift the traditionally instructional design (e.g. teacher-centred, delivery-based-focused) [10]. Lastly, In an AR learning environment, students can leads cognitively overloaded because large amount of information they encounter, the multiple technological devices they are required to use, and the complex tasks they have to accomplish [11, 12]. Besides, it is acquires students to gain and synthesize multiple complex skills in spatial navigation, collaboration, problem solving, technology manipulation, and mathematical estimation

3. Methodology

This part is divided into three main parts. Section 3.1 describes experimental setup and analysis and Section 3.2 illustrates the development of instructional kit for use in the teaching and learning process show the operational framework has been developed.

3.1. Experimental Setup and Analysis

A total of 5 experts from different background were selected as shown in Table 1. Expert evaluation is used early in the design process of teaching kit, which aimed to ensure that design problems are not built in. Experts were given the questionnaire survey which consists of two parts, (i) usability: evaluation to improve the acceptance and user experience and (ii) design content: evaluation to determine the suitability of content for targeted user. Experts were no given any specific time to fill up the questionnaire as it is conducted face to face. However, it is only taking approximately, 30 minutes minute to finish.

Table 1: Experts Profile

No.	Evaluation Elements	No of Expert
1.	Subject matter experts (Welding) for specimen/content evaluation	3
2.	Teaching representation kit	2
	Total	5

3.2. Development of Augmented Reality Teaching Kit

The development of this instructional was based on the ADDIE development model. ADDIE stands for Analysis, Design, Development, Implementation and Evaluation that represents the important phases in developing a good instructional kit. Figure 1 shows in summary the process involved in developing the instructional kit using ADDIE model.

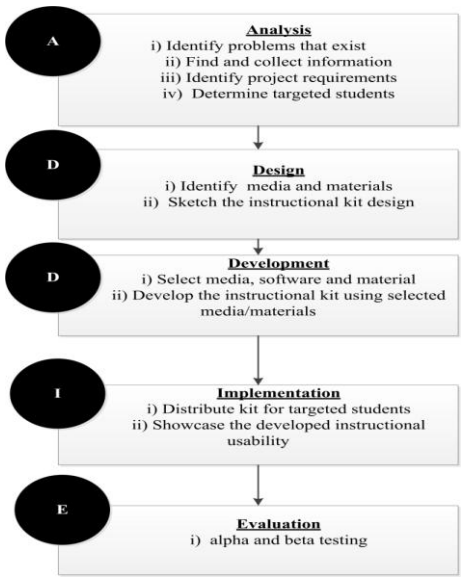


Fig. 1: Development of AR kit instructional using ADDIE model

Analysis: Firstly, describe the process of what is going taught in the classroom. At this stage, instructional designer determines the analysis need based on existing problem such as knowledge gaps, skills and attitudes. The analysis process covers the problems faced,

product requirements include the objective of developing the product. The analysis phase becomes the determinant of the 'input' selection that is the basis for the development of a product.

Design: In this stage, instructional designer determines on how the information is going to be learn. To meet this purpose, the instructional method, learning activities and assessment breakdown need to be clear at analysis stage. For this design stage, the instructional designer producing a teaching kit sketch that can be easy to carry out by the teacher for teaching and learning.

Developement: The multimedia components are prepared during this stage. This is the process of producing the instruction materials, all the kits which will be used during instruction and any kind of support materials. The product is created during this phase and an evaluation, which is mostly for correction, is made and modifications are carried out if necessary. Furthermore, The instructional designer should develop the teaching kit according to the features in the design phase which involves cost, materials, and safety aspects. These aspects should be applied to create an attractive, easy-to-carry and user-friendly teaching kit.

Implementation: In this stage, the training materials and related materials are implemented temporarily, to determine their impact on the real world. This phase involved the development of teaching kit as planned in the development phase. In this phase, testing was also made. Testing will be made on teaching kit which will be developed by the researcher. This phase will also involve target users in which users in which users will use this teaching kit prototype before being evaluated by an experts.

Assessment: For this stage, the teaching kit will be evaluated from two aspects of the assessment such as usability assessment and suitability. From the aspect of usability assessment, five experts will evaluate the developed teaching kit in the context of Useful contents, suitable for teaching kit, useful of subject contents, space-free, ease to handle, ease to use, content safety elements, technical aspects, user friendly and attractiveness. Whereas in terms of suitability, teaching kit will be evaluated by two teachers who teach the subject of Welding Technology in terms of effectiveness to target consumers.

For this study, the analysis phases, an observation and preliminary survey is conducted in order to determine the educational objectives. It is included the problems faced both from students and teachers' perspectives. For example, the common welding failure happens during the practical session in Batu Pahat Vocational College, Johor Malaysia. Based on the preliminary survey, this study found there are three main problems as follows:

- Lack of visualization skills in which students are facing difficulties in applying the theory and knowledge in the classroom into practical
- Traditional pedagogical approaches used by teachers.
- The cognitive load is not well organized by educators during practical sessions

Next, the design phase is discussed on a selection of educational contents and materials. In this context, the initial draft of teaching kit must be designed in order to plan and avoid the time consuming progress during the development process as shown in Fig. 2

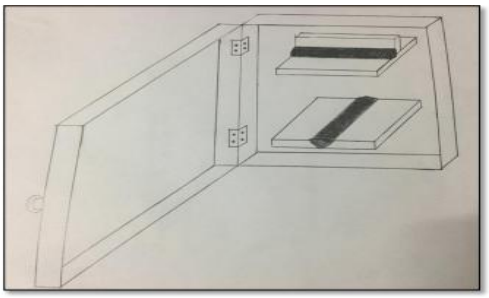


Fig.2: Initial draft of teaching kit's contents

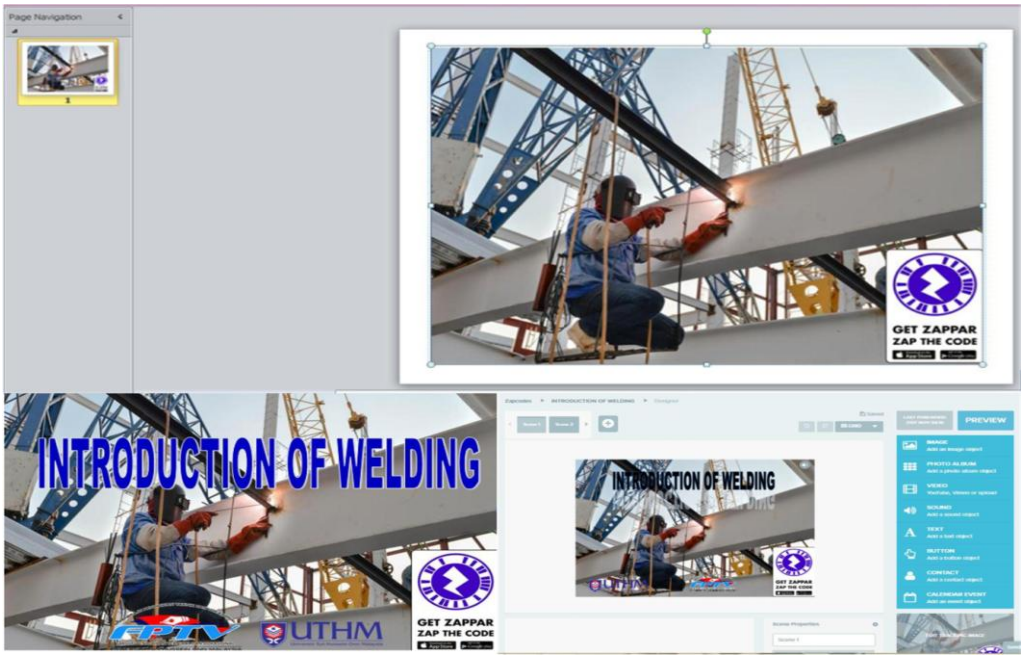


Fig. 3: Development of AR teaching kit

The development process for the teaching kit includes pre-design analysis (e.g. initial sketches, story board, contents, graphic) and practical material (ready to use, good accessibility) to be used for targeted user and meet the educational objectives. Table 2 shows the analysis and selection process for design the teaching aid. For example, ergonomics elements that have been considered in this study is aimed for identifying risk, reducing risk, verifying risk reduction, managing injuries and maintaining teaching sustainability. Besides, all the materials used is developed from open-source softwares.

Table 2: Selection Elements.

No.	Selection Elements	Description
1.	Ergonomics	Teaching kit must be suitable for targeted students and teacher
2.	Safety	User friendly materials and kits.
3.	Materials	Graphically, long term usage.
4.	Cost	Free source

Figure 3 shows the partially development of AR teaching kit using selected kits such as Microsoft publisher, Zappar interactive delivery channel serving video, animation, games, competitions, additional information, data capture mechanics), Pawtoon (creating animated presentations and animated explainer video), and Wondershare (video editing software). As implementation, this teaching kit is tested to 30 students in Vocational College in order to determine the usability, student achievement, and feedback. The researcher are currently implementing the effectiveness of the teaching kits, and shall reported in the subsequent publication. Lastly, the evaluation phase. In ADDIE model, there are two main evaluations which are summative and formative. In our previous paper, researchers have explicitly discussed on the teaching style, visualization and cognitive load toward development of augmented reality teaching kit. In this paper, researchers have discussed on the usability testing based on the expert validations. The selection of experts is based on her/his teaching experience and subject matter experts.

4. Result and Discussion

In this section is presented the usability testing based on the expert point of views, (i) expert evaluation of teaching kit and (ii) individual expert validation. Based on Fig. 4 a sample mean is calculated for all the questionnaire item score. A successful teaching kit is one in where the stated learning outcomes or objectives align with teaching activity and assessment. For the design items questionnaire, experts were agreed the proposed teaching kit is easy to handle (88%) that indicate the highest score for this elements. Besides, the useful of subject contents presented among the lowest score of, (72%), however it is still deemed accepted threshold of 70% based on Tuckman and Waheed value on achieving a high acceptance level [13] .

In addition, for the teaching kit design the user friendly items shows the highest percentage score, 88% which presented the video, text and graphical representation on this suitable to be used for the targeted students. Its followed by the technical aspect used (84%) and the attractiveness of the teaching aids (80%). The developed teaching kits, are generally based on the a few characteristics (e.g. informative but it is not just entertainment, very useful and can be used in many lessons and at different class levels, helping in realization of stipulated learning objects, suitable to the cognitive level of the students.

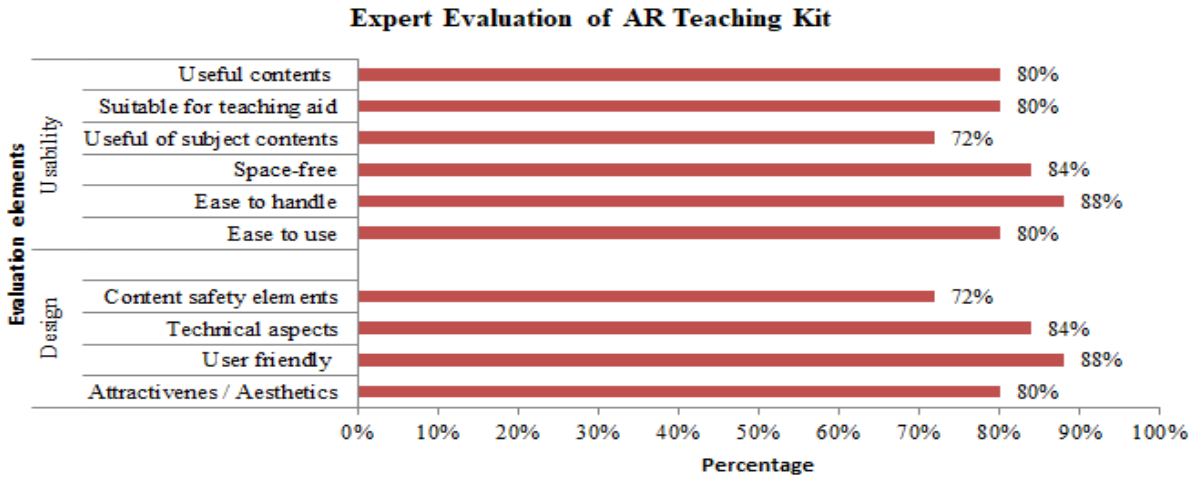


Fig. 4: Experts Evaluation

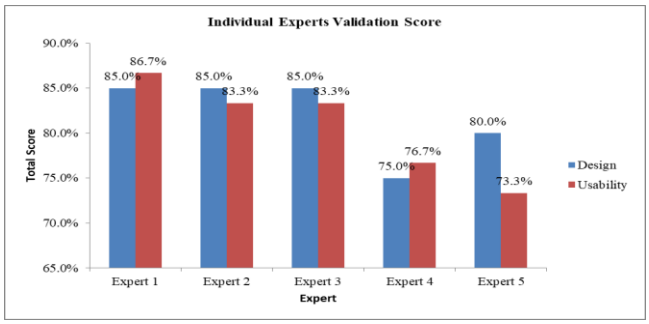


Fig. 5: Development of AR teaching kit

Fig. 5 shows the individual score of developing AR teaching kit. The questionnaire survey is sorted into two parts, design and usability score. Three of the experts were obtained highest score for both usability and testing score, on the other hand, there are some improvements need to be improved. Thus, our findings show, the teaching kits are acceptable to be used as the teaching kits in welding subject.



Fig. 6: Usability and suitability testing for teaching kit

Fig. 6 shows the teacher doing an evaluation of the teaching kit in the classroom to check the features, the suitability of the material with the contents of the taught lessons is important to ensure that the content of the lesson is presented clearly to the students, so that the student's strength, clarity and attractiveness must be fulfilled [14].
According to Sung, Chang and Liu [15] the features emphasized in the design of the AR teaching kit are easy to operate, having multiple functions and small and light sizes. The findings show the appropriate size of the AR teaching kits and the easy way to handle the teaching and learning process. The advantage of this AR teaching kit is dynamic, which is besides being used for experimental or practical activities in workshops, this kit also can be used for the purpose of making demonstrations in the classroom [15].
Besides, the use of teaching kits in the teaching and learning process is able to enhance students' understanding. The advantage of using AR is to allow students to imagine objects and concepts that are invisible to the naked eye. AR envisions concepts and objects in various ways and perspectives which enable students to master the subject [16]. The evaluation results from the development of this AR teaching kit showed that the the teaching kit was able to assist students in improving their understanding and performance in learning [17]. In addition, the use of additional teaching materials by teachers during the learning and teaching process will help improve the cognitive and affective qualities of students demonstrating that the developed teaching kits work well in the teaching and learning process[18]. Furthermore, the use of AR teaching kits can provide more insight than teachers' teaching styles that are solely based on teachers.

5. Conclusion

Overall, the analysis results from the study found that the teaching kits developed are in line with the objectives of the study which have been described. The contents, welding defect are also able to assist students and attract students with the help of AR technology that can facilitate teachers throughout the teaching and learning process. The developed AR teaching kits need to have friendly features users were easy to carry and small size. In addition, safety features that are taken into account when developing this teaching kit to ensure the users are safe during the implementation. For instructors, the use of teaching kits gives an alternative strategy in the learning process where the latest technology is introduced and able to increase student motivation to pay attention during teaching process. The purpose of this teaching kit will get the students attention more using technology in learning rather than traditional methods which is apply a text module only. The use of AR technology in education is able to attract students, which students are able to understand, interpret, analyze and interact continue with the virtual world. However, the development of a teaching kit must satisfy the content in a subject in order to achieve the goal the development.
In further research, researchers wish to develop a teaching kit can cover the topic of the scrutiny skills subject. There are three levels that need to be contained in the content: high, medium and low levels. These three levels should be in the content so that the teacher can choose the appropriate level according to the student's performance. Lastly, based on the finding, it shows the promising research contribution that's able to meet both students and teacher requirements.

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