JTET

Journal of Technical
Education and
Training

Development of Augmented Reality Applications in Teaching and Learning for a topic of Current and Voltage Division for Technical and Vocational Education

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Abstract: The combination of technology Augmented Reality (AR) with educational content aims to create new ideas that can improve the effectiveness and attractiveness of teaching and learning for students in real-life scenarios. The use of AR technology can make the process of teaching and learning more enjoyable, in which students' interest in learning can be stimulated. The AR technology has three characteristics. The first feature is that AR technology is a combination of virtual objects with the real world. The second feature is that AR operates in real time and interactively. The last feature is that it has 3 dimensions (3D) for virtual objects. In this study, the ADDIE model includes five phases, namely Analysis, Design, Development, Implementation and Evaluation, which are utilised to develop applications based on AR technology in education for the topic of Current and Voltage Division. To identify the effectiveness of the application of AR technology, a survey using questionnaire was conducted among pre-service teachers to know their perceptions of the development of AR applications namely as Voltrent AR. As this is a quantitative study where questionnaires were distributed to 73 students from the class of Bachelor of Technology with Education (Electric and Electronics) with Honours and Bachelor of Technology with Education (Living Skills) with Honours at Universiti Teknologi Malaysia (UTM) Skudai, Johor. Most respondents gave very positive feedback on the use of AR in education, especially for the topic of Current and Voltage Division. AR is viewed as a medium of instruction that is innovative, interesting and effective. Voltrent AR application development is successfully developed based on the ADDIE model, and the application development of the constructivism theory was applied in this AR application. Thus, the AR application development has reached the desired objective of producing application-based Augmented Reality as a teaching aid.

Keywords: Augmented reality, ADDIE model, constructivism theory

1. Introduction

The use of technology in teaching and learning activities has been applied since a long time ago. The use of technologies, such as Information communication technologies (ICT) as a medium and tool of instruction in teaching and learning, can assist both instructors and students in their respective teaching and learning Carr-Chellman (2011). This is because ICT in education is the main medium of instruction and teachers act as facilitators in line with the country's ICT policy in education, which began in 2010 as announced by the Ministry of Education Muhammad Pozi & Khalid, 2017).

The use of technology is more dependent on the ability of students and content to be delivered by the instructor (Gagne et al., 2005). According to Kirkley (2004), the changes caused by technology in the education system will inevitably provide an interesting, realistic, authentic, and fun learning environment as well as improved the learning process that will lead to better academic results.

According to Haller, Billinghurst and Thomas (2007), to ensure that the education system can deliver quality education, the education system in Malaysia has undergone tremendous changes. The changes caused by this technology in the education system will provide a learning environment that is attractive, realistic, authentic, and fun. In turn, it can enhance the learning process and lead to better academic results. This development has led to an increasing number of researchers, including different faculties that have shown interest in integrating various emerging technologies in teaching and learning activities. Consequently, various technologies have been incorporated into the world of education such as internet usage, e-learning computer, social web, simulation, and the latest technologies such as virtual world and Augmented Reality (AR). According to Baldiris, Fabregat and Graf (2014), the application of AR in electronics technology is an emerging technology in the field of education. AR is a system that combines the real world with virtual objects (Danakron, Ali, Abd Halim (2013). With reference to Fleck, and Simon (2013), AR is one of the technologies that allow experience and location-based learning by manipulating time, position, angle, rotation and movement of the virtual object while allowing the user to understand a particular concept. AR aims to develop technology that allows the incorporation of real-time digital content with the real world using a computer (Omar et al., 2019; Gustafson & Branch, 2002). According to Jabar et al., (2020), AR technology allows 2-dimensional and 3-dimensional objects to be viewed in the real world. This technology can load certain information into the virtual world and display them in the real world with the help of tools such as computers, smartphones (android) and webcams. Users will not be able to see 2-dimensional and 3-dimensional virtual objects in the real world. In order to see the virtual objects, the computer and the camera are required as intermediaries

The applications based on AR technology is very helpful to attract students' interest in teaching and learning approach. According to Savill and Kent (2003), the use of advanced technology such as mobile devices increase student motivation, organizational skills, create a sense of responsibility, shape learning collaboratively and help to student progress more quickly and efficiently. According to Fleischman (2001), the use of AR provides a productive learning environment to assist the teaching and learning process conducted in theory classes. The problems faced in the current educational system are that AR-based applications are not widely used as a teaching aid particularly in technical and vocational education (TVE). This is because the teaching aids is currently more focused on the use of lecture notes and teaching modules (Jambari et al., 2018). As a result, students often lose interest and focus during the teaching and learning process. Due to the pandemic Covic-19 and online teaching become most important, thus the application of AR was created to produce the learning environment more effective particularly in engineering and technical and vocational courses. Thus, the presence of AR-based applications can optimise the teaching and learning process, resulting in a new and fun learning experience. Therefore, this study aims to develop an AR-based learning application based on the ADDIE model and identify perceptions on the effectiveness of AR-based learning applications for the Current and Voltage division.

2. Augmented Reality (AR) Technology

AR technology is a new technology that promises a huge advantage to the world of education today. The definition of AR has various meanings by researchers from the field of computer science and the field of education. Milgram et al. (1994) define AR as the combination of virtual objects with the real world where users will be able to see in real-time. In addition, there are researchers such as Azuma (1997), Kaufmann (2003) and Zhou et al., (2008) which defines AR technology based on characteristics. AR technology has three characteristics namely first, AR technology is a combination of virtual objects with the real world. The second feature of these researchers stated that AR operates in real-time and interactively. The last feature is that AR is created in 3Dimensional (3D) form for virtual objects. Höllerer and Feiner (2004) also stated that AR technology is a system that combines both information, namely computer-processed information and actual information. Martin et al., (2011) define AR technology as a system that uses a webcam to combine information such as images and videos. El Sayed et al., (2011) stated that this AR carries the meaning of inserting virtual objects in real scenes such as additional information to incomplete information in the real world.

According to Pence (2011), AR consists of three methods which are; Marker-based AR, Markerless AR and GPS based tracking. A marker-based AR is an object displayed in a real environment that requires a specific marker or label. According to Rizki and Hariadi (2012), markerless technology that is evolving through android devices resulted from AR technology being more attractive and can be used regardless of time and place. GPS based tracking methods are now increasingly popular and widely used in mobile phone applications such as Internetwork Operation System (IOS) and Android. This method will access GPS and compass by taking the data available in the mobile device which in turn will show in real-time (Yahya et al., 2011).

2.1 Application Development Theory AR

Teaching and learning using technology have high efficacy results through the integration of the pedagogy principles and instructional design principles (Larson & Blockee, 2014). The Constructive theory was applied regarding the development of the Voltrent AR. The constructivism theory describes the active process of students in developing knowledge and new concepts based on experiences. Therefore, the design of applications through this theory emphasises aspects such as building new knowledge based on experience and knowledge of the existing students (Ertmer & Newby, 2013). In addition, it is concerned with the preparation of learning content that is acceptable to students. The next aspect is the use of various information access channels and collaboration tools for learning. Finally, the learning should be student-centred.

2.2 Application Development Model AR and Graphics

Instructional design is a process of creating a body of teaching as printed modules, software and so on. There are various forms of an instructional design model for use in the process of software design. Construction software contains the model that can be used as a guide when designing a piece of software. The model has always been a reference for developing the software, namely ADDIE Model. A study by Larson and Blockee (2014), also adopted the same model while developing AR teaching aid for the vocational subject.

2.3 ADDIE Model

The ADDIE model of instructional design is the foundation that can be used in any learning strategy (Larson & Blockee, 2014). In addition, it is a generic model, which has a systematic approach to the process of designing instruction and provides designers with a systematic framework to ensure that the products facilitate effective education, and that creative processes are very efficient. The model is shown in Figure 1, which consists of five phases.
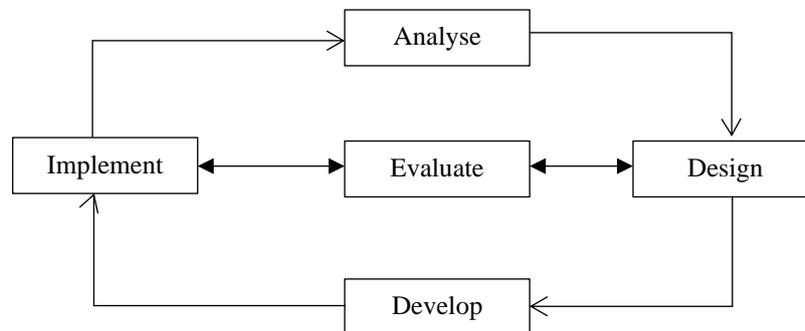
Fig. 1 - Chart ADDIE Model (ADDIE Rossett (1987)

3. Methodology

The methodology of the research has been described in detail in the sub-section as follows.

3.1 Research Design

This study uses the quantitative method to identify the perceptions on the design and content of AR-based learning applications for the Voltage and Current division. The researcher using purposive sampling for this research. The respondents consist of seventy-three students from the program of Bachelor of Technology with Education (Electric and Electronics) with Honours and Bachelor of Technology with Education (Living Skills) with Honours who taken the subject of Basic Technology Electronics. The respondents are 40 female and 33 males, who are all future teachers. The questionnaire used consists of two parts: Part A and Part B. Part A covers the respondent demographics and Part B is concerned with product development.

3.2 Development Model

The ADDIE Model was selected as a guide in developing the AR which included five phases as in Figure 1. This model is appropriate in terms of the preparation of a systematic step in the development of AR applications.

3.2.1 Analysis Phase

The analysis phase is the process of determining and identifying problems. Among the forms of analysis conducted are analysing the learning environment, analysis of student characteristics and problems in learning, Furthermore, this analysis can help in determining the skills or knowledge that should be learned as well as identify the attitudes of students and teaching goals (Dick & Reiser, 1989). From the survey, by using google form represent that 50 percent of students leaking on the skills and knowledge to solve the problem of the current and voltage divided topic in the Basic Technology Electronics course. Thus, this software was developed to overcome the problem, particularly in the current and voltage divided rule.

3.2.2 Design Phase

This second phase aims to determine and design the instructional method to be used. This stage is implemented after the analysis process is completed. At this stage, the design phase explained the overall view of the form, structure, theoretical approach, type of media and technology to be used. In addition, this stage also involves the process of forming objectives specific to teaching.

In this research, the circuit design process was done using WPS Office 2019 software. This software is selected due to being free, easy and very user friendly. Two types of circuits namely Voltage and Current Divider are selected. The battery and resistor are used to design the circuit. Figure 2 and Figure 3 show the results of the circuit that was created by using WPS Office 2019.
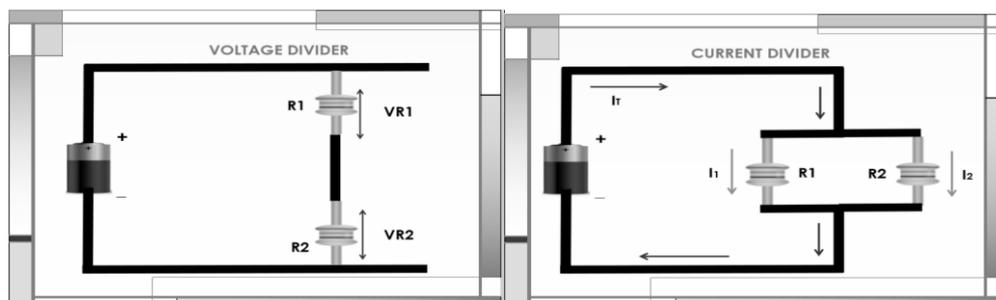
Fig. 2 - Voltage divider circuit   **Fig. 3 - Current divider circuit**

3.3.3 Development Phase

During this development phase, the researcher was used the Unity software to ensure the circuit animation for the voltage divider and current divider is successfully generated. The use of Vuforia software is to ensure that the quality of the picture is produced and transferred to Unity software. In addition, the researchers are able to build these applications more efficiently, which improve the software quality and user-friendliness. The Vuforia and Unity software are used for developing applications based on this AR technology. There are eight criteria established by the researchers in the construction of this application namely as Voltrent AR by using Vuforia and Unity software which includes:

a)   This teaching aids can attract users.
b)   The teaching aids must have a clear visualization.
c)   The teaching aids must have a clear explanation.
d)   This teaching aids can reveal the complex topic of Current and Voltage division.
e)   The teaching aids is in need of tools.
f)   The teaching aids is using user interfaces (UI) of interest.
g)   The teaching aids influence the teaching and learning process.
h)   This teaching aids can facilitate the learning process of the PDP in line with the 21st century

Figure 4 shown the main display of Vuforia software for developing the AR application.
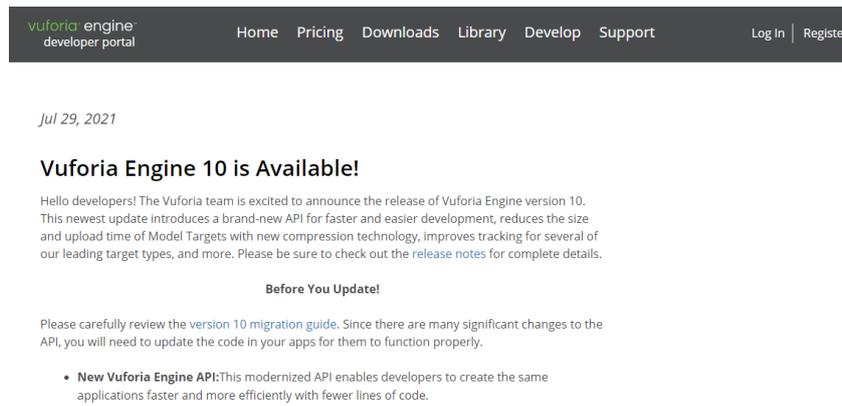
Fig. 4 - Main display of Vuforia Software

3.3.4 Implementation Phase

The implementation phase involves the process of running a learning program or module in a real-life context. It aims to deliver or implement teaching efficiently and effectively. There are three button options placed on this main display namely the Voltage, Current and exit buttons as shown in Figure 5. The Voltage button is to go to the next page which is the voltage section, and the Current button is to go to the next page which is the current section. While the exit button is to exit this application.
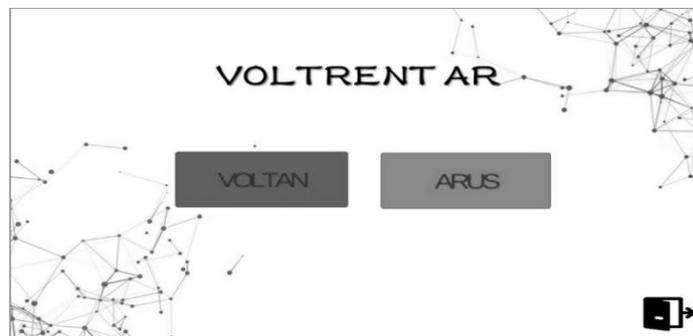

Fig. 5 - Main menu display

3.3.5 Evaluation Phase

The evaluation phase was focusing on the development of the product referring to the eight criteria as in subsection 4.2.3. A total of 73 students from the program of Bachelor of Technology with Education (Electric and Electronics) with Honours and Bachelor of Technology with Education (Living Skills) with Honours who learnt the course of Basic Technology Electronics were chosen to answer the question by using google from. The questionnaire was distributed online and data was analysed using SPSS 20.0. The main purpose of this stage is to validate the eight criteria of the product as mention in subsection 3.3.4

4. Results and Discussion

This assessment contains eight criteria related to the review of this application. The questionnaire was distributed to a total of 73 students of Bachelor of Technology with Education (Electric and Electronics) with Honours and Bachelor of Technology with Education (Living Skills) with Honours who learnt the course of Basic Technology Electronics. The respondents were selected to answer the questionnaire for Part B regarding the eight criteria for product development in order to identify the validity of the design and content of the product. The data was analysed using SPSS 20.0 and represented as a percentage. Table 1 shows the results of the research conducted.

Table 1 - Research results

1	2		3	4
Strongly disagree (SD)	Disagree (D)		Agree (A)	Strongly agree (SA)
No	Description	Scale		
		SD	D	A	SA

No	Description	SD	D	A	SA
1	The teaching aids are attractive to study the topic of current and voltage division.	-	-	5(6.8%)	68 (93.2%)
2.	The visualisation of teaching aids is clear.	-	-	13(17.8%)	60 (82.2%)
3.	The explanation of the content is easy to understand.	-	-	18(24.7%)	55 (75.3%)
4.	The teaching aids can reveal the complex topic of current and voltage division	-	-	13(23.1%)	60 (82.2%)
5	The teaching aids is user friendly.	-	-	-	73 (100%)
6	The user interface of the teaching aids is interesting.	-	-	5(6.8%)	68 (93.2%)
7	The teaching aids influence the teaching and learning process.	-	-	5(6.8%)	68 (93.2%)
8	The teaching aids can facilitate the learning process in line with the 21st-century education.	-	-	-	73 (100%)

Based on the survey results in Table 1, criteria 5 and 8 had achieved the highest ratings, with 100% responses on the scale of strongly agree. This result shows that all 73 respondents fully agree that the application developed is user-friendly and facilitate the learning process of the teaching and learning in line with the 21st teaching aid education. The second-highest rating is from criteria 1, 6 and 7. A total of 68 respondents strongly agree with these three criteria and only five respondents agree that teaching aids is attractive, has an interesting User Interface and simplifies the teaching and learning process. Overall, the respondents strongly agree that this application is highly effective to be used in the teaching and learning process.

With relating to constructivism which is a theory of learning that focuses on students' active process of gain knowledge and new concepts based on experiences. Moreover, this theory emphasises student-centred learning. The theory also stresses that the preparation of learning content must focus on content that will be easily accepted by students. Table 1 shows that, overall, the respondents agree that this AR application meets the criteria. The 68 respondents strongly agree that AR application is able to attract users and 73 respondents strongly agree AR application is user friendly. Thus, with emphasis on aspects such as student-centred learning and learning content preparation tools based on the Constructivism theory, the development of Augmented Reality applications will simplify the teaching and learning process.

Furthermore, in this study, all phases in the ADDIE model have been applied, which are Analysis, Design, Development, Implementation and Evaluation, to develop an AR application namely as Voltrent AR. The ADDIE model is selected for the Voltrent AR development as it is a popular model of instructional design and is often used as a source of reference for other models (Carr-Chellman, 2011). Larson & Blockee (2014) show that almost all models of instructional design based on the ADDIE model have five stages, namely Analysis, Design, Development, Implementation and Evaluation. After Voltrent AR was successfully completed, the researchers have obtained user feedback through the questionnaire conducted among 73 students from the class of Bachelor of Technology with Education (Electric and Electronics) with Honours and Bachelor of Technology with Education (Living Skills) with Honours, all of whom are future teachers. The finding also stated that most students agree the Voltrent AR is attractive and user friendly to learn voltage and current division in electronics courses. Furthermore, the WPS Office 2019, Vuforia dan Unity that has been selected are the appropriate tools in producing AR applications as teaching aids.

5. Conclusion

The development of this AR application has achieved the desired objective of producing an AR application that facilitates and accelerates the learning process for the topic of Voltage and Current Division. Most students strongly agree that the Voltrent AR is easy, attractive and user friendly to learn voltage and current division in electronics courses. The movement of 3D objects or animations added to the learning content makes it resemble real objects or content while the application is working. This causes the students can see the process of voltage and current distribution taking place in a circuit that is invisible to the naked eye. Furthermore, with this application, the students are able to view it intermediately via smartphone. Students can also understand this topic more easily because a description of voltage and current distribution is provided in this application. It is hoped that the production of AR-based application teaching aids can facilitate the teaching and learning process for students, teachers and instructors. Furthermore, the AR software also has a feature of teaching aid to attract the interest and attention of students, in terms of display and user-friendly interface.

AR applications that contain teaching aids have features such as animation and various colour combinations. Finally, this application was developed with the expectation that the students can have better focus when teaching and learning take place and facilitate the learning process in line with 21st-century education.

Acknowledgements

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