

Development of Application for Augmented Reality for Three States of Matter

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Abstract: The rapid development of technology and information has a powerful impact on education. Among the technologies that have been used is the use of Augmented Reality which can help improve the effectiveness of the delivery of learning content in the classroom such as facilitating students learning the topic of matter in chemistry form four by looking at the structure of particles in three dimensions and integrating them into the real world. The topic of the three states of matter is difficult for students to understand, especially for students with chemophobia and students who are less interested in learning about this topic. Therefore, this study is to design and develop Augmented Reality applications for the state of matter molecules (solid, liquid and gas) and to evaluate and test the functionality of the application. In this study, the researcher applied the product development method using the ADDIE design model which has five phases that is the analysis phase, design phase, development phase, implementation phase and evaluation phase. The research instrument used by the researcher is a questionnaire and expert verification form distributed to two multimedia experts and teachers who teach chemistry subjects. The results show that all the experts have responded positively to the development of this application in terms of content design, interaction design and interface design. The application is also well developed and has achieved the objectives of the study. This study can be further expanded by developing this application for other topics and using the iOS platform as well as uploading to the Apps Store or Play Store so that it can be exposed and used by anyone.

Keywords: Augmented Reality, ADDIE Model, Applications

1. Introduction

In accordance with the strategic essence of the 10th Malaysia Plan (10MP), innovations in technology have sparked widely over the application of technology in almost all sectors. Without a doubt, education is not excluded from the explosion of advanced technology. This has led to the rapid and widespread usage of technology in education. In the field of education in Malaysia, teaching aids

are no longer unique to use in the learning process as it makes the learning environment more attractive and at the same time achieves the aim of implementing 21st-century learning method as the teaching and learning process is implemented. Various technologies that have been used can help to improve the effectiveness of the delivery of classroom content. One of these technologies is the use of Augmented Reality in education.

Augmented Reality technology is capable of motivating students through intuitive functions and user-friendly interactions that will have an impact on better understanding the teaching and learning process (Chen, 2006). Billingham and Duenser (2012) supports that with this Augmented Reality technology, users or students will be able to observe and interact with virtual content in real situations. According to Mat & Halim (2002), he argues that multimedia technology plays an important role in making teaching more effective, active, and enjoyable as it helps student to see abstract and difficult things with naked eye.

The Secondary School Curriculum (KSSM) curriculum is designed to enable students to better understand chemistry in terms of theory, concept and application in daily life while developing their ability to recognize and solve related problems (Abu Hassan, 2003). The curriculum also aims to produce students with knowledge and skills in chemistry as well as to give them a degree in chemistry (and technology) at a higher level (Abu Hassan, 2003). However, to make sure that the goal is realized, school-based learning methods should be diversified, especially in science and mathematics as these subjects involve abstract elements and concepts that are difficult to understand (Md Dalhar & Bilal Ali, 2009).

There are several issues related to the level of acceptance and understanding of students in the classroom, especially in the subject of chemistry. One of the issues stated was that the subject of chemistry was too difficult for students to understand as they only understood things that are visible to the naked eye. In addition, some of the students with chemophobia in studying chemistry are concerned with learning chemistry as they are concerned with assessing and worried in using laboratory's apparatus and materials and this will have an impact on students' level of understanding. Furthermore, students tend to lose interest in studying chemistry because the teaching method used by the teachers does not appeal to student's interest and the limited use teaching aids will make the learning environment less interesting.

Therefore, by using Augmented Reality technology as teaching material, it will be able to increase student's morale and interest as it was best used when studying this topic. This is because the arrangement of the particles in each substance such as solid, liquid and gas are not visible to the naked eye (Sangguro, 2013). Accordingly, this Augmented Reality application can help students to see the arrangement of particles in three dimensions and integrate them into the real world.

1.1 Objectives

Three objectives were set to be achieved while conducting this research. The objectives are as follows:

- 1) To design an Augmented Reality application for the state of matter of molecules (solid, liquid and gas).
- 2) To develop Augmented Reality applications for the state of matter of molecules (solid, liquid and gas).
- 3) To evaluate and test the functionality of Augmented Reality applications for the state of matter of molecules (solid, liquid and gas).

1.2 Literature Review

Augmented Reality is a system that combines real information and virtual objects which is the information generated by computer in real-life environment, interaction between virtual objects in

virtual-real method and displays virtual object orientation aligned with real objects (Hollerer & Feiner, 2004) while matter is something that have mass and occupied space. In this research, matter consists of solid, liquid and gas material which can be found in the Earth itself. Matters have alignment, movement of particle according to temperature and force of attraction between particles. Augmented Reality allows student to obtain new experience in increasing their level of knowledge as well as intriguing them to concentrate more towards teaching and learning process in progress (Zaki, Zain & Zaniabdin, 2018). Students will understand more because they can observe and learn every process that were visualized in every perspective and viewpoint of 3D objects easier (Teguh Martono, 2011).

2. Methodology

The method used in this research is a method of development or study of development (Sugiyono, 2012). Development studies are the research method used to produce a product and test the effectiveness of the product. In this research, the design model used is the ADDIE model involving five phases of the analysis phase, design phase, development phase, implementation phase and evaluation phase. Then, a quantitative data collection method was developed for the development of Augmented Reality applications for three states of matter.

2.1 Population and the sample

The researcher selected three experts which are two Creative Multimedia Lecturers and one chemistry teacher from SMK Raja Muda Musa, Bestari Jaya, Selangor to evaluate the application of Augmented Reality for the three developmental phases. Creative multimedia lecturers are selected as interface experts to evaluate the functionality, application interactions and models developed using 3Ds Max software. Meanwhile, a chemistry teacher is a content expert to verify that the information obtained and used in the application is valid or not.

2.2 Research Instrument

In this research, the quantitative data collection method was selected as the research instrument using the questionnaire form. This is because the development of the Augmented Reality application for three states of matter requires feedback from the relevant respondents to determine whether they satisfy the needs of the user and achieve the set of objectives.

2.3 Data Analysis

The data obtained by the researchers from the experts involved were analysed for frequency and percentage values. Besides, the researcher obtained expert results based on the selected Likert scale. This makes it easier for researchers to evaluate the frequency and percentage of each response. Next, the expert also provides comments and suggestions on the questionnaire conducted. The comments and suggestions provided should be evaluated by the researcher for improvement in the development of the Augmented Reality application for three states of matter.

3. Results and Discussion

Two experts have evaluated the level of functionality, interaction design and interface design for Augmented Reality application for three states of matter that is creative multimedia lecturers with expertise in multimedia and interfaces. Additionally, a specialist in Chemistry teacher has evaluated the content and functionality of the application being developed

3.1 Expert Analysis for Interface Design

Part C of the expert questionnaire form contains thirteen items that have been developed for the interface design evaluation of the Augmented Reality application for three states of matter. Data were

analysed and presented using frequency and percentage values. Table 1 shows items, frequency, and percentages for testing the interface design by experts.

Table 1 Frequency rate and percentage of experts that test the interface design

No.	Item	Very Disagree 1	Disagree 2	Not Sure 3	Agree 4	Very Agree 5
<i>(C) Interface Design and Multimedia Element</i>						
1.	Content provided is visible to be read by user	0	0	0	2 100%	0
2.	Information displayed is not too packed in an interface.	0	0	0	2 100%	0
3.	Color usage on text within the application was appropriate	0	1 50%	1 50%	0	0
4.	Color usage on application’s background is appropriate	0	0	0	2 100%	0
5.	Color usage on button is appropriate	0	1 50%	0	1 50%	0
6.	Size usage on button is appropriate	0	0	0	2 100%	0
7.	Size usage on text is appropriate	0	0	0	2 100%	0
8.	Type of text used was appropriate	0	0	0	2 100%	0
9.	Usage of audio background for the application is clear	0	0	0	2 100%	0
10.	Usage of background audio for the application is appropriate	0	0	0	2 100%	0
11.	Application have applied elements of consistency in terms of arrangement in every interface	0	0	0	2 100%	0
12.	Application have applied elements of consistency in terms of color in every interface	0	0	0	2 100%	0
13.	Application have applied elements of consistency in terms of button in every interface	0	0	0	2 100%	0

Based on the results of the questionnaire analysis in Table 1 the researchers found that all the experts agreed on the design of the developed application interface. However, item four found that one expert disagreed that 50% was equivalent and one expert was uncertain 50% with the use of text colour used in this application. In addition, item six also indicates that an expert disagrees with 50% and another expert agrees that 50% of the percentage value of the colour usage statement on the button is appropriate.

In addition, these developed applications require enhancements such as reviews and suggestions from experts who state that the Solid, Liquid and Gas buttons found on the Main Menu page need to use a clear text colour to look counter to the background of the page.

3.2 Expert Analysis for Interaction Design

Part D of the expert questionnaire contains seventeen items that have been developed for assessing the interaction design of the Augmented Reality application for three states of matter. Data were

analysed and presented using frequency and percentage values. Table 2 shows items, frequency rates and percentages to test the interaction design by the expert.

Table 2 Frequency rate and percentage of experts that test the interaction design

No.	Item	Very Disagree 1	Disagree 2	Not Sure 3	Agree 4	Very Agree 5
<i>(D) Interface Interaction Design with Users</i>						
1.	Application allows user to exit the application at any time	0	0	0	2 100%	0
2.	Navigation button was attached at the exact interface					
i.	Start (States of Matter)	0	0	0	2 100%	0
ii.	Setting	0	0	0	2 100%	0
iii.	User Manual	0	0	0	2 100%	0
iv.	Main Menu (Types of Matter)	0	0	0	2 100%	0
v.	Solid	0	0	0	2 100%	0
vi.	Liquid	0	0	0	2 100%	0
vii.	Gas	0	0	0	2 100%	0
viii.	Shape & Volume	0	0	0	2 100%	0
ix.	Compressibility	0	0	0	2 100%	0
x.	Rigid or Fluid?	0	0	0	2 100%	0
xi.	Scan Augmented Reality Camera	0	0	0	2 100%	0
xii.	Exit	0	0	0	2 100%	0
3.	Application use non-linear interaction	0	0	0	2 100%	0
4.	Navigation button developed in the application works perfectly	0	0	0	2 100%	0
5.	Navigation button's position in the application is appropriate	0	0	0	2 100%	0

Based on the results of the questionnaire analysis in Table 2, the researchers found that the experts agree with the interaction design of the developed application. However, these developed applications require improvements such as reviews and suggestions. One of the experts suggested adding a rating such as a quiz to ensure that the developed application creates a two-way interaction between the user and the developer.

3.3 Expert Analysis for Content Design

The content expert evaluation form contains six items that have been developed for the content design evaluation of the Augmented Reality application for three states of matter. Data were analysed and presented using frequency and percentage values. Table 3 shows the items, frequency, and percentages for the evaluation of the content design of the application by the expert.

Table 3 Frequency rate and percentage of experts that test the content design

No.	Item	Very Disagree	Disagree	Not Sure	Agree	Very Agree
		1	2	3	4	5
<i>(B) Application Content Design</i>						
1.	Content achieve objective in increasing student's level of understanding	0	0	0	0	1 100%
2.	Content given is the same as Form 4 Chemistry syllabus	0	0	0	0	1 100%
3.	Arrangement of particle displayed is precise according to real content	0	0	0	1 100%	0
4.	Content given is easy to understand by student	0	0	0	0	1 100%
5.	Language used in the application was easy to understand	0	0	0	1 100%	0
6.	Content used is precise with the application's title	0	0	0	0	1 100%

Based on the results of the questionnaire in Table 3, the researchers found that all the experts agreed with the content design of the developed application. However, these developed applications require improvements such as reviews and suggestions from experts who state that the developed application is good and should be expanded to use it for other relevant titles in the future.

3.4 Discussions

Based on the findings and analysis of the data obtained, the discussion covers research questions developed by the researcher which involves the application of Augmented Reality for three states of matter and includes expert verification after testing and evaluating functionality in terms of content design, interface design and interaction design.

The researcher developed the application of Augmented Reality for three states of matter for form 4 students who take science courses in chemistry and based on the ADDIE design model involving five phases of the analysis phase, design phase, development phase, implementation phase and evaluation phase. Additionally, this application was developed using Unity, Vuforia and 3dsMax software. The applications apply Augmented Reality technology and several multimedia elements such as graphics, audio, animation, and text. Furthermore, the researcher has evaluated and tested the level of functionality of this application in terms of interface design, interaction, and content of the application to experts.

4. Conclusions

This research aims to develop an Augmented Reality application for three states of matter as an extra learning resource for form 4 students who take science courses, especially in chemistry subjects. Besides, this application can help students to understand the topic of matter well while providing an overview of the three states of matter in the Augmented Reality model. As such, the development of this application is also a learning alternative for students to refer to in-person learning beyond the time of learning and teaching.

This research can be further expanded using the iOS platform so that this application can be exposed and used by iPhone smartphone users. Therefore, by using platforms like iOS, researchers can upload to the Apps Store and the Play Store where anyone can get access to and use this application. Also, the

researcher recommends that the entire topic of chemistry subject form 4 be included in the application platform to give students the freedom to follow the learning process in which they are located. Besides, researchers are also proposing improvements to the Augmented Reality model and multimedia elements used to make it a more attractive and effective application in the future.

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