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Development of Augmented Reality Application for Chemical Bond

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Abstract: Chemical bond in Chemistry for secondary school education is one of the subjects in science courses that are difficult to understand by most students. There are many factors that can cause this problem such as from the learning method, the use of education tools and understanding level among students. Some of the problems are such as it is difficult to understand the concepts and processes in chemical bonds. The lack of use of learning tools also creates less interest among the students. This study also about the use of augmented reality technology and how to implement it in learning. Augmented reality is a technology that allows users to interact with virtual object in real situation. Thus, an application Augmented Reality for Chemical Bond is developed as one of the solutions to solve the situation. The objective of this study is to create and develop the application and to test the functionality of the application. This application is combined with multimedia elements such as text, graphic and animation in providing explanation about the process of chemical bond. User Centered Design (UCD) development model is used as a guideline in the development of the study. Application of 3D Max Studio, Unity 2017.1.2, Adobe Photoshop CS6 and Vuforia will be use in the process of creating this product. It will be developed in the form of an android application to make it more user friendly. The Augmented Reality for Chemical Bond has gone through the evaluation process by using feedback form and based on the data analysis from the evaluation, it has been shown that this application can be used by users with some improvement.

Keywords: Chemical bond, chemistry, application, virtual, augmented reality, development model

1. Introduction

Chemical bond is one of the important topics to be learned in chemistry subject for secondary education (Murtiningrum, 2013). It is because the understanding in this topic is needed by students for them to learn other topics in the subject. This topic is about understanding the characteristics of elements in the Periodic Table and bonding process between the elements. It is important for students to understand the bonding process because it is related with other topics in the subjects (Phang, 2014). Chemical bonds play an important role in learning about chemical equation and process of creating new

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elements in chemistry. So, the students will have some difficulties in learning the next topics in this subject if they have a low level of understanding in this topic (Ardiansah, 2016).

Some of the students' problems that occur in understanding the chemical bond is because the students have problems in differentiating the elements involved in the chemical bond that is ionic and covalent bond (Nordin, 2010). This can occur because of the students difficulty to identify the characteristics for each of the elements that are involved in the chemical bond that brings in student's confusion in this topic (Yunus, 2013). The students also have problems to see clearly on how the process of chemical bond occurs (Yunus, 2013). This is because the process cannot be seen with eyes and can only be learned with explanation from the teacher and reference from books. This can cause the students to have different views about the bonding process and brings confusion to students in learning the concepts of chemical bond. This topic also involved some difficult concepts that make the students have a lack of interest in learning it in class.

Augmented reality is a technology that combines digital elements in the real world (Billinghurst, 2012). It allows interaction between user and digital elements in the real world. The use of this technology became more popular because of its features that involved the use of three-dimension elements that can display realistic effect (Zhou, 2008). It also can be used to convey information to users in a more interactive way (Dunser, 2008). The use of augmented reality technology is seen as one of the solutions for problems of students in learning chemistry. It is because augmented reality can help in explaining the concepts used in the chemical bonding process with clearer and more precise information. It also can be applied as displacement for real objects as the process cannot be seen by eye view. The use of multimedia technology also can make the learning process more interesting, effective and active as it involves almost all human sensors (Zainuddin, 2009).

2. Methodology

This study is conducted by using the UCD (User Centered Design) model as a development model. This model consists of three main phases: analysis phase, design and prototype development phase and the last phase is testing and evaluation phase. This study is conducted by descriptive method as the evaluation is done by experts by using questionnaire. Figure 2.1 below shows the UCD model use in this study.

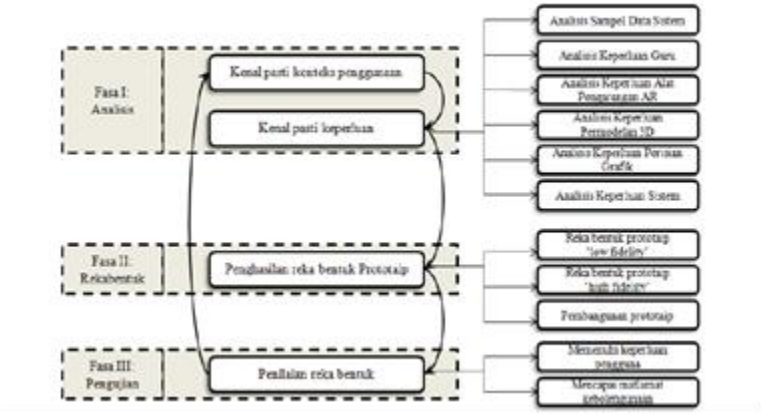

Figure 1: UCD (User Centered Design) Model (Saforuddin, 2014)

The analysis phase consists of two parts, user context analysis and developer need analysis. The first part required the researcher to analyze the scope of the chemical bond topic to identify the content that needed to be developed in the application. The scope of the contents are about two types of chemical bond, ionic and covalent bond. It will be covered about definition, process and example about both types of chemical bond. The analysis also covered the platform that will be used by users to use the

application which is the android platform. The next part is developer needs analysis which is about the needs that the developer will use to develop the application. The developer needs software and hardware to be used to develop the application. Some software that need to be used are Unity 2017.1.3 for interface development, Vuforia for augmented reality and 3ds Max 2018 for 3D model that will be used as example for ionic and covalent bond.

The second phase is about design and prototype development. There are three parts in this phase. The first part is design of low fidelity of prototype. The design of the application will be created roughly by using paper and pencil without putting detailed features. Next part is the design of a high fidelity prototype. The design will be done in form of a storyboard with detailed explanation about the function and features of the application. The third development of prototype. The design will be used to develop the prototype for the application using the software that has been analyzed before.

The last phase is about the testing and evaluation process in which the application will be tested and evaluated by experts to see if it can be use based on three criteria, content, interface design and user interaction. This phase will be involved with experts in multimedia, education and chemistry field.

2.1 Sample

The sample for this study will be the experts that are involved in the testing and evaluation process. There are three experts that are experts in multimedia field and science chemistry subject. Two of the experts are lectures from the Faculty of Technical and Vocational Education, UTHM which is expert in multimedia and user interaction field. They will conduct the evaluation based on interface design and user interaction. One of the experts is a chemistry teacher from Sekolah Menengah Kebangsaan Chenderiang, Tapah Perak and will conduct the evaluation based on the content of the application.

2.2 Instrument of Study

This study will be conducted by a descriptive method which is the data will be collected from the evaluation process by using questionnaire. The questionnaires consist of two types, content of application and interface design. The questionnaire was divided into four parts which were called as Part A, Part B, Part C and D. Part A consisted of demographic data. Part B contained six questions content of application to see whether it is the same as the content in the syllabus of the chemical bond topic. Part C consisted of ten questions about the interface design of the application. Part D consisted of five questions about user interaction. A likert scale with a five points system was used to measure responses on the questionnaire (Joshi et al., 2015). The respondents indicate their opinion by circling a number in the column adjacent to the statement. Items were scored on the following keys: 1 – Strongly Disagree, 2 – Disagree, 3 – Not Sure, 4- Agree and 5- Strongly Agree.

2.3 Data Analysis

Data analysis will be conducted by calculating the percentage of agreement by the experts based on their responses in the questionnaire. The data will be represented in a table and a discussion will be conducted to see whether the development of the application can achieve its objectives.

3. Results and Discussion

There are three aspects that will be tested and evaluated in application of augmented reality for chemical bond. The first aspect is about the content of the application. This aspect is evaluated to find out whether the content is accurate with the syllabus in chemistry subject. This aspect will be evaluated by a chemistry teacher from SMK Chenderiang, Tapah, Perak. Data analysis has been conducted and present in a table. Table 1 shows the result from the data analysis based on the questionnaire.

Table 1: Data analysis from evaluation of content aspect

No.	Question Item	Percentage of Agreement(%)				
		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	The content matches with the syllabus of the topic of Chemical Bonds for the subject of Chemistry.	0%	0%	0%	0%	100%
2	The information provided is easily understood.	0%	0%	0%	0%	100%
3	The content provided can be clearly understood by students	0%	0%	0%	100%	0%
4	The content is organized from easy to difficult level.	0%	0%	0%	100%	0%
5	The sentence structure used in the application is easy to understand.	0%	0%	0%	0%	100%
6	The chemical bonding model displayed coincides with the type of chemical as in the syllabus	0%	0%	0%	100%	0%

Based on the Table 1 above, the assessor strongly agreed that the content in the application is accurate with syllabus of chemical bond for chemistry subject. The assessor also strongly agrees that the information displayed in the application is easy to understand. Next, the assessor agreed that the content in the application can be easily understood by students and it is displayed in order from easy to difficult. The assessor also strongly agreed that the sentence structure used in the application is easy to understand. Lastly, the assessor is agreed that the model of chemical bond is accurately displayed with types of chemical bond in the syllabus of chemical bond for chemistry subject.

The second aspect is about the interface design of the application. This aspect is evaluated to find out whether the design of the interface is suitable and easy to use for the user. This aspect will be evaluated by two assessors who are experts in multimedia field from the Faculty of Technical and Vocational Education, UTHM. Data analysis has been conducted and present in a table. Table 2 below shows the result from the data analysis based on the questionnaire.

Table 2: Data analysis from evaluation of interface design aspect

No.	Question Item	Percentage of Agreement (%)				
		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	The selection of 3D objects in this application is in accordance with the topic of chemical bonds.	0%	0%	0%	50%	50%
2	The quality of application in terms of display resolution is good.	0%	0%	0%	50%	50%

3	The use of text colors in this application is appropriate.	0%	0%	0%	0%	100%
4	The use background color of the application is appropriate.	0%	0%	0%	50%	50%
5	The color of the buttons in the application is appropriate.	0%	0%	0%	50%	50%
6	The size of the buttons in the application is appropriate.	0%	0%	0%	0%	100%
7	The size of text in the application is appropriate.	0%	0%	0%	0%	100%
8	The type of font for text in the application is appropriate.	0%	0%	0%	50%	50%
9	The use of 3D objects developed in this application is clear.	0%	0%	0%	50%	50%
10	This application applies elements of consistency in terms of layout in each interface.	0%	0%	0%	0%	100%

Based on the Table 2 above, the one assessor strongly agreed that 3D models in the application are suitable with chemical bond topic and the quality of display of the application while the other assessor chose to agree with both question items. Next, both assessors also strongly agree that the color of the text used in the application is suitable. One assessor strongly agreed with the background color and the button color of the application while the other assessor agreed with the question item. Both assessors are strongly agreed that the size of the button and text are suitable to be used in the application. Next, the one assessor strongly agreed about the type of font used in the text and the clarity of the 3D model in the application while the other assessor chose agreed with the question items. Lastly, both assessors strongly agreed that the consistency element is applied in every interface of the application.

The third aspect is about the user interaction design of the application. This aspect is evaluated to find out whether the user interaction concept is implemented in the application. This aspect will be evaluated by two assessors who are expert in multimedia field from the Faculty of Technical and Vocational Education, UTHM. Data analysis has been conducted and present in a table. Table 3 below shows the result from the data analysis based on the questionnaire.

Table 3: Data analysis from evaluation of user interaction design

No.	Question Item	Percentage of Agreement (%)				
		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	This application allows users to exit this application at any time.	0%	0%	0%	0%	100%
2	The developed navigation buttons are linked to the correct interface.	0%	0%	0%	50%	50%
	i. Start	0%	0%	0%	0%	100%

	ii. Menu	0%	0%	0%	0%	100%
	iii. Ionic Bond	0%	0%	0%	50%	50%
	iv. Ionic Bond (Details)	0%	0%	0%	0%	100%
	v. Ionic Bond (AR Camera)	0%	0%	0%	0%	100%
	vi. Covalent Bond (Details)	0%	0%	0%	0%	100%
	vii. Covalent Bond (AR Camera)	0%	0%	0%	50%	50%
	viii. Home	0%	0%	0%	0%	100%
	ix. User Manual	0%	0%	0%	0%	100%
	x. Exit	0%	0%	0%	50%	50%
3	This application uses non-linear interactions.	0%	0%	0%	50%	50%
4	The navigation buttons developed in this application are functionable.	0%	0%	0%	50%	50%
5	The position of the navigation buttons in this application is appropriate.	0%	0%	0%	0%	100%

The development process of application augmented reality for chemical bond is based on the UCD (User Centered Design) model. This model consists of three main phases, analysis phase that include user context and developer need analysis, design and prototype development phase and testing and evaluation phase. Several software has been used in the development of the application process such as Unity 2017.1.3, Vuforia, Visual Studio, 3ds Max and Adobe Photoshop All of the software required in order to develop an augmented reality application that have included multimedia elements such as animation, graphic and text. The design of the application process has been done in a systematic method and the design also has been suited to the user.

Application of augmented reality for chemical bond is developed based on the design and export in the form of .apk file for Android platform. Most of the experts agree with the design of the application based on the data analysis as it has features such as the use of 3D models representing the chemical bond that is suitable for learning tool. According to Yunus (2013), the chemical bond brings in student's confusion and they can learn best with the existence of teaching aid that visualize the chemical bond process.

The application augmented reality for chemical bond have been tested and evaluated by experts and based on the data analysis, it can be concluded that the experts agree that all the content, interface design and user interaction that are developed in the application are suitable to use in learning chemical bond. With the development teaching aid, students can do a self-revision if they cannot catch up during class hours. Therefore, having a low level of understanding in chemical bond topic (Ardiansah, 2016) can be reduced and students can move to next topics smoothly.

4. Conclusion

The application of augmented reality for chemical bond is developed as an alternative for students to learn about chemical bond. It is developed by implementing the use of augmented reality technology with 3D model to help students understand chemical bond. This application has successfully developed and has been tested by experts. It has been concluded that this application can be used by users with some improvement such as addition of quiz about chemical bond and animation element.

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