Development of Media Three-dimensional (3D) Visualization using Virtual Reality on Chemistry Education

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Abstract. This study aims to develop and test feasibility three-dimensional (3D) visualization of media using virtual reality in chemistry learning. The development model used in this study is Research and Development (R&D) model. This study implemented the stages of planning, preliminary development of the product, preliminary field testing, main product revision adapted from Borg and Gall. The development of the learning media in this study was validated by media expert, material expert, peer reviewers, and subject teachers, and was tested to 23 students. The results of this study revealed that three-dimensional (3D) media using virtual reality is feasible to use as learning media for high school students. The percentages of validation results are 74% by media and material experts, 76% by chemistry teachers, 84% by peer reviewers, and 77% by students. Overall, the average total percentage score of feasibility of the three-dimensional media is 78% categorized to ‘good’. In conclusion, the developed three-dimensional (3D) learning media using virtual reality is feasible to use in the chemistry learning process for the material of reaction rate.

1. Introduction
Learning in the education field should be interactive, inspiring, challenging, and improving the quality and motivation in learning process [1]. The use of technology can assist in the improvement of knowledge called the ‘information super highway’ [2]. The development of technology use also makes new innovations appear that they can be developed in learning process. In chemistry learning, students are expected to have scientific attitude, and doing the chemistry experiment helps students have scientific experience, understand the advantage and disadvantage of chemistry learning, and understand chemistry concepts to solve problems in daily life [3]. Moreover, chemistry is considered difficult because it discusses more abstract concepts, such as the concept of atoms, oxidation numbers, chemical equation, and energy [4]. That one of the most efficient ways in learning chemistry is through laboratory [5].

A laboratory is very important to have chemistry learning be easy to understand for students [6]. The function of laboratory is to complete the theoretical materials that were received, to gather a courage to discover scientific fact from an environmental and social object, and to add skills in utilizing the tools [7]. One of chemistry materials that need a practicum is reaction rate. This concept cannot be only explained in speech method. There needs a practicum that helps in explaining the concepts which ease students in constructing the concepts, because reaction rate is a change that can be observed occasionally but the concentration change in reaction rate cannot be observed directly [8]. However, not all schools have laboratory that facilitates the process in laboratory.
Based on the observation conducted by seven schools in Ternate, there are many schools that have minimum facilities, such as the tools and materials provided in the laboratory, expired materials, and insufficient laboratory. To solve the problem on the minimum facilities in practicum, technology can be utilized, namely virtual laboratory with several facilities done in a computer-based interactive multimedia software [9]. One of recent technologies is the use of three-dimensional (3D) using virtual reality (VR). Virtual reality is a sophisticated technology that integrates multi-sensory, such as sound tracking and gesture as if the students were in the environment and interacts actively. This virtual reality is able to use to ease students in understanding the chemistry learning.

In the learning, virtual reality can make the students be more active because it provides more interactive environment [10]. Virtual reality can created an environment which is abstract and can be stimulated by computer so that students can interact to the simulated environment [11]. Virtual reality can also assist teacher in teaching because the use of virtual reality can create an activity which makes human’s brain and the function of senses are able to work together with computer’s help [12]. The development of virtual reality does not only include in education field but has been developed for extent needs [13]. Virtual reality also cannot be separated from visual display in which the visual is in the form of three-dimensional (3D) that the category of each visual display is different [14]. The visual display used in this study is head-mounted display (HMD).

The use of virtual reality in the education field, particularly in chemistry education, is necessary for schools that still lack of facilities in their laboratory, and the use of virtual reality is able to minimalize the danger in conducting the practicum [15]. The use of virtual reality can also improve students’ interest in learning [16]. The development of virtual reality is expected to assist teacher in solving the problem, particularly chemistry learning that requires other learning media to explain chemistry material. In general, the implementation of activities in the laboratory is very important in chemistry learning, but for some reasons there are activities that require to be conducted in the laboratory cannot be carried out well. One of the ways that helps students in understanding chemistry material about reaction rate is through media learning. The media is three-dimensional (3D) technology. The technology of three-dimensional (3D) visualization is introduced with visual reality (VR). Three-dimensional technology using virtual reality can help students solve problems, such as the lack of facilities in the school that has been observed because the school has used form of software for practicum [14]. This study aims to develop and test the feasibility of using virtual reality media which will be applied to high school students in the chemistry learning process.

2. Research Methods
This study is descriptive quantitative research which describe about feasibility study of three-dimensional (3D) visualization media using virtual reality. The three-dimensional of learning media using virtual reality was developed by adapting a development model by Borg and Gall (1989), namely collecting information, planning, preliminary development of the product, preliminary field testing, and main product revision. Research and development of education is one method that aims to produce desired products in the field of education both in the form of media, test the validity, effectiveness and feasibility of the products used.

The first stage is collecting information. This stage is need analysis phase of this study, namely field observation to find out information about the implementation of the learning process in classroom, to obtain relevant sources to the study about development of three-dimensional media using virtual reality by literature review and need analysis. The second stage is planning, namely collecting material and reference related to three-dimensional media development using virtual reality, including designing the product and designing the learning. The third stage is preliminary development of the product, namely merging the design of product and learning. The product that has been finished was validated by material and media expert. Media expert is a lecturer who is expert at developing the learning media.
The validation conducted by material expert, media expert, chemistry teacher and peer reviewer using five-scale questionare was modified from Likert-scale. The learning media using virtual reality were validated by two judgment expert from content expert who proficient on teaching-learning chemisty and media expert who proficient on media development. Judgement content expert assessed both learning and material aspects. While, judgment media expert assessed both performance and opwrational aspects. Moreover, media assessment also validated by six chemistry teacher and ten peer reviewer. Validation of media feasibility by teacher and peer reviewer consider on four aspects i.e. audio-visual, software engineering, learning, and material. The instrument of virtual reality media were developed from Squires & Preece (1996), Nesbit & Leacock, (2009) Oyelekan & Olurundare (2009) dan Kustandi & Sutjipto (2011). The aspects developed are in the form of learning, material, appearance and operational aspects. There are four aspects were developed namely learning aspect, content aspect, performance aspect and operational aspect. The indicators of assessment can be seen in Table 1.

**Table 1. The Indicators of media assessment**

| Aspects           | Indicators                                                                 |
|-------------------|-----------------------------------------------------------------------------|
| Learning          | 1. The suitability of indicators with material                              |
|                   | 2. The suitability put in the learning media                                |
|                   | 3. The clarity of the user target                                           |
|                   | 4. The ease of media access in learning                                    |
|                   | 5. Interactive subject of the learning with learning media                  |
| Material          | 6. The provision of material explanation                                     |
|                   | 7. The suitability of the composition of colors, shapes, and steps           |
|                   | 8. The clarity of practicum simulation with virtual reality media           |
|                   | 9. The conspicuousness of material in motivating the user                   |
|                   | 10. The suitability in choosing the background color                        |
| Audio Visual      | 11. Font suitability                                                        |
|                   | 12. Font size suitability                                                    |
|                   | 13. Font color suitability                                                  |
|                   | 14. Layout suitability                                                       |
|                   | 15. Picture size suitability                                                 |
|                   | 16. The effectiveness and efficiency in media development and use           |
| Software Engineering | 17. Ease of operation                                                        |
|                   | 18. The creativeness and innovation in learning media                       |
19. The accuracy in the choices of operation type with the program
20. The opportunity of media development towards science and technology development

The fourth stage is preliminary field testing, namely the readability of media. In this stage, the media were tested to 23 students to obtain the analysis and the consideration for main product revision. The fifth stage is main product revision to complete the learning media based on the feedbacks and the results obtained from when the media were tested.

The study was conducted using three-dimensional visualization of media on chemistry material of reaction rate which contains simulation of practicum. Data obtained from material expert, media expert, teachers and students were analyzed by calculating the formula and were suit to the criteria and aspects of media feasibility [17].

| No | Rentang Skor (i)                                | Kategori       |
|----|-----------------------------------------------|----------------|
| 1  | $X_i + 1.8 SBI < \bar{x}$                     | Very Good      |
| 2  | $X_i + 0.6 SBI < \bar{x} \leq X_i + 1.8 SBI$  | Good           |
| 3  | $X_i - 0.6 SBI < \bar{x} \leq X_i + 0.6 SBI$  | Adequate       |
| 4  | $X_i - 1.8 SBI < \bar{x} \leq X_i - 0.6 SBI$  | Poor           |
| 5  | $\bar{x} \leq X_i - 1.8 SBI$                 | Very Poo       |

Note: $X_i$ = average score; $X_i = 1/2$ (ideal maximum score + ideal minimum score); SBI = 1/6 (ideal maximum score + ideal minimum score)

3. Results and Discussion

Three-dimensional (3D) visualization of learning media using virtual reality on the reaction rate material was designed in an Android-based application. Visual display is used to provide cyberspace in three-dimensional display. The visual display developed for projecting image to the screen is active stereos-copy that needs shutter glasses. Every eye receives different images because every filter of eyeglass lens come out a set of images. The type of passive solution cannot be used on desktop display [18]. The illustration of shutter glasses is seen in Figure 2.

![Figure 2. Shutter Glasses](image)

The start display of three-dimensional visualization of learning media using virtual reality can be used as substitute of experiment activity in laboratory. Its illustration is seen in Figure 3.
The experiment conducted in laboratory needs tools, materials, and procedures in trying the display. The experiment display can be seen in Figure 4.

In testing the developed media, the data were general testing about feasibility media. The result data of three-dimensional visualization of media using virtual reality by the experts are seen in the following table.

| No | Aspects               | Score | Category |
|----|-----------------------|-------|----------|
| 1  | Learning Aspect       | 3.6   | Good     |
| 2  | Material Aspect       | 3.8   | Good     |
| 3  | Audio-Visual Aspect   | 3.5   | Good     |
| 4  | Operational Aspect    | 4.0   | Very Good|

The validation results by material expert were focused on the learning aspect and material aspect while the validation results by media expert were focused on audio-visual aspect and software engineering aspect. The media expert assessed audio-visual aspect with the score 3.5 and its percentage score is 70% which belongs to ‘good’ criteria, while the software engineering aspect score is 4.0 with the percentage score 80% categorized to ‘very good’ criteria. Then, the material expert assessed learning aspect with the score 3.6 and its percentage score is 72% categorized to ‘good’ criteria, while the material aspect score is 3.8 with the percentage score 75% and belongs to ‘good’ criteria. Therefore, the results of validation by the experts showed that the development media of three-dimensional visualization using virtual reality is feasible to use as chemistry learning for the
material of reaction rate. However, there are feed-backs that the description the tool names should be clearer and the tool choices that the students will use should have different color.

Table 4. Media Validation Results by Teachers and Peer Reviewer

| No | Aspects              | Chemistry Teachers | Peer Reviewers | Category   |
|----|----------------------|--------------------|----------------|------------|
| 1  | Learning Aspect      | 3.8                | 3.9            | Good       |
| 2  | Material Aspect      | 3.8                | 4.0            | Good       |
| 3  | Audio-Visual Aspect  | 3.7                | 4.5            | Very Good  |
| 4  | Software Engineering | 4.5                | 4.3            | Very Good  |

Table 4 showed the media validation conducted by chemical teachers and peer reviewers. According to five chemical teachers who have given the feasibility score for the media, the learning and material aspect has each 3.8 with the percentage score 76% while the audio-visual aspect score is 3.7 with the percentage score 74% and the software engineering aspect is 4.5 with the percentage score 80%. Ten peer reviewers also assessed the developed media in this study. The validation conducted by peer reviewers showed that the learning aspect score is 3.9 with the percentage score 78% while the material aspect score is 4.0 with the percentage score 80%. Then, the result score for audio-visual aspect is 4.5 with the percentage score 90% and the result score for software engineering is 4.1 with the percentage score 87.50%. Based on the assessment carried out by the chemistry teacher and Peer Reviewer it was stated that this shows that virtual reality is very feasible to use but there are some inputs from teachers and Peer Reviewers that the media is made easier in choosing the desired object.

After the media were assessed by the experts, subject teachers, and peer reviewers, the students also assess the media, namely the aspect of learning and material and the aspect of media appearance and operation. On stages to get input and advice given by students on media readability. There are 23 students involved in using three-dimensional visualization media using virtual reality and assessed that media. The results of the media by students can be seen in table 5.

Table 5. Media Validation Results by Students

| No | Aspects                  | Score | Category |
|----|--------------------------|-------|----------|
| 1  | Learning and Material    | 3.8   | Good     |
|    | Aspect                   |       |          |
| 2  | Display and Operational  | 3.9   | Good     |
|    | Aspect                   |       |          |

Based on the results of media readability by students, the learning and material aspect score is 3.8 with the percentage score 76% while display and operational aspect score is 3.9 with the percentage score 78%. Then, the average total percentage score of students’ readability of media is 77%. Based on the feasibility table, this media categorized as good cause of it was developed a series of laboratory tools in the form of software, which is operated by computer and can simulate the activities in the laboratory as if the user were in an actual laboratory, cause of the media of virtual reality has never been used before by students in the learning process, it can increase students’ motivation in the learning process due to the students’ interest in virtual reality media (Shim et al. 2003). Virtual strengths are more economical, easy to use for students while learning process both in the classroom and independent learning. Furthermore, it can increase the students’ understanding because they can be repeated to practice if they do not understand about the material. And also, student are safe to carry out because of minimum occupational health safety [19]. In other words, the use of three-dimensional visualization media using virtual reality is categorized as a ‘good’ criterion so that it can be applied in learning to facilitate students in understanding and memorizing material given to them [20].
4. Conclusion
This study focuses on developing the product which is a three-dimensional visualization of media using virtual reality. Media expert, material expert, chemical teachers, peer reviewers and students assessed the media and the total ideal percentage is 78% categorized to ‘good’ criteria. The results of this study revealed that the media of three-dimensional visualization using virtual reality that is developed can be used as one of learning media for the material of reaction rate at senior high school, and the use of technology in the learning process can influence learning achievement.

The media of three-dimensional visualization using virtual reality can assist teacher in doing the practicum without using the tools, materials, and the laboratory itself. It solves teacher’s problem about the lack of tools and materials. This technology can increase the understanding on the learning content [21]. The developed technology using virtual reality can be used as the effective learning media to enhance students’ involvement in order to motivate them in learning. The media of three-dimensional visualization using virtual reality is also able to help students who are usually passive in the real laboratory and it becomes an opportunity for the chemical learning media in the future.

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