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RESEARCH PAPER

The Effect of Using Augmented Reality-Based Learning Media on Chemistry Students' Conceptual Understanding on Molecular Shape

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Abstract: This study aims to examine the effect of using Augmented Reality-based learning media on students' conceptual understanding of molecular shape material. This research is a quasi-experimental study with a post-test-only design. The class used was class X Mathematics and Natural Sciences in one of the Bengkulu City High Schools, which received molecular shape material, consisting of 1 control class and 1 experimental class. The control class is a class that uses PowerPoint media as usual with 2-dimensional image visualization. In contrast, the experimental class is a class that uses augmented reality-based learning media with 3-dimensional visualization. The instrument used is a post-test instrument referring to conceptual understanding indicators. The results were analyzed using a t-test. The results of the analysis showed that the significance level was 0.002. This result indicates that it is smaller than the significance level, or it can be concluded that there is a significant difference in the average understanding of the concept between the control class and the experimental class.

Keywords: augmented-reality; learning media; molecular shape; chemistry

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INTRODUCTION

Education becomes a conscious and planned effort to create an atmosphere and learning process that expects students to develop their potential actively. The purpose of this education should be prioritized to be realized. To achieve this, the government and educational institutions have made many efforts. This is inseparable from one of the components of the education system in a country, namely the curriculum. The academic curriculum is always reformed according to the times. The current high school curriculum refers to the curriculum 2013, which has transformed competency-based achievements into learning outcomes. These achievements include knowledge, skills, attitudes, and competencies. This curriculum is expected to produce better and more qualified graduates nationally.

Learning is a two-way interaction between teachers and students, and there is a directed communication toward a predetermined goal [1]. The learning carried out should run effectively and efficiently. Effective means that the learning is fun and by the learning objectives, whereas efficient means that the time used in learning can be utilized optimally. The achievement of these learning objectives is highly expected in every learning.

In addition to the curriculum, other fields develop with the times. It's technology. Technology is one of the essential parts of the advancement of education in Indonesia. Technology-based learning has been widely carried out in Indonesia in the framework of the industrial revolution 4.0. Technology

development today gives rise to many innovations that can be used in learning. Not only PowerPoint but currently many technology-based learning media have been developed in various types. Media development should be one of the concerns of students' needs in learning. The learning media used in the classroom can increase the effectiveness of the learning process and the delivery of messages. Learning media is divided into traditional media and technology-based media. This technology-based media usually involves interactive video, media integration, and hypermedia [2]. In the selection of learning media, teachers must be able to consider that the selected media will help students in achieving these learning goals [3]. The uses of this learning media include making learning more interesting for students, teaching materials that have a clearer meaning, allowing students to customize goals for better learning, variative teaching methods, and students will do more learning activities [4]. The selection of technology-based learning media will make learning more effective [5]. Media like this can simply explain concepts by combining animated visuals and audio, making them suitable for independent learning activities [6].

One of the subjects that require learning media is chemistry. Chemistry is one of the fields of science in which there is rote material and calculations. Some chemical materials are abstract, which makes them difficult for learners to understand. Such materials are atomic theory, electron configuration, chemical bonds, and molecular forms. Many learners find it difficult to imagine how the shape of the molecules formed by the bonds between the elements. The low visualization of these learners will have an impact on the learners' understanding of the material of this molecular form. Students need a learning medium to visualize this molecule's shape in 3 dimensions.

Augmented reality is one of the technologies that can be utilized to visualize this form. Augmented Reality, which can be shortened to AR, is a technology that can visualize 3-dimensional objects into real-world objects with the help of patterns made on real objects [7]. This pattern is usually called a marker. This marker must be accessible to the camera because if it is blocked by something, it is too tilted, or the lighting is too bright/dark, and then the marker will be difficult to detect by the camera [8]. The working principle of augmented reality is tracking and reconstruction. The camera detects markers on real objects, then the data obtained is reconstructed into virtual form in the real world. The reconstruction process is carried out by projecting a virtual object that will be displayed on a real object that has such a marker. These objects are usually 3-dimensional in shape.

In learning, augmented reality has several advantages, namely being able to study material in 3-dimensional form, visualize invisible objects, make learning more flexible, and bridge formal-non-formal learning [9]. With the existence of teaching media, students are expected to be able to visualize the shape of molecules in chemistry. When they understand the form, the brand concept of this material will also be better.

MATERIALS AND METHODS

This research is quasi-experimental research or pseudo-experiment. This study used a post-test-only design using two classes, namely the control class and the experimental class. The sampling technique used is cluster random sampling, namely class X MIPA 2 as the control class and class X MIPA 4 as the experimental class. A control class is a class with learning, as usual, using PowerPoint as a learning medium. This PowerPoint contains the shape of a molecule but in a 2-dimensional state. The experimental class is a class with learning using augmented reality media or 3-dimensional visualization of shapes. The Venetian design used can be seen in Table 1.

Table 1. Research Design

Class	Treatment	Post-test
Control Class	-	P1
Experiment Class	X1	P1

Description:

X1 = learning using augmented reality-based learning media

P1 = giving post-test questions to see the understanding of the concept of molecular form

The instrument used in this study's post-test sheet contains questions about the material of the molecular form. The number of questions tested is 12 questions consisting of description questions. This set of questions has been validated by chemists. The results obtained from both classes were then analyzed using the t-test in SPSS. The hypotheses used in this study are as follows:

Ho: There is no significant difference in average learning outcomes between classes that use augmented reality media and classes that do not use them.
Ha: There is a significant difference in average learning outcomes between classes that use augmented reality media and classes that do not use it.
The null hypothesis will be rejected when the significance of the test is smaller than the degree of signification used.

RESULTS AND DISCUSSION

This research has been conducted at one of the public high schools in Bengkulu City. The class used is two classes, the first class as the control class and the second class as the experimental class. Class X MIPA 2 is a control class that conducts learning using PowerPoint as a learning medium. In the PowerPoint, there is material about the shape of molecules, but still in the form of images or 2-dimensional form. Class X MIPA 4 is an experimental class that conducts learning using augmented reality-based learning media or with 3-dimensional modeling.
Learning is carried out in two meetings per class. This learning is carried out using a discovery learning model assisted by student worksheets. For this learning, students can predict the molecular shape of a molecule based on the initial knowledge of the bonds formed and the repulsive force between the forming atoms. The learning activities carried out are adjusted to the learning model used. The syntax of the learning model can be seen in Table 2.
The first learning activity is the provision of stimuli by the teacher. The provision of this stimulation uses the image of several molecules that have differences in their constituent atoms and the repulsion angles between their atoms. These molecule images have similarities in the number of electron domains but have different molecular shapes, for example, tetrahedral with triangular pyramids. Both have 4 electron domains. In tetrahedral, the four-electron domains are bond electrons, while in the triangular pyramid, there is 1, which becomes a free electron. This activity is carried out to stimulate students regarding knowledge of chemical bo
their repulsive force. Learners will thir
how such bonds can be formed. The p
of these stimuli must be appropriate so that students can explore their curiosity.

Table 2. Syntax and Learning Activities

Syntax of discovery learning	**Learning activities**
Stimulation	Students are given pictures in the form of several molecules that have the same electron domain.
Problem Statement	Do students identify problems that occur, such as why molecules with the same electron domain but have different molecular shapes?
Data Collection	students collect data through observation of molecular shapes
Data Processing	students answer the questions on the worksheet
Verification	students check the results of the discussion with the existing theory
Generalization	students equate perceptions of molecular shape

The second learning activity is to identify the problems that they must find in the learning. Identification of this problem is used so that students can find out about the problems that exist in the shape of the molecule. Students are then asked to write down problems that can be drawn from the stimulus provided. The results of problem identification by students include:

- Why do the two molecules have different molecular shapes? Though the number of electron domains is the same.
- What is the interaction between the electron domains?

The next activity is data collection. This data collection involves augmented reality-based media or 3-dimensional shapes for ex-classes and PowerPoint media by involving 2-dimensional images. This media involvement is an aid for students to identify the shapes of molecules and answer the formulation of problems that have been proposed in previous learning activities. In addition, students are also asked to learn existing theories regarding the shape of these molecules.
Processing data is the next learning activity. In this learning activity, students are asked to answer the questions on the worksheets that have been distributed. This activity is continued with verification activities.
The last learning activity is a generalization. In this activity, students held a class discussion led by the teacher in-class discussion.

The results of the post-test can be seen in Table 3.

Table 3. Post-test outcome

	Control Class	Experiment Class
Number of Students	35	36
Mean	55.68	64.61
Normality Test	0.200	0.200
Homogeneity Test	0.436	

Based on Table 3, the average or mean of the experimental class is superior to the control class. The difference between the two is almost 10 points. The normality and homogeneity test results showed that both classes had normally distributed and homogeneous data. The t-test results of the two classes showed that the significance magnitude was 0.002 or less than the significance level used, which was 0.05. This shows that there is a significant difference in average learning outcomes between students who use augmented reality-based media and students who do not use these media. This difference shows the influence of the use of augmented reality-based media. The use of media like this can increase student power [10].

The augmented reality media created puts forward a 3-dimensional shape. This 3-dimensional form is needed in studying abstract chemical materials. Examples of such materials are atomic forms that can describe different atomic shapes in 3 dimensions, electron configurations that can describe rotating electrons surrounding the nucleus of an atom, a molecular form that can describe how electron domains repel each other, and so on. The implementation of augmented reality is very supportive of learning molecular form material [11]. The 3-dimensional depiction of these molecular forms makes it clear for students to imagine the shape of molecules that have only appeared in 2 dimensions. In addition, media such as this makes it easier for students to learn concepts effectively because they can be used anywhere for as long as possible with a compatible smartphone [12]. Students who mostly have smartpho helped by the existence of media like using a smartphone, they can acces anywhere and anytime. Of course, this is an advantage of digital-based media.

In learning using the discovery learning model, students are guided to be able to find the cause of the occurrence of different molecular shapes even though they have the same number of electron domains. At first, students only think that the position of the bound atoms is what it is. However, through investigation and some theories, students finally know that there is a repulsive force between the electron domains in the molecule. Students who use the help of augmented reality-based 3-dimensional media find it easier to investigate the shape of molecules. Students can change the molecule's position so they can see the shape of the molecule from the upper, lower, front, back, or side directions. This is what makes the experimental class students able to know this repulsive style's existence. The existence of media like this can help teachers in explaining material [10]. In addition, the existence of this media can improve the ability of multiple representations of students in similar materials [13]. This is different from the control class, which only observes in 2-dimensional form without being able to see the shape of the molecule from various directions. The weakness of the 2-dimensional form, students can see from one direction only.

CONCLUSION

From the present work, it can be concluded that the augmented reality media material in the form of molecules that have been developed can be used as a medium of learning in the classroom. The results of implementation in the classroom can be concluded that there is a significant difference in average learning outcomes between classes that use augmented reality media and those that do not. Future research is expected to be able to develop similar media with various materials. This can support the achievement of learning objectives faster.

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