THE EFFECTIVENESS OF USING 3D SIMULATION MEDIA IN ONLINE LEARNING OF MOLECULAR GEOMETRY ON IMPROVING LEARNING

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Abstract. *Molecular geometry is one of the materials in chemical bonds that are abstract. Where students must think imaginatively in predicting the three-dimensional shape of an existing molecule. But because it is abstract the majority of students have difficulty understanding and visualizing the theory of molecular form. This problem is coupled with online learning that makes it difficult for teachers to convey molecular geometry materials. The solution to the problem is the use of interactive learning media for PhET 3D simulation. This study aims to determine the effectiveness of the use of 3D simulation media in online learning of molecular geometry materials. This research is an experimental research in the form of pre- experimentation with the design of one group pretest posttest. Data collection techniques are carried out with tests and questionnaires. Sampling is done by purposive sampling. The result of N-Gain data analysis of experiment class 0.79 with percentage of N-Gain score of 79.8 % with high criteria. This shows that the use of 3D simulation media in online learning of molecular geometry molecular shapes is very effectively used in the teaching and learning process. Hypothesis testing is carried out t-paired with a level of trust of 5%. Interpretation of hypothesis testing by looking at the value of Sig (2 tailed) of 0.00 where 0.00 < 0.05. it can be concluded that there are significant differences in the use of 3D simulation media. Based on effect size test the value obtained is 0.98 with high criteria. These results can be interpreted that the use of 3D simulation media in molecular geometry learning has a scale of effect or strong influence on student learning outcomes. The result of student response data analysis there are four aspects, namely, aspects of students' interest in following learning, material understanding, ease of problem solving, and group cooperation. Aspects of students' interest in following learning and material understanding aspects have excellent criteria. As for the aspect of ease of problem solving and group cooperation has good criteria.*

Keywords: *3D simulation media, Online learning, Molecular Geometry, Learning outcomes*

INTRODUCTION

The Covid-19 pandemic is sweeping all regions of the world. At this time, the world community is busy with preventing the transmission of Covid-19 so that a temporary suspension of all activities outside the home is applied. Indonesia is one of the countries affected by the outbreak, making social distancing and physical distancing as a policy of social and physical distancing restrictions have an impact on stopping the learning process in schools. This pandemic crisis has severely disrupted the education and learning system. Conventional learning, which is usually held normally through face-to-face learning in schools, must be disrupted in its implementation. The current crisis is forcing all components of education to innovate normal learning into distance learning through online or online learning.

Online learning is defined as a learning system that is carried out by not meeting face to face, but using a platform that can help the teaching and learning process carried out even though it is remote [1]. Online learning is one of the learning models carried out using Education and technology tools in the midst of the current pandemic [2]. At this time online learning is applied in all subjects, including chemistry subjects. Chemistry lessons themselves are included in a complete lesson where in the lesson there are theories, concepts, laws and facts. However, some concepts in the study of chemistry pose difficulties and misconceptions for learners because most of them are related to abstract concepts, for example molecular geometry [3].

Molecular geometry is one of the learning materials in chemical bonds that are abstract. Where students have to think imaginatively in reconciling the three-dimensional form of a molecule that exists. In online learning of molecular form material, usually teachers only use visual media in the form of molecular images contained in reading books, powerpoint materials, or in student worksheets that are distributed during virtual classes. However, the use of molecular images is considered ineffective because students have difficulty visualizing in three dimensions the shape of the molecule [4]. Another solution to the learning of molecular geometry is the use of three-dimensional props such as molimod. However, in the implementation of virtual classes, online learning is difficult to do because teachers cannot interact directly and demonstrate using molimod, so the use of molimod as a teaching tool in person is considered less than optimal.

Learning media is an important instrument for conveying messages in the learning process to facilitate the learning process carried out and make it easier for students to understand the subject matter [4]. Another learning media that can be an option for molecular geometry material is 3D visual simulation media, where the learning media has the advantage that it can be easily accessed by teachers and students both in conventional learning and online learning. Nowadays, the development of 3D learning media is very common and easily accessible to facilitate the understanding of molecular geometry material [5].

One of the results of the development of 3D learning media is PhET. PhET or Physics Education Technology Interactive Simulations is a simulation created by the University Of Colorado in 2002 that contains learning simulations, including chemistry learning for the benefit of classroom learning or individual learning. In the chemistry learning simulation, there is a learning medium for molecular forms based on VSEPR theory in a three-dimensional model that makes it easier for students to understand the shape of molecules that are abstract or cannot be seen directly as if they were real. The use of 3D PhET simulation media is expected to have a positive influence on students because it has the advantage of emphasizing the relationship between real-life phenomena and the underlying science, supporting interactive and constructivist approaches, providing feedback, and providing a creative workplace [6]

Previous research on the use of 3D PhET simulation media has been carried out, one of which is by Atmawinaldi, et al (2019) with the title *"The Influence of PhET Media on Student Learning* Outcomes *on Molecular Form Material"*. Based on the results of this study, it can be seen that the use of PhET media has a significant influence on student learning outcomes on molecular form material. Previous research on the use of simulation media was carried out on conventional learning while the research carried out by the author focused on the use of 3D simulation media during online learning. This research is important to do because it is relevant to the current state of learning. Currently, the use of 3D simulation media in online learning of molecular form material is not yet commonly used, so it is necessary to conduct research to find out how effective it is on student learning outcomes [7].

The use of 3D PhET simulation media as a learning medium on molecular geometry material is expected to have a positive influence on student learning outcomes, especially in online learning and can be an alternative media used so that molecular geometry learning can run effectively. Based on the description, the author is interested in conducting research under the title "The Effectiveness of using 3d Simulation Media in Online Learning of Molecular Geometry Materials towards Improving Student Learning".

METHOD

This research was conducted at one of the state high schools in Semarang City, from November 2020 to December 2020. The type of research used in this study is a pre-experimental study of one group of pretest-postes (One Group Pretest-Posttest Design). Experimental research methods are research methods used to look for the influence of certain treatments on others under controlled conditions [8]. This experimental research involves one class, that is the experimental class. The measurements in this study were carried out twice, one measurement at the beginning by giving an initial test before being given treatment and after being given treatment, another measurement was taken by giving the final test. The variables in this study are independent variables and dependent variables, the independent variable in this study is a 3D simulation learning media used in molecular geometry learning materials, and the dependent variables in this study are student learning outcomes. The population in this study is all students of class X SMA X Semarang. While the sample in this study was class X students totaling 30 students who were selected with purposive sampling techniques, that is, sampling using individual or researcher considerations. The criteria used in this study were class X high school students who had never studied molecular geometry material before.

The data collection technique is carried out by observing student responses during live meetings in virtual classes of molecular geometry learning, learning outcomes tests, student response questionnaires, and documentation in the form of video discussions during Live Meetings as well as documentation of group presentation results. In this study, the research instruments used were test questions and questionnaires. The data analysis technique for learning outcomes in this study is effectiveness testing (N-Gain Test). In this study, learning media is said to be effective in improving student learning outcomes if statistically student learning outcomes show a significant difference between initial understanding before learning and understanding after learning (significant gains). The category of N-gain can be seen in the following table.

Table 1. Category Score Gain

N-Gain Score	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

The category of N-gain gains in the form of percent (%) can be seen in the following table.

Table 2. Categories Of N-Gain Effectiveness Interpretation

Presentaese (%)	Interpretation
< 40	Ineffective
40-50	Less Effective
56-75	Quite Effective
>76	Effective

The technique used to determine the presence or absence of significant differences in student learning outcomes is used t test and effect size test. Student Response Data Analysis was carried out by researchers to find out how students responded to the use of 3D simulation media in the online learning process of molecular geometry material that had been carried out.

RESULT AND DISCUSSION

Molecular geometry is one of the materials in chemical bonds that is abstract. In this material, students are expected to be able to think imaginatively in visualizing the three-dimensional form of a molecule or existing compound. In online learning, molecular geometry material requires interactive learning media that can have a positive impact on student learning outcomes. Interactive learning media that can be an option to be applied in online learning of molecular geometry material is a 3D PhET visual simulation media. PhET is a 3D simulation learning media that can be easily accessed by teachers and students in online learning to facilitate understanding of molecular geometry material [5].

The use of 3D PhET simulation media is expected to have a significant influence on student learning outcomes, especially in online learning. The use of learning media is said to be effective in improving student learning outcomes if statistically student learning outcomes show a significant difference between initial understanding before learning

and understanding after learning which is shown by obtaining a significant N-Gain value [9]. Based on the results of data collection through pretest and posttest scores as well as student response questionnaires to the use of 3D simulation media in online learning of molecular geometry material at SMA X Semarang, the following data were obtained:

Table 3. Student Learning Outcomes Value Data

Average Pretest score	Average Posttest score	N-Gain score	N-Gain Criteria	N-Gain score (%)	N-Gain Criteria
46	88	0.79	High	79.8	Effective

Normality testing was carried out using One sample of kolmogorof smirnov with a signification level of 0.05. The data analyzed are pretest data and posttest data. This test aims to find out whether the research data obtained is normally distributed or not. The decision-making criteria are seen from the significant value obtained. If the significant value obtained is more than 0.05 then the data is abnormally distributed, and if the significant value is more than or equal to 0.05 then the distributed data is normal. Based on the normality test conducted in this study, the results were obtained that the data had a significant value of 0.200 and had a normal distribution.

Based on the data shown in Table 3, the results of the effectiveness test can be known from the N-Gain value obtained, which is 0.79 with high criteria. The percentage of the N-Gain score is 79.8% so that it can be interpreted as an effective result. The results are based on an increase in the student's initial test score and final test score on learning molecular geometry material. This increase occurred after the implementation of learning using 3D simulation media. These results indicate that the 3D simulation media used in learning is considered very effective for improving student learning outcomes on molecular geometry material. The results are in accordance with the study by Dewita (2020) which states that learning media based on 3D visualization and molecular animation are very feasible and effective to be applied to the learning process of molecular forms and intermolecular forces [9].

The technique used to determine the presence or absence of significant differences in student learning outcomes is used t test and effect size test. The data hypothesis testing carried out in this study was a paired t-test with a confidence level of 5%. This test was carried out to find out whether there were significant differences between the pretest results that had not been given treatment and the postest results that had been applied using 3D simulation media. Hypothesis testing interpretation by looking at the Sig value (2 tailed) of 0.00 where $0.00 < 0.05$. Because the Sig (2 tailed) value obtained was less than 0.05, it can be concluded that there was a significant difference in the use of 3D simulation media in terms of student learning outcomes on molecular geometry material. In addition to using the t test, to determine the effectiveness of the use of 3D simulation media, an effect size test was carried out. The effect size test is a method carried out with the aim of knowing the scale of effectiveness of using 3D simulation media that has been applied to learning. Based on the tests carried out, it is known that the effect size value obtained is 0.98 with high criteria. These results can be interpreted to mean that the use of 3D simulation media in learning molecular geometry has a strong scale of effect or influence on student learning outcomes.

In this study, the 3D simulation media used was PhET simulation media. Based on the results of research on 3D PhET simulation media, it is considered to have a significant influence on student learning outcomes on molecular geometry material. Learning outcomes themselves are the most important part of learning. According to Anni in Khadira, et al (2009) learning outcomes are changes in behavior obtained by students after experiencing learning activities [10]. According to Suprijono (2010) learning outcomes as patterns of action, values, understandings, attitudes, appreciation and skills [11]. The results of this study are in accordance with the research from Nurhayati, et al (2014) which states that the learning outcomes of students taught by the demonstration method assisted by 3D PhET simulation media are better than the learning outcomes of students using conventional methods [12].

The difference in student learning outcomes is due to the demonstration method assisted by PhET software animation media is considered more attractive for students to take part in classroom learning and students do not only imagine abstractly about abstract concepts about molecular geometry explained by the teacher. The information is in accordance with the research conducted by Yuafi (2015) which concludes that there is an influence on the use of Physics Education Technology (PhET) learning media on student learning outcomes because it can create active, creative, efficient and fun learning [13]. Improving student learning outcomes by using PhET simulation media because it can involve students in learning activities. Even though learning is carried out online in virtual classes, students can still be actively involved because 3D PhET simulations can be accessed individually on their respective devices.

The advantages of PhET simulations can be run online or offline, where in this PhET can be displayed a material that is abstract and can be explained directly by this media so that students easily understand the material. The simulation provided by PhET is very interactive and invites students to learn by exploring directly.

Student responses are used as a reference to find out whether 3D simulation media is effective in improving student learning outcomes. Student responses are known through data collection techniques using questionnaires. There are four aspects analyzed, namely, aspects of student interest in participating in learning, understanding the material, ease of problem solving, and group cooperation.

Table 4. Interpretation of Student Response Questionnaire Calculations

No.	Range of Values	Criterion
1	0-1	Bad
2	1-2	Less Good
3	2-3	Good
4	3-4	Very Good

[13]

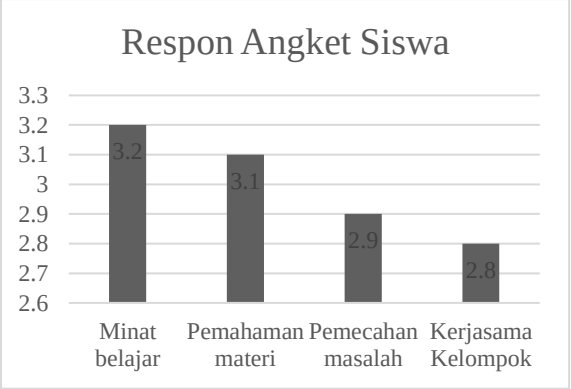

Figure 1. Student Questionnaire Responses to the Use of 3D Simulation Media

Student Response Data Analysis was carried out by researchers to find out how students responded to the use of 3D simulation media in the online learning process of molecular geometry material that had been carried out. There are four aspects that are analyzed, namely, aspects of student interest in participating in learning, understanding the material, ease of problem solving, and group cooperation. Based on the interpretation of the data in table 4, it is known that aspects of students' interest in following learning and aspects of understanding the material have very good criteria. As for the aspects of ease of problem solving and group cooperation, it has good criteria.

In the aspect of interest in learning, the score obtained is 3.2 with very good criteria. The results are in accordance with interviews and observations. Based on the results of interviews and observations made by researchers, it is known that students feel more interested and interested in studying molecular geometry material with 3D PhET simulation media because of its attractive appearance. In addition, students can actively try individually 3D PhET simulation media through their respective devices so that molecular geometry materials can be easily more easily understood than learning using conventional media.

In the aspect of understanding the material, the score obtained was 3.2 with very good criteria. The results obtained are in line with the results of interviews and observations. Based on the students' descriptions, they found it very helpful in understanding molecular geometry material with the use of 3D PhET simulation media, because they could visualize in three dimensions the shape of the molecules studied.

With the use of 3D PhET simulation media students not only understand the material based on the theory taught but can also understand the visual form of molecules based on vsepr theory.

The problem-solving aspect is the third aspect analyzed by the researcher. The score obtained in this aspect is 2.9 with good criteria. These results are in accordance with the results of interviews and observations. Based on students' descriptions, 3D PhET simulations can help them in solving problems or questions given. PhET 3D simulation media have a feature where they can easily find out the presence or absence of free electron pairs and electron bond pairs in compound molecules. With this feature, they think it is easier to solve problems and problems of molecular geometry material than to have to predict and draw conventionally.

In the aspect of group cooperation, the score obtained was 2.8 with good criteria. The results are in accordance with interviews and observations. Based on the results of interviews and observations made by researchers, in general, students can work together in groups to do molecular geometry tasks. Each group was given time to discuss working on group assignments with the help of 3D PhET simulation media. Although based on obsevation, there are still obstacles when discussing due to the lack of interaction between members, students have been able to complete group tasks. Each member can access 3D PhET simulation media so that although there is minimal interaction, each member can contribute according to their respective duties.

PhET 3D simulation media certainly still has its drawbacks, namely, there are some compound molecules that are not available in the simulation feature. However, broadly speaking, this learning medium is very useful in learning science, especially chemistry. This media can be an interactive learning media that can be chosen in conventional learning as well as in online learning. Learning with PhET simulation media is also considered more interesting and effective to improve student enthusiasm and learning outcomes on molecular geometry material. This is in accordance with the research by Sutrisno, et al (2017) which states that molecular geometry modeling with PhET simulation media is very good and effectively used in chemistry learning [14].

CONCLUSIONS AND SUGGESTIONS

Based on the research conducted, the conclusions obtained are (1) The use of 3D simulation learning media has a significant influence in improving student learning outcomes in online learning of molecular geometry material, (2) The use of 3D simulation learning media can improve student learning outcomes in online learning of molecular geometry material, (3) Students' response to the use of 3D simulation learning media is very good and facilitates students' understanding of online learning of molecular geometry material.

The advice that can be given by researchers from the results of this study is that (1) teachers and students can better adapt to the implementation of online learning. (2) teachers can implement appropriate learning models and use interactive learning media that support (3) teachers can be more creative in utilizing existing technologies and creating varied learning.

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