21 Development Student Submicro Journal of Physics Q-3.pdf

by

Submission date: 19-Aug-2020 05:03PM (UTC+0700)

Submission ID: 1371347845

File name: 21 Development Student Submicro Journal of Physics Q-3.pdf (658.41K)

Word count: 2967

Character count: 16091

Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Development of student's submicroscopic representation ability on molecular geometry material using Augmented Reality (AR) media

Development of student's submicroscopic representation ability on molecular geometry material using Augmented Reality (AR) media

I Wulandari[1], **F S Irwansyah**[1]*, **I Farida**[1] **and M A Ramdhani**[2]

[1]Department of Chemistry Education, UIN Sunan Gunung Djati Bandung, Bandung, Indonesia

[2]Department of Informatics, UIN Sunan Gunung Djati Bandung, Bandung, Indonesia

* Corresponding author's email: ferli@uinsgd.ac.id

Abstract. The purpose of this research is to apply a learning using Augmented Reality media to develop submicroscopic representation ability. The method used is a classroom research on the fourth semester students of Chemistry Education department, UIN Sunan Gunung Djati Bandung. Information obtained by measuring students' activities during learning, completion of worksheet, and submicroscopic representation ability after learning. The results obtained from the worksheet completion are included in the *very good* category (with an average of 86), with the highest ability shown in the determination of bonding domains and non-bonding domains based on Lewis structure (with an average of 94). Moreover, the results of submicroscopic representation ability tests after learning are included in the *very good* category (with an average of 81.5), with the highest ability shown in the determination of bonding domains and non-bonding domains based on Lewis structure (with an average of 92). This is because students discuss and collaborate very well and are supported by Augmented Reality (AR) media. Thus, Augmented Reality (AR) media can be used as one of media in developing students' submicroscopic representation ability on molecular geometry material. Development of Students' Submicroscopic Representation Ability on Molecular Geometry Material Using Augmented Reality (AR) Media.

1. Introduction

On every aspect of life, chemistry plays a very important role, including in the aspect of food, clothing and shelter. However, not all can be observed simply in studying chemistry so that chemistry is considered difficult to learn by students at both schools and colleges [1][2].

Chemistry mostly carries abstract concepts, therefore, it requires a good understanding of macroscopic, submicroscopic and symbolic phenomena to understand the concepts [3]. In particular, in understanding the concept of chemistry at the submicroscopic level considered difficult because students count on memorization strategy only. Memorization strategy is not good because it does not allow students to connect macroscopic phenomena with submicroscopic phenomena well, so that it is difficult to imagine how the process and structure of a reacting substance [4]. This difficulty is due to lack of visualization in describing molecular matters at the submicroscopic level. Meanwhile, the concept of chemistry can be understood thoroughly if the visualization can be illustrated well, therefore, it can help students to have a better understanding [5].

The concept of molecular geometry is an abstract concept with concrete examples. to understand the concept of chemistry at the submicroscopic level can be helped by describing it molecularly [6]. The description can use media, but the delay in the media used can also affect the description of the concept [7] whereas the media used can be used as a tool to visualize the concept of chemistry requiring molecular description, thus, submicroscopic representation ability can be developed [8]. Multimedia is a digital product that presents and combines text, sound, images, animation, audio and video, implemented with tools and connection so that users can navigate, interact, work, and communicate[9]. In education, multimedia is used as a teaching medium, either in classroom or self learning[10]. In learning process, multimedia has proven to be able to create a fun learning atmosphere[11], enhance learning motivation[12], create student-centered learning[13], improve the level of understanding[14], increase the effectiveness of learning[15], and make efficient investment of learning means[16].

In general, the media used are in the form of 3D using stick and ball models on molecular geometry material and are taught by introducing some examples of the basic forms of molecules, and then applied with the VSEPR theory using the ball and stick models [17]. However, the ball and stick models still cannot give good description because they have a rigid structure resulting in the difficulty of understanding the difference of the bond angle. Another difficulty is the similar size of the atoms even though the colors provided are various. Thus, the use of media with ball and stick models does not adequately represent the 3D arrangement of molecular structures[18].

Currently, technology of information and communication has been growing in the field of learning such as the use of Augmented Reality (AR) technology in the form of 3D display[19]. AR technology provides a display of three-dimensional objects that look real, so that molecular geometry material can be equipped with a real picture of how the real shape of a molecule is [20]. In addition, the use of AR technology can increase interest and motivation of students in the learning process, supported by AR media features that can provide visualization that looks real compared to other technologies [21].

2. Methods

This research is conducted with classroom research method. This research develops the ability of sub microscopic representation on molecular geometry material using augmented reality media. The target of this research is the fourth semester chemistry students taking the course of inorganic chemistry I. Students work in groups on problems contained in worksheet using AR media grouped randomly. Reliability of AR media features in this research uses analytical, logical, conceptual, and operational verification [22].

3. Results and Discussion

The results of this research are obtained from students' worksheet completion based on the indicators of submicroscopic representation completed with the description of the use of AR media worksheets and written tests based on indicators of submicroscopic representation.

3.1. The Analysis Results of Students' Worksheet Completion Using AR Media on the Concept of Molecular Geometry

Students work on worksheets in groups. The ability of students to complete worksheets using AR media on the concept of molecular geometry is seen from the score obtained in the learning group. Student worksheets are arranged based on indicators of submicroscopic representation ability to be developed. The relationship between the indicators of the submicroscopic representation ability and questions provided in the worksheets can be seen in table 1.

Table 1. Relationship between Indicators of Sub-Microscopic Representation Ability and Worksheet Questions.

No	Indicators of Submicroscopic Representation Ability	Question Number
1	Students can determine and describe the right Lewis structure based on formal charge rules	1a, 1b, 2a, 2b, 3a, 3b, 4a, 4b, 5a and 5b
2	Students can define bonding domains and non-bonding domains based on the Lewis structure	1c, 2c, 3c, 4c and 5c
3	Students can determine the right molecular geometry based on Lewis structure and the difference between bond angles on the image in each given marker	1d, 2d, 3d, 4d and 5d
4	Students can determine the right molecular geometry based on the bonding domain and the non- bonding domain on the image in each given marker	6
5	Students can analyze the influence of non-bonding domains and the differences of bond angles in determining molecular geometry based on Lewis structures	7

The recapitulation of the results of the worksheet completion results using AR media on the concept of molecular geometry can be seen in Figure 1.

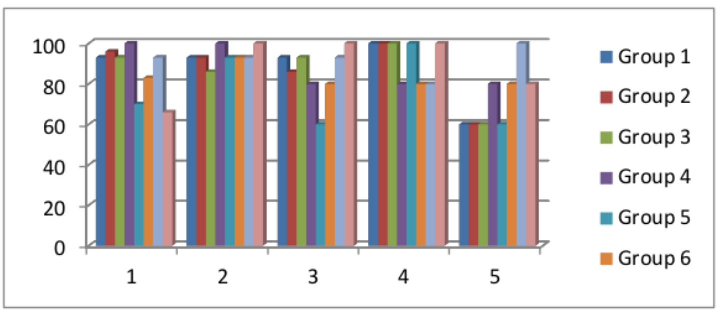

Figure 1. Recapitulation of worksheet scores achieved in each Submicroscopic Representation ability Indicator

Based on the research results, the highest average score in the development of submicroscopic representation ability is on the second indicator, i.e. students can determine the bonding domain and non-bonding domain based on Lewis structure with the score of 94, showing that students can solve the problem on the second indicator very well.

3.2. Analysis of Students' Submicroscopic Representation Ability Using AR Media on Molecular Geometry Concept.

Analysis of students' individual submicroscopic representation ability using written tests based on submicroscopic indicators. Written tests are carried out after completing worksheets, consisting of 5 essay questions carrying indicators of submicroscopic representation ability.

The relationship between the indicators of the submicroscopic representation ability to be developed and questions provided in the worksheets can be seen in table 2.

Table 2 Relationship between Indicators of Sub-Microscopic Representation Ability and Worksheet Questions.

No	Indicator of Submicroscopic Representation Ability	Question Number
1	Students can determine the valence electrons of the atoms forming a compound correctly	1a, 2a, 3a and 4a
2	Students can describe the Lewis structure of a molecule based on formal charge rules	1b, 2b, 3b and 4b
3	Students can determine the number of bonding domains and non-bonding domains at the central atom of a molecule based on Lewis structure	1c, 2c, 3c and 4c
4	Students can determine the right molecular geometry based on the number of bonding domains and non-bonding domains in the image in each given marker	1d, 2d, 3d and 4d
5	Students can analyze the influence of bonding domains and non-bonding domains on determining the geometry of molecules based on Lewis structure	5

Student's written test results based on submicroscopic indicators can be seen in Figure 2.

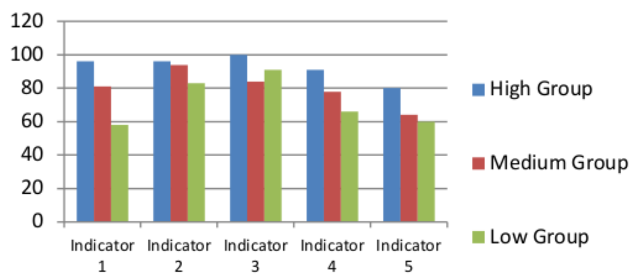

Figure 2. Recapitulation of Written Test Scores achieved in each Submicroscopic Representation ability Indicator.

According to the indicators of submicroscopic ability, the score achieved by the students on the third indicator, i.e. students can determine the number of bonding domains and non-bonding domains at the central atom of a molecule based on Lewis structure, is 92 showing an excellent criterion.

Overall, all stages of the development of submicroscopic representation ability on molecular geometry materials using AR media show excellent results due to good discussion and use of AR media. Discussion in groups includes exchanging ideas in solving a problem. Good results can be achieved if accompanied by good discussions as well [23]. Moreover, the use of AR media can provide a real visualization in 3D making concepts actually hard to observe able to be well visualized [24]. Based on the research results, students in the learning group answer marker numbers correctly, therefore, it can be said that AR media can represent molecular geometry forms that are easy to understand. It shows that the use of AR media can visualize well the concepts at the submicroscopic level[20]. However, some students in the learning group still use memorization strategy, thus, they cannot represent pictorial objects on AR media in determining molecular geometry. Shown from the answer on the worksheet, some groups correctly answer the marker number, but with irrelevant geometry. The understanding of a concept is based on macroscopic, submicroscopic and symbolic abilities. If a concept is studied based on macroscopic and symbolic levels only, the visualization of the concept at submicroscopic level tend to be defined separately [25]. Therefore, students are expected not only to focus on memorizing in learning a concept, but also to represent the concept at the submicroscopic level.

4. Conclusion

Based on the research results conducted on the fourth semester students of Chemical Education department, UIN Sunan Gunung Djati Bandung, in the learning process, the ability of submicroscopic representation on molecular geometry material is included in the *very good* criterion with an average score of 86. The highest ability is shown in the determination of bonding domains and non-bonding domains based on Lewis structure with an average score of 94. The lowest ability is shown in the ability to analyze the influence of non-bonding domains and the difference of bond angles based on Lewis structure with an average score of 72.5. After the learning process, overall it is included in the *very good* category with an average score of 81.5. The highest ability is shown in the determination of the number of bonding domains and non-bonding domains based on Lewis structure with an average score of 92. The lowest ability is shown in the ability to analyze the influence of bonding domains and non-bond domains based on Lewis structure with an average score of 68.

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Acknowledgements
Authors expressed the appreciation and thank you to the Research and Publishing Center of UIN Sunan Gunung Djati Bandung, which has provided funding support for the publication of this article.

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