Application of Augmented Reality (AR) media on conformation of alkanes and cycloalkanes concepts to improve student’s spatial ability

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Abstract. The purpose of this study is to apply the Augmented Reality (AR) media to improve the student’s spatial ability on alkanes and cycloalkanes conformation. The method of this study was quasi-experimental control group pretest-posttest design for the second-semester students of the Chemical Education at UIN Sunan Gunung Djati Bandung. Data carried out through tests and non-test (worksheet and observation), and further analyzed using statistical methods by mean of SPSS version 23. The results showed that the student’s spatial ability on conformation of alkanes and cycloalkanes was increased with N-gain results categorized as moderate (mean 0.58). This means that AR conformation can visualize the movement of an object.

1. Introduction

The conformation of alkanes and cycloalkanes is one of the abstract concepts in organic chemistry [1]. This concept examines the molecular structure in three-dimensional spaces, as well as changes in the molecular form [2]. In case of molecular conformation, it is crucial to discuss about molecular clusters that regulate σ and chiral bonds [1]. The concept of the conformity of Alkanes Cycloalkane relies on the three-dimensional molecular structure (3D) whereas in textbooks it should be represented as a two-dimensional object (2D) [3]. The three-dimensional (3D) molecular structure that should be represented in two dimensions (2D) makes the topic conformation challenging to be learnt because it requires the ability to transfer between the mental and the printed images [2]. This capability is known as spatial skill, which refers to the ability to visualize the movement of an abstract object [4, 5]. Oliver & Rosa reported that the spatial ability affects the chemistry students’ performance since it has molecular properties and a visual representation in understanding molecular interactions [6].

High spatial capability resulted in higher achievement in stereochemical materials [7]. These capabilities can be improved by using visual literacy [8]. The visualizations needed
the visualized 3D molecular structure rather than that of the 2D [2]. Therefore, it is necessary to use the learning media that can visualize in the 3D form so students are more easier to understand the conformation concepts [9]. 3D visualization is intended to be physically or chemically, provides clear and precise information, and suitable with technological developments [10]. Currently, there are several developed softwares such as the Chembio3D software on the isomer structure [11] and chemical drawing software on stereochemistry [12]. Through the advanced improvement in computer technology, some of the latest computer applications even can also be accessed via smartphones [13]. Apps in smartphones that can visualize in 3D are augmented reality (AR) technology [14]. AR technology is actually not a new thing, but it can be utilized to improve the learning quality [15]. In particular, AR technology can help students to create, to discuss, and to understand the learning material through a combination of real objects and virtual objects [16]. Therefore, AR technology can be applied as a learning media [17]. In this study, we attempt to use the AR technology as a learning media of the conformation of Alkanes Cycloalkanes. This application is expected to improve students’ spatial capabilities.

2. Methods
This research uses pre-experimental methods with one group of Pretest-posttest design. The pretest and posttest were carried out to obtain information of students’ spatial ability before and after learning process (AR media implementation), respectively. The obtained data were then analyzed to determine the students’ spatial ability as a result of AR media application by calculation of N-Gain between pretest and posttest. The instruments used in this study included the lesson plan, augmented reality media, and spreadsheets. The research design is illustrated in Table 1.

| Table1. Pre-experimental method |
|-------------------------------|
| Pre-test | Treatment | Post-test |
| O₁       | X         | O₂        |

where O₁: Pre-test; X: Treatment, i.e., learning with augmented reality; and O₂: Post-test

3. Results and Discussion
The results of the Pretest analysis demonstrated that students generally have difficulty in visualizing the molecular rotation that occurs in the conformation of Alkanes Cycloalkanes. Students tend to describe the conformation form of Alkanes Cycloalkanes without considering the number of H atoms and the bonding exist in the molecules. Based on the observation results of AR implementation on learning process, it can be mentioned that students can learn the visualization of the molecular conformation of Alkanes Cycloalkanes. The increased percentage of students’ understanding on the conformation of Alkanes Cycloalkanes can be seen in the table 2.

| Table 2. N-Gain value on any spatial ability indicator |
|-----------------------------------------------------|
| No | Problem indicator | Skor N-gain |
|----|--------------------|-------------|
| 1. | Describe the complete structural formula of some compounds | 0.96 |
| 2. | Determining the type and properties of bonds found in the compounds | 0.38 |
| 3. | Analyze the compounds that are experiencing conformation. | 0.50 |
| 4. | The conformation of several compounds of alkanes and Cycloalkyana. | 0.52 |
According to table 2, after the application of AR in learning alkanes cycloalkanes conformation, it is found that the indicator 1 has the highest increase where the students have been able to describe structure formula of alkanes, alkenes, alkyl, and cycloalkanes completely by observing the H atom and chemical bonding exist in the compounds.

The second indicator determines the type and nature of the bonds found in the prescribed compounds. The n-gain value of this indicator is 0.38 categorized as. It shown that the students’ spatial ability in spatial orientation as explained by Anggriawan & Budiasih [5] especially in determining single bonds, double bonds, and triple bonds still insufficient where the ability to visualize objects from a different point of view need to be further improved.

The third indicator is analyzing the compounds that are experiencing the conformation. Students are required to apply the type and nature of bonds to analyze compounds that are experiencing conformation. This indicator shows the overall n-gain value of 0.50 (medium category). In this regard, high spatial visualization capabilities are required to transform from two dimensions (2D) to three dimensions (3D) especially for the molecule having single bond and rotation angle of 60° [2].

The fourth indicator is that the learner can describe the conformation formed from several compounds of alkane and cycloalkynes with the N-gain of 0.52 (medium category). According to Oliver & Babylonia [6], the high spatial ability affects the students’ understanding concepts that require molecular models. Based on the results, it can be inferred that AR media can improve spatial ability since it can visualize well the molecules from 2D to 3D.

In the fifth indicator, students determine the most stable form of conformation. In this indicator, students are required to analyze the structure of conformation to obtain information of the molecular stability where the N-gain is of 0.32 (medium category). This is due to the AR media used only visualized the shape and the sum of strain energy. So that, the students must have spatial skills in the aspect of high spatial visualization as an excellent cognitive process [8] the highest stability of the molecular conformation can be actually explained using energy graph or strain where the interaction between the C-C atoms or H-H atoms can be clearly seen [18].

Overall, the students’ spatial ability indicator of the conformation of alkanes cycloalkanes classified in medium category. It can be said that AR media can improve students’ spatial capabilities. This result is in line with Behmke et al. [19] where the AR media can transform molecular models on 2D paper into 3D form to develop students’ molecular capabilities. Some students still have low spatial skill where the experienced difficulty on visualizing the molecular rotation on conformation [8]. Winfield et al. [20] mentioned that the molecular conformation demanded the imagination in the arrangement of a space that is different from the rotation surrounding the Sigma bond. These results correspond to the finding by Stull et al. [21], where spatial ability is essential to solving problems in organic chemistry especially determining the appearance of molecules after rotation in the 3D visualization [22].

4. Conclusion
In this research the implementation of alkane dan cycloalkanes learning program based on the visualization of 3D molecular structure using augmented reality media has been
carried out. The result of the study found an average N-gain of 0.58 included in the medium category. The application of augmented reality media can improve student’s spatial ability for the conformation of alkanes and cycloalkanes concepts. These result indicate that the AR media can visualize the rotation that occurs in the alkane and cycloalkanes conformation from 2D molecular structure to 3D molecular structure.

5. References

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