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Interactive Multimedia by Stimulating Visual-Spatial Intelligence Trial

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Abstract

Covalent bonding is abstract and unobservable therefore it is necessary to develop interactive multimedia which presents visualization in three dimensions (3D) as an aid to representing unobservable matter. This study focuses on investigating the effectiveness of interactive multimedia by stimulating visual-spatial intelligence on the covalent bond that has been developed. This study is according to the Research and Development model based on Sugiyono's model including finding potential & problems, collecting data, product design, product validation, product revision, and limited to product trials (Stage 6). The effectiveness of interactive multimedia is examined from the improvement of student learning outcomes after using interactive multimedia. The results showed that 81.2% of students were in the high category and 18.2% in the medium category. N-gain results show that interactive multimedia was effective to enhance learning outcomes. The results showed that 81.2% of students were in the high category and 18.2% in the medium category. This study shows that interactive multimedia by stimulating visual-spatial intelligence is effective to enhance learning outcomes.

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Introduction

Chemistry is a study of matter and its changes. One of its topics that is often considered difficult to grasp is covalent bonding. Many researchers have probed the difficulties in learning covalent bonding and the cause of it. It is because covalent bonding is associated with chemical bonding and structure which is naturally abstract and unobservable (Tsaparlis et al., 2018; Yustin & Wiyarsi, 2019). The other cause is the students' inability to render the representation given to be conceptual understanding (Dawati et al., 2019; Erman, 2017). This kind of topic requires sub-microscopic and symbolic representation understanding. A covalent bond topic by its nature involves reasoning with visual information because its character requires external representation through various modes and one of them is a visual mode (Bergqvist et al., 2013; Dickmann et al., 2019). Hence, learning covalent bonding subject is a complex cognitive activity that requires visual-spatial intelligence (Oliver-Hoyo & Babilonia-Rosa, 2017).

Visual-spatial intelligence which is also known as visuospatial or visual-spatial thinking, visual-spatial cognition is the capability to capture the world of space and transform these visual-spatial perceptions in various forms, including thinking intelligence in the form of visualization, three-dimensional images and shapes, and sensitivity to balance, relations, colors, lines and spaces visual. Basically, visual-spatial intelligence is often used in everyday life when we seek to reason with visual representations because this component of cognitive functioning allows us to render visual information. But, visual-spatial intelligence in each person, especially in this case is student, has different level thus there is some way to enhance or improve it (Bobek & Tversky, 2016; Eskisehir & Ozlem, 2015; Gani et al., 2017; González Campos et al., 2019; Hindal, 2014; Roca-González et al., 2017; Septia et al., 2018; Wahyudi & Arwansyah, 2019). Visual-spatial intelligence can be nurtured through some direct experience with physiological visual processes (Carlisle & Nieswandt, 2015). Visual-spatial intelligence becomes an important thing to be stimulated or fostered because it has a statistically significant correlation with student learning outcomes. Moreover, visual-spatial intelligence is indeed known to improve students' learning outcomes (Abdi & Desfandi, 2020). Otherwise, lack of visual-spatial intelligence can cause difficulties in the learning process such as in covalent bonding topics which requires translating abstract information ability into conceptual understanding (Dawati et al., 2019; Erman, 2017).

Many researchers also have encountered that using interactive multimedia can support students' understanding so it enhances the learning outcomes (Leow & Neo, 2014; Nusir et al., 2013; Wiana et al., 2018). Interactive multimedia is a term used for the collection of multiple mediums like text, graphics, audio, video, animations (Gouhar & Mahapatra, 2016). Interactive multimedia enable students to control the content flow of information. Because multimedia combines and integrates text, picture, sound, animation, video, it is possible to visualize and represent abstract topics such as chemistry (Astuti et al., 2018; Herdini et al., 2018; Kurniawan et al., 2018). It provides many conveniences and also strengthens students in understanding concepts. Sahronih et al. (2019) showed that interactive multimedia utilization significantly affects the improvement of learning outcomes in science. The other example is the research which has been conducted by (Arham & Dwiningsih, 2016), he conducted trials on 12 students and showed that interactive multimedia could improve student learning outcomes, especially in chemistry. The use of interactive multimedia either dynamic, simulated, or analogical representations can represent the essence of the concepts in an attempt to match the true ideas, therefore, helping students in enhancing the understanding. It also eases students' difficulties through the tools that have been designed to help visualize infinitesimal chemical entities such as atom and bond (Bernholt et al., 2019; Chiu & Wu, 2009).

As a result, interactive multimedia can be used as a tool that is expected can enhance students' understanding by integrating text, pictures, three-dimensional form of the molecule which is designed for stimulating spatial-visual intelligence (Castro-alonso & Fiorella, 2019). In other words, combining interactive multimedia and spatial-visual stimulus is one of the ways to enhance students' understanding of a covalent bond. Such as research conducted by (Isaloka & Dwiningsih, 2020) shows that interactive multimedia with visual-spatial-oriented meets validity and practicality requirements. Corresponding to another research that also shows that multimedia using 3D virtual modeling and visualization is valid and can be used as an instrument for enhancing students' understanding (Dwiningsih & Safitri, 2020; Nurviandy et al., 2020). Visualization of the concept inside interactive multimedia in form of both two-dimensional and three-dimensional could be used for communicating concepts to students as well as to foster or stimulate visual-spatial intelligence. Previously, the author has developed interactive multimedia by stimulating visual-spatial intelligence in the subject of covalent bonds. The developed interactive multimedia consists of material on covalent bonds, a gallery of several covalent molecules in 3-dimensional (3D) form, and quizzes. To that end, this study has focused on the aim to examine and determine the effectiveness of interactive multimedia by stimulating visual-spatial intelligence.

Method

The experiment was using Research and Development (R&D) design according to Sugiyono's model. This research procedure is limited to product trials to investigate the effectiveness of interactive multimedia. From potential and problem-finding procedures to product revisions have been discussed in the previous article and are ready to be continued to the next stage. At the product trial stage, interactive multimedia was tried out in limited groups. Following in figure 1 are the procedure graphs of R&D research using Sugiyono's model.

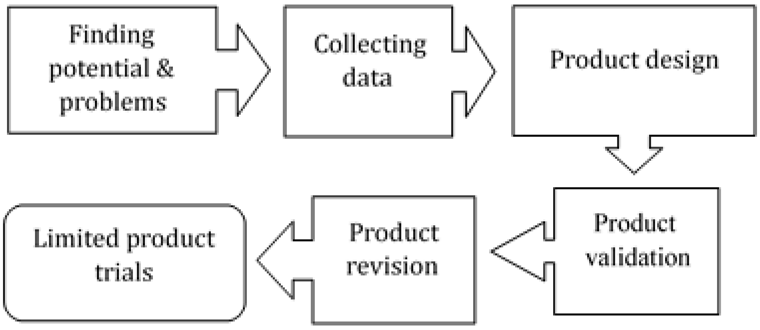

Figure 1. Research and Development (Sugiyono, 2016)

This trial was conducted with experimental research namely a One-Group Pretest-Posttest Design which is comparing the results after and before receiving treatment and be conducted in one group without a comparison group. The subject of this experiment is 16 students of *SMA Negeri 1 Sidayu* (SMANSI).

$$O_1 \; X \; O_2$$

O_1 = Implementation of pretest before treatment
X = The treatment was given was interactive multimedia trials
O_2 = Implementation of pretest after treatment

The instrument used in this research was the learning outcome test sheet. Learning outcome tests are used to determine the effectiveness of interactive multimedia based on the results of the students' pretest and post-test. Student learning outcomes analysis is executed by analyzing through increasing student learning outcomes. The increase in student learning outcomes is obtained from the pretest and posttest results which are then used to calculate the normalized gain (N-gain). Gain is the difference between the posttest value and the pretest value and shows an increase in students' understanding of the concept of covalent bond sub materials. The N-gain can be calculated using the following formula.

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}}$$

Explanation:
S_{post} = posttest score
S_{pre} = pretest score
S_{max} = maximum score

Table 1. N-gain levels categories

N-gain score	Level
g > 0,70	High
0,30 < g ≤ 0,70	Medium
g ≤ 0,30	Low

Based on the Gain score category, multimedia can be said to be effective if there is an increase in student learning outcomes with the average gain score obtained reaching the "medium" or "high" category.

Results and Discussion

Interactive multimedia for covalent bonding materials which has been developed has several main sections which are *objectives*, *materials*, *galleries*, and *quizzes*. The *objectives* section contains the objectives of the learning using interactive multimedia. *The materials* section contains a summary and main explanation of the covalent bonding. *The galleries* section provides the three-dimensional shape of some molecules. *The quizzes* section is the last section that is provided and can be used as a practice to check students' understanding by themself. This interactive multimedia development is carried out with the R&D (Research and Development) design based on Sugiyono's model which goes through several stages, including finding potential & problems, collecting data, product design, product validation, product revision, and limited product trials (Sugiyono, 2016). The results of the previous stage which include the validity of interactive multimedia have been discussed in the other article so in this study, researchers will continue to discuss the result of the research in the limited product trial stage.

The multimedia design which has been revised in the product revision stage was applied to 16 students of SMAN 1 Sidayu Gresik (SMANSI) to probe its effectiveness. Interactive multimedia application to students is a form of treatment to stimulate the students' visual-spatial intelligence. The effectiveness of interactive multimedia was examined from learning outcomes progress which can be seen from the results of pretest and post-test data comparison and its normalized gain (n-gain). The pre-test is a bunch of questions to measure students' understanding of covalent bonding before treatment is given. While post-test is a bunch of questions to measure students' understanding in covalent bonding as well but after treatment is given. The results of the pretest and posttest of 16 students are shown in Figure 2.

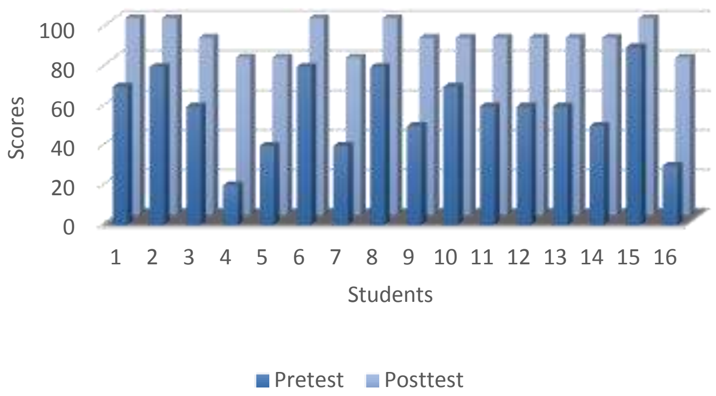

Figure 2. Outcome learning results

Based on the results in Figure 2, the pre-test scores of the 16 students who were tried out shows that merely 4 students reached mastery learning. The results of the post-test given after using interactive multimedia by stimulating visual-spatial intelligence showed that all students achieved mastery learning. The N-gain obtained by each student has increased learning outcomes by 18.8% in the medium category and 81.2% in the high category. Based on the N-gain obtained, it shows that the developed interactive multimedia by stimulating visual-spatial intelligence is effective because it improves the student learning outcomes. Many studies in line have proven that interactive multimedia usage with a variety of different features can improve student learning outcomes in a variety of different materials (Made Rajendra & Made Sudana, 2018; Sahronih et al., 2019). Without exception, this interactive multimedia is equipped with visualization of covalent molecules in 3-dimensional (3D). This interactive multimedia utilize visual modes of explanation to stimulate the students' visual-spatial intelligence by emphasizing basic covalent bonding concepts and guiding students to estimate covalent bond formation, visualize and interact with a covalent molecule in three dimensional (3D) picture.

As mentioned before, this interactive multimedia has several sections which are *objectives, materials, gallery, and quizzes* sections. In the *material* section, besides students will be provided with basic concepts of covalent bonding including its definition and its example, students also have the direct opportunity to estimate the covalent bonds of certain molecules which will be possible to occur by configuring electrons its element component. If the students' estimation about the electron configuration of the atom's molecule is correct, the students will be shown the 3D form of its molecule. But, if students' estimation still goes wrong, the students will have other chances. The students will have 5 chances to try to answer incorrectly. If in the fifth chance they still answer it incorrectly, the right answer will appear in the box and continue automatically to show the 3D form of the molecule as well. The portrayal of the *material* section is just as the figure 3.

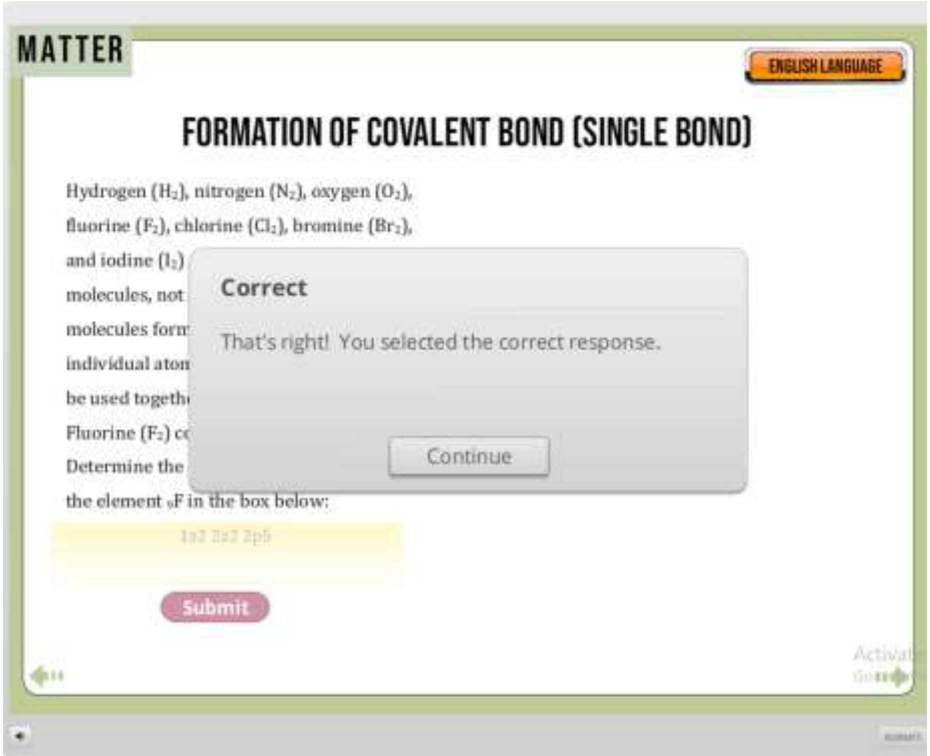

Figure 3. Example of material section

After passing through the material section to the end, students can then access the *gallery* section to be able to interact with several covalent molecules that are available instead of molymod. It can be zoomed and rotated as students desire even the color of the molecules and their bonds have been adjusted with CPK coloring (a famous color for atom marker of different elements in molecular models) to make it easier for students to remember the elements and their characteristics which are also mentioned in the gallery section.

Based on the behavioral learning theory which states that the response is influenced by external stimuli, interactive multimedia equipped with visualization of covalent molecules in 3-dimensional (3D) is a form of external stimulus to enhance visual-spatial intelligence which works on the learning outcomes. Actually, there are many ways to provide stimulation to improve visual-spatial but in this study, researchers focused on providing stimulation in the form of viewing molecular models from different sight points of view which are existed in the *gallery* section by directly operating the molecule as can be seen in figure 4 below (Carlisle & Nieswandt, 2015).

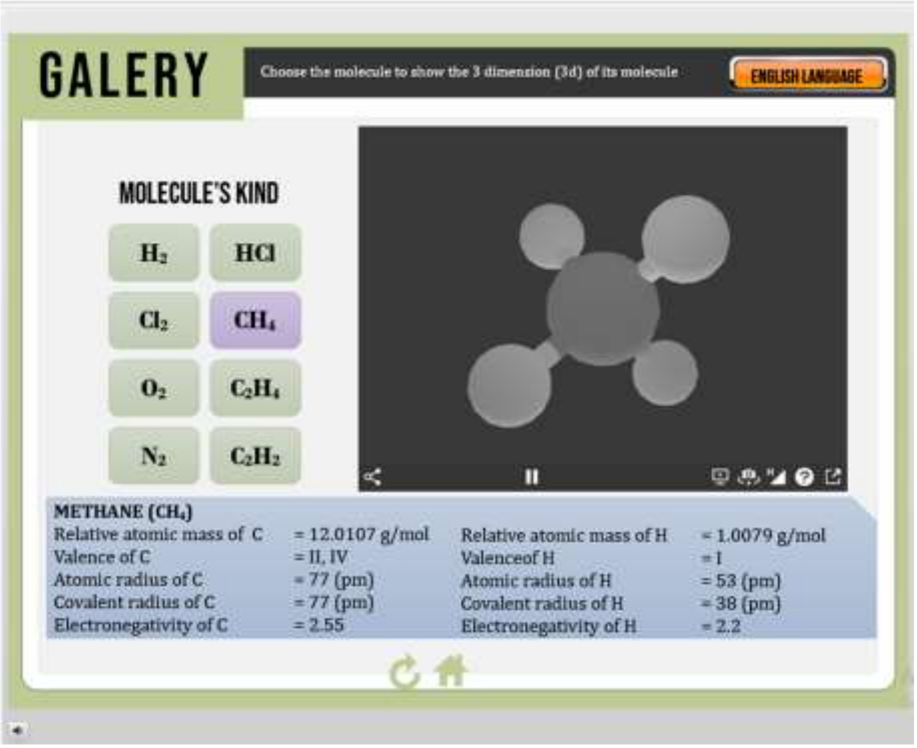

Figure 4. Three-dimensional (3D) Gallery section in interactive multimedia

For this ongoing-developing interactive multimedia, the *gallery* section only presents eight kinds of the molecule which are hydrogen (H_2), hydrochloric acid (HCl), chlorine (Cl_2), and methane (CH_4) molecule as single covalent bonding examples. Oxygen (O_2) and ethene (C_2H_4) molecules as the double covalent bonding representative and the two last molecules which are nitrogen (N_2) and ethyne (C_2H_2) molecule as the example of triple covalent bonding. In this section of interactive multimedia, the students can observe in detail the form of the molecule while they also can see the information of the component atom of each molecule. The information presented is the information that has a relation to covalent bonding formation. It includes the relative atomic mass, the valence electron of atoms, the atomic radius, the electronegativity, and also covalent radius of the atom.

Actually, pre-test and post-test were given not only to investigate understanding in covalent bond but also these tests were given out of the necessity to probe students' visual-spatial intelligence. Some of the pre-test and post-test questions that were given contained Purdue Spatial Visualization Test: Rotations (PSVT:R) which is considered to be the best cognitive measure of visual-spatial intelligence. The results PSVT:R test questions are shown in figure 5.

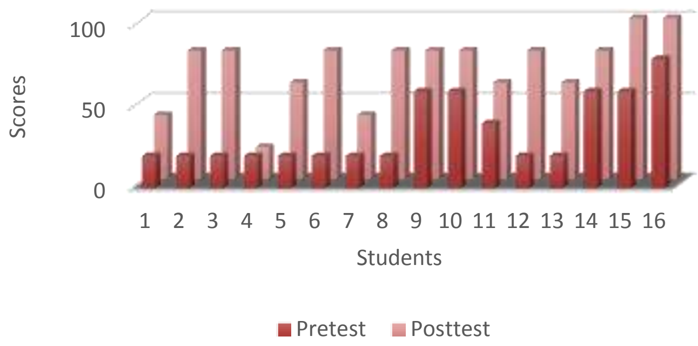

Figure 5. Purdue Spatial Visualization Test: Rotations results

The N-gain obtained by each student has increased PSVT:R test results by 18,75% in the low category, 37,5% in the medium category, and 43,75% in the high category. This suggests that there are enhancements of capable of mentally rotating pictures, or changing egocentric reference frames to adopt different perspectives. The results indicate that engaging in the interactive multimedia utilization, especially in the *material* and *gallery* section can stimulate visual-spatial intelligence which affects students' visual-spatial intelligence improvement, therefore, it increases the learning outcomes as a result of enhancing students' understanding of covalent bonding topics. Lowrie et al. (2018) has mentioned that there were substantial learning outcomes enhancements after getting visual-spatial intervention in the learning activity. By interacting directly with the 3D molecule in the gallery such as zooming in, zooming out, rotating the molecule, it gives students experience which can foster visual-spatial intelligence. Supporting the graph in Figure 5, there was an enhancement in students' visual-spatial ability after using the interactive multimedia. By the enhancement of students' visual-spatial ability, the understanding concept increases and it was marked by the learning outcomes which pose the progression presented in Figure 2. It happens because there is a relation between covalent bonding topic understanding and visual special intelligence. Covalent bonding topic is a topic which submicroscopic and symbolic which abstract in gaining understanding so it needs visual-spatial intelligence. So, the better the visual-spatial intelligence of the students, the better the covalent bonding understanding of the students. It was supported by (Cole, 2017) in her thesis that there is a significant and positive correlation between visual-spatial ability and understanding concepts in chemistry no exception in covalent bonding topics. In line with (Stieff, 2019) who has revealed that visualization-supported inquiry activities have indicated substantial success in improving student learning outcomes in chemistry because almost every chemistry concept is abstract.

Despite the result that gives a good sign, this developing interactive multimedia has a weakness and limitations that need improvisation in the future. The weakness of this interactive multimedia is only can be used in schools that allow students to bring a laptop or already have computers in learning activities. This interactive multimedia is also still developed by using the "Articulate Storyline 3" application that have some limitation to develop the content of the interactive multimedia. The researcher suggests developing this interactive multimedia using the other application which is more friendly user and advanced.

Conclusion

Based on the results of the research and discussion that has been described, it can be concluded that interactive multimedia by stimulating visual-spatial intelligence can be declared as effective which is viewed from the student learning outcomes which have increased by 81.2% in the high category and 18.8% in the medium category. Interactive multimedia can be used for stimulating visual-spatial intelligence by enhancing the visual-spatial intelligence of students. The result of the research shows that The N-gain obtained by each student has increased PSVT:R test results by 18,75% in the low category, 37,5% in the medium category, and 43,75% in the high category.

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