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The Effectiveness of Interactive E-Modules as Learning Media to Train Visual Spatial Intelligence in Chemical Bond Material

Ria Fatmawati & Sukarmin Sukarmin*

Department of Chemistry Education, Faculty of Mathematics and Natural Sciences, Surabaya State University, Jl. Ketintang, Ketintang, Kec. Gayungan, Surabaya City, East Java, Indonesia 60231

* Corresponding Author e-mail: sukarmin@unesa.ac.id

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Abstract

This study aims to determine the effectiveness of interactive e-module that train students' visual intelligence on chemical bond material. Chemical bond is one of the high school chemistry materials that has basic concepts that must be mastered in order to understand other chemistry topics and abstracts require the ability to understand what must be stimulated. This study was compiled based on the 4D research and development (R&D) model. The subjects and population of this study were students of class XI IPA at SMAN 12 Surabaya. The effectiveness of the review of cognitive domain tests and spatial visual intelligence tests before and after the use of a 3D visualialization base interactive e-module. The analysis of this study used N-gain and normality statistical tests until the data were normally distributed. The effectiveness of the media was stated to be very effective with an N-Gain score on the cognitive test of 0.8 in the high category and the spatial visual intelligence test of 0.8 in the high category which shows the relationship between cognitive domain tests and visual spatial tests can improve understanding of chemical bond material. The results of the research show that it is feasible to implement.

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INTRODUCTION

As a science, chemistry is at the center of natural sciences because of its role in daily life. Chemistry is a that investigates matter's composition, structure, characteristics, and changes (Buthelezi, 2013). Chemistry also involves abstract concepts that are invisible to the sense of sight, chemistry has three levels of representation, including macroscopic explaining the representation of observable phenomena such as in laboratory experiments; Submicroscopic describes the depiction of particles' structure or activity, such as molecules and ions, whereas symbolic represents the representation of signs and symbols used to represent particles and their behavior, such as chemical formulas or chemical equations (Johnstone, 2006). In contrast, symbolic representation depicts macroscopic phenomena using atomic symbols, molecular formulae, mathematical equations, chemical equations, graphs, analogies, and reaction processes (Rosmiati, 2022).

The submicroscopic level cannot be observed directly, therefore it is important to provide students with visualization at the submicroscopic level. This is done to help students remember chemical explanations which are the basis of knowledge in explaining chemical phenomena that will be associated with chemical concepts and can connect the three levels of chemical representation (Davidowitz & Chittleborough, 2009). increased capabilities representation of students using submicroscopic animation media in higher learning than representation ability of students who do not using submicroscopic animation media (Azizah Mashami & Andayani, 2014)Chemical bond is one of the basic chemical concepts that is difficult to understand, because chemical bond material covers all three levels of representation and is a basic concept that must be mastered in order to understand other chemistry topics (Agustina, 2017)

Facilitating chemistry learning requires representation to visualize abstract concepts and there are many concepts that have not been visualized in real terms making difficult for students to understand the material if they only imagine (Ilyasa & Dwiningsih, 2020) In order to understand the content of the material by way of visualization to be able to make a good representation. Improved visual spatial intelligence is required for students in the chemistry learning process which will increase the power of visualization in chemistry learning so that students in the future can support work skills, in conceptualizing, designing, and planning.

According to (Wu & Shah, 2004) is to resent chemical properties in an interactive way and visualize 2D and 3D. One of the efforts to visualize 2D and 3D is through learning media that can help students understand chemistry, especially the material of chemical bonds. Also opinion molecules are abstract and cannot be seen directly with the eyes, it is crucial for students to have strong visual-spatial skills in order to comprehend the forms of molecules on chemical bond (Winata, 2023)

Interactive learning media is not only able to visualize concepts but also provides exercises that can be done repeatedly with feedback. According to the behaviorist concept, this can build students' abilities in existing material (Peter Atkins & Julio de Paula, 2006) Visual spatial intelligence indicators cover four aspects of visual spatial intelligence related to chemical material, namely symmetry, visualization, translation, and rotation (Deborah L. Carlisle, 2014) Digital technology can play an important role in the approach mainly due to its symbolic and processing capabilities. Because it will support the educational process in the industrial revolution 4.0 era, good learning media must correspond to the era of current technology breakthroughs. There is a need for the teacher's job to change from being considered a source of learning in the era of industrial revolution 4.0 to being the exclusive source of learning (Hussin, 2018).

The criteria for the effectiveness of a product is based on those who use the product can produce the desired goals (Tjeerd Plomp & Nienke Nieveen, 2013).) Research entitled 3D visualization types in multimedia applications for science learning: that learning media that incorporate aspects of visualization can have "extraordinary" effects on students due to the benefits of observing and re-examining visual spatial sections (3D illustrations) that involve high levels of conception and cognitive processes, that the use of information, communication, and technology can be good opportunities to create applications or chemistry learning media with effective tools to develop new methods and techniques in chemistry education (Korakakis et al., 2009). Use of interactive multimedia-assisted student worksheet media resulted in high visual spatial intelligence test scores in chemistry learning (Hulu & Dwiningsih, 2021)

The learning that is put into practice needs to be able to improve student learning outcomes in terms of motivation, focus, and comprehension. If a learning environment can make the most of all student resources and support individual learning preferences, this goal can be successfully accomplished (Khery, 2014).

METHOD

Subject and Population

15 students from class XI IPA were used in this study, which was carried out in July 2023 at SMA Negeri 12 Surabaya. The participants in the study were given information on chemical bonds.

Research

One group pretest-posttest was used in this investigation. Pretest and Posttest of Cognitive and Visual Spatial Data are Collected Using the Test Method (Sugiyono, 2016).

$$\mathbf{O_1 \times O_2}$$

Figure 1. Pretest-Posttest for one group

O_1 : Cognitive pretest scores and visual spatial intelligence skills were carried out before being given a 3D visualization based interactive e-module using a test.
X : The treatment of students use of a 3D visualization based interactive e-module.
O_2 : Cognitive pretest scores and visual spatial intelligence skills were carried out after being given a 3D visualization based interactive e-module using a test.

Analyze

Data analysis used statistical analysis normality test and N-Gain. Analysis search test, namely the normality test to determine the normality of the data obtained is normally distributed or not. This process is carried out using SPSS 26 software with Sig > 0.05 where the pretest and posttest data were normal (Sugiyono, 2016). Additionally, to analyze the outcomes of the cognitive and spatial intelligence tests using the N-Gain scores, use the following formula:

$$\text{N-gain} = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ score - Pretest\ Score}$$

The criteria in Table 1 were used to interpret the N-Gain score values.

Table 1. Interpretation of N-Gain Score (Richard R. Hake, 1999).

N-Gain Score (g)	Category
0,00<(<g>)≤0,30	Less
0,30<(<g>)≤0,70	Medium
0,70<(<g>)≤1,00	High

Interactive E-Modules on chemical bond material are declared effective if students experience an increase in learning outcomes based on the n-gain criteria 0.30<(<g>)≤0.70, namely the medium or high category.

RESULTS AND DISCUSSION

Assert that a product's effectiveness is determined by how well it aids its users in achieving their objectives. Efficacy as seen by the outcomes of the pretest and posttest. The pretest is administered prior to the therapy, which consists of interactive e-modules based on 3D visualization, and the posttest is administered following the treatment (Tjeerd Plomp & Nienke Nieveen, 2013) N-Gain analysis is utilized to compare the before and after using media (Nismalasari et al., 2016). The results of the pretest and posttest in this study were obtained before and after.

Table 2. The Result of N-Gain of Cognitive Test

Category N-Gain Score	Total of Students
Less	0
Medium	5
High	10

The table above contains the N-Gain cognitive test results. An aggregate average of 0.8 in the high category with 10 questions is attained. Five of the fifteen students fall into the medium category, and ten fall into the high category. This is brought about by the considerable and favorable difference between the cognitive pretest and posttest. The obtained N-Gain score was 0.3. As a result, the designed interactive 3D visualization e-module has proved successful in enhancing students' cognitive understanding of chemical bonds.

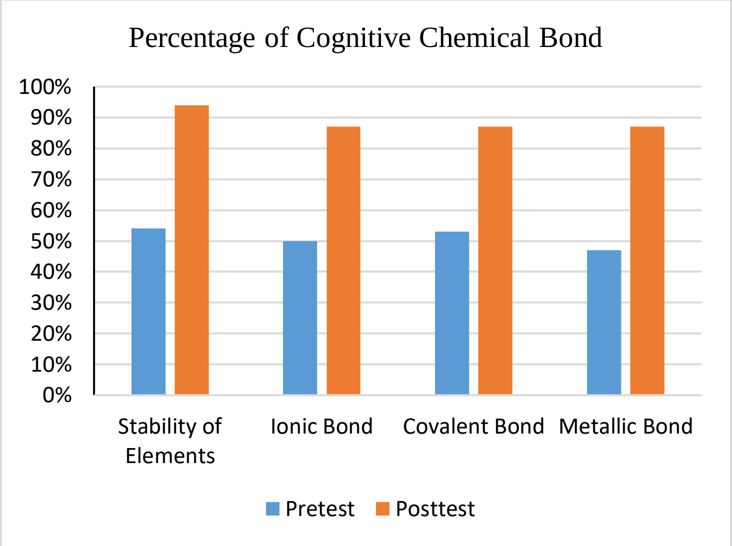

Figure 2. The Percentage Cognitive of Chemical Bond Material Pretest and Posttest

Based on Figure 2 above, it is explained that there is an increase in cognitive test in students such as through the first submatter, namely stability of element show data pretest 54% to posttest 94%, where the presentation of the structure Lewis and gain or lose electrons to achieve stability in the element. Example The element sodium loses electrons to achieve stability.

Then, for the second submatter, namely ionic bond which is presented with questions about definition, properties of compounds, classification in ionic bonds and show data pretest 50% to posttest 87%.

Furthermore, on the third submatter namely covalent bond show data pretest 53% to posttest 87%, where the presentation of the process of forming covalent bond compounds, coordination covalent bonds, types of covalent bonds, the nature of compounds and the polarity of covalent compounds.

And the last is the metallic bond submatter, students are expected to be able to know definitions of metallic bonds, seas of electrons, properties of metallic bonds, and metal alloys that can be used in daily activities. And show data pretest 47% to posttest 87%,

Table 3. The Result of N-Gain of Visual Spatial Intelligence Skill Test

Category N-Gain Score	**Total of Students**
Less	0
Medium	6
High	9

Visual spatial intelligence skill test n-gain value of 0.8 taken from the average score based on indicator have 15 question improve can score increase it. Out of 15 learners, 6 learners are in the medium category and 9 learners are in the high category. The significant and positive difference between the visual spatial intelligence skill pretest and posttest. The N-Gain score obtained ≥ 0.3. Therefore, 3D visualization base interactive e-module that has been developed is proven effective in improving students' knowledeg about chemical bond in visual spatial test.

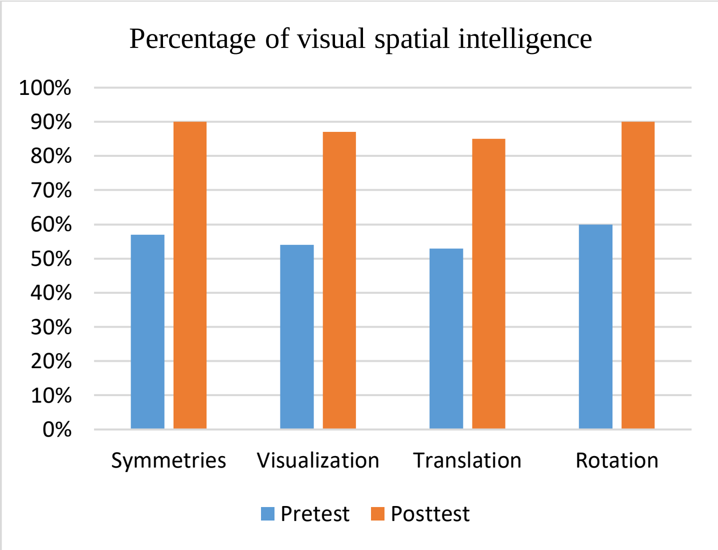

Figure 3. The Percentage Visual Spatial Intelligenece Skill Pretest and Posttest

Based on Figure 2 above, it is explained that there is an increase in visual-spatial intelligence in students such as through the first indicator, namely symmetry show the data 57% tp 90%, where the presentation of the three-dimensional shape of a compound is identified as symmetrical and asymmetrical. For example of symmetry in interactive e-modul can be seen in the figure 4 below.

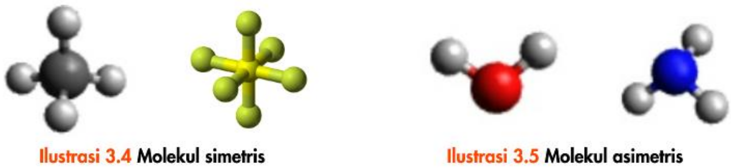

Figure 4. Symmetry of covalent bond submatter

Then, for the second indicator, namely visualization show the data 54% tp 87%, which is presented with questions about visualizing images that can increase students' understanding they are expected to be able to answer verbally to the choices available. For example of visualization in interactive e-modul can be seen in the figure 5 below.

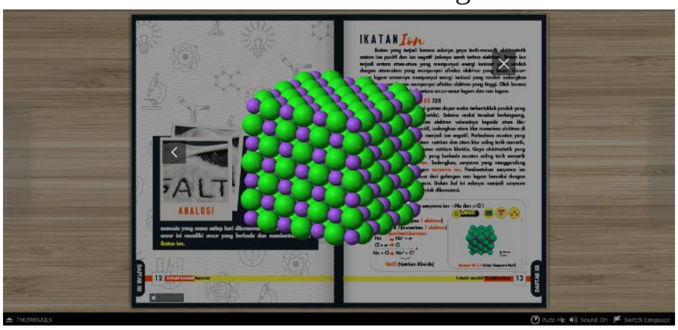

Figure 5. Visualization structure crystal of molecule NaCl

Furthermore, on the third indicator, namely translation where the presentation of static and dynamic media forms is concerned students are expected to choose otherwise. And show the data 53% tp 85%. For example of visualization in interactive e-modul can be seen in the figure 6 below with animation of electron NaCl 3D to 2D.

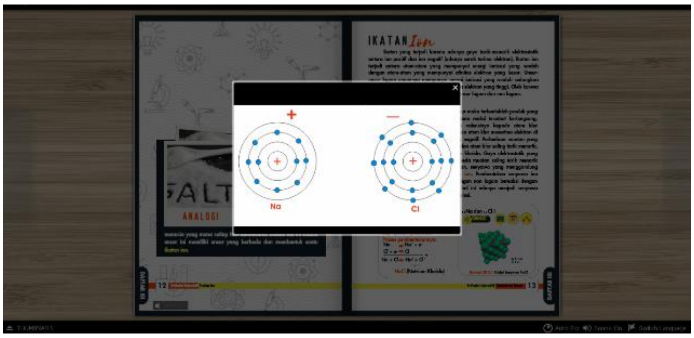

Figure 6. The translation process of the NaCl compound

And the last is the rotation indicator show the data 60% tp 90%,, students are expected to be able to rotate the interactive questions presented by knowing the elements, bonds, and shapes with observations in a 360^{o} rotation with zoom-in and zoom-out. For example of visualization in interactive e-modul can be seen in the figure 7 below with degree of compound.

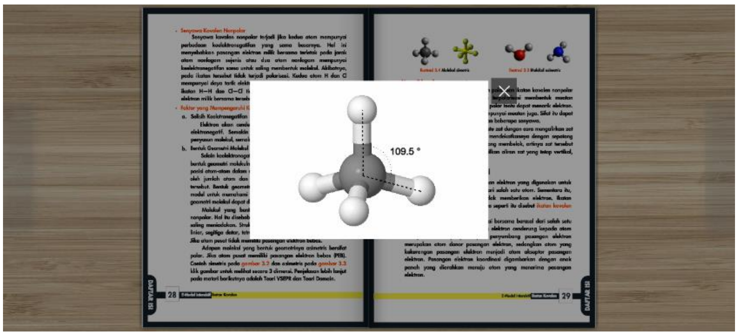

Figure 7. Visualization in interactive e-modul

Then, with the both data N-Gain cognitive and visual spastial test in chemical bond were tested for the distribution of the data using the normality test with SPSS 26 software.

Table 2. Test results for the normality of pretest and posttest values

One-Sample Kolmogorov-Smirnov Test

	Pretest	Posttest	Pretest Visual Spasial	Posttest Visual Spasial
Asymp. Sig. (2-tailed)	.095^{c}	.091^{c}	.157^{c}	.128^{c}

Based on the table above, it was found that the pretest and posttest material for chemical bonding and spatial visuals obtained a value of Sig > 0.05 where the pretest and posttest data were normal (Sugiyono, 2016)

Media interactivity incorporates the use of technology, allows users power over multimedia to perform tasks, has stimulus and response back, and is simple to use like 3D visualization interactive e-module on chemical bond (Sanjaya Mishra & Ramesh C. Sharma, 2015). And Cognitive skills and visual spatial intelligence are closely related. The findings are consistent with those of this study, indicating that interactive media that depicts chemical representations can help students become more visual spatial intelligent when learning chemistry based on more study (Nur Huda & Kusumawati Dwiningsih, 2021)

CONCLUSION

The effectiveness of the interactive e-module to train spatial visual intelligence on chemical bonding material is measured by the difference in N-gain before and after using the media. The N-Gain on the cognitive domain test and the N-gain on the visual-spatial intelligence test get the same score the average score is 0.8 in the high category. Cognitive tests and visual-spatial intelligence tests have interrelated relationships and influence each other for students' understanding of chemical bonding material. The results of the research show interactive e-module are feasible to implement to train visual spatial intelligence skill.

RECOMMENDATIONS

It is expected that e-module interactive to train visual spatial intelligence skills. And it is hoped that this research can be used as a reference for other researchers to develop visual spatial learners in other materials and can utilize existing technologies for further development that further helps students' understanding, such as using augmented reality cameras for objects in the media being developed as well as other adaptations that are flexible enough to be used without a stable internet network.

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