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The Effectiveness of Interactive Multimedia 3D Modeling of Metallic Bondings to Optimize Visual-Spatial Intelligence

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Abstract

The research aims to test the effectiveness of three-dimensional (3D) modelling of metallic bonding as a learning media to optimize student visual-spatial intelligence. The respondents of this research were 25 students of the class 2017 in Universitas Negeri Surabaya. Data was collected online three times, including initial knowledge test, small group test, and large group test. The data collection method uses multiple-choice tests consisting of ten questions about metallic bonding and five visual-spatial questions. There is a 20-minute limit to answer all those questions after getting the experience to use the media. The effectiveness is analyzed based on classical learning completeness obtained from the average individual completeness value. Based on the results, the interactive multimedia 3D metallic bonding model effectively optimizes visual-spatial intelligence. The percentage of classical completeness in the small and large groups is 75.00 and 76.00 (%), respectively. This value is classified into the high category based on the recapitulation of student learning outcomes level.

Keywords: 3D modelling, interactive multimedia, metallic bonding, visual-spatial

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1. Introduction

As one of science subjects, chemistry has several concepts that cannot be actualized directly but only through schematic modeling. Modeling or abstraction requires the ability to visualize (describe indirectly) in supporting the learning process (Brown & Brown, 2002; Robert & Chevrier, 2003).

Chemical bonding is one of the tricky main topics in chemistry for students. Based on the data National Examination scores in 2017, the percentage of students understanding the chemical bonding subject, including ions, covalent, and metallic bonds in East Java Province and the national data was 41.67 and 44.44%, respectively. In 2018, the percentage of students understanding the chemical bonding in the East Java Province and the national data was 52.38 and 51.98%, respectively. This data shows more than 45% of students do not understand chemical bonding overall.

The 21st century is marked as the century of openness or the century of globalization, which means life humans in the 21st century experience fundamental changes that are different from the order of life in the previous century. This century is also known as the knowledge age. In this era, all alternative efforts to supply life necessities in various contexts are more knowledge-based (Wijaya et al., 2016; Kurniawan, 2017).

Measures provide life necessities of knowledge-based education, knowledge-based economic development, knowledge-based social empowerment and development, and industry-based knowledge development (Mukhadis, 2013; Ollino et al., 2018).

As one of the countries in Southeast Asia, Indonesia has the Information and Communication Technology Development Index (ICT Development Index (IDI)) which increased from 2015 to 2017. IDI value Indonesia in 2015, 2016, and 2017 was 3.88, 4.34, and 4.99, respectively (Badan Pusat Statistik, 2018). This value indicates that the classified of ability to understand and follow technological developments are good socially. It is supported by the number of Internet users in Indonesia, around 123 million users, which ranks 6th globally (Hidayat, 2014).

Metallic bonding is a type of chemical bonding often described as an array of positive ions in a sea of electrons. The outer electrons have become delocalized over the whole metal structure. It means they are no longer attached to a particular atom or pair of atoms but can be thought of as moving freely around in the whole structure (Housecroft & Sharpe, 2008; Effendy, 2007). The concept of sea electrons in metallic bonding requires three-dimensional modeling to facilitate how metallic bonding can be formed and its characteristics compared to ionic, covalent, and covalent coordination bonding (Miessler & Tarr, 2004; Greenwood & Earnshaw, 1997; Connelly et al., 2005). Therefore, one aspect that needs to be improved is the ability to use information and communication technology (ICT) for learning chemistry, especially chemical bonding topics (Habraken, 1996; Braund & Reiss, 2004). Interactive media is one of the kinds of technologies classified into ICT commonly used in a language context. There was a significant difference in the psychomotor skills of students taught and retention abilities in cognitive with interactive multimedia technology (Rajendra & Sudana, 2018). Implementing interactive multimedia in blended learning can improve student learning outcomes in the medium and high categories. The development of virtual lab-based media can improve the validity percentage by around ≥ 61 (Arham & Dwiningsih, 2016; Dwiningsih et al., 2018).

The learning method in metallic bonding often focuses on memorizing or visual-spatial concepts (Kincheloe, 2004; Al-Balushi & Al-Hajri, 2014). In this research, the authors wanted to make it easier for students to understand the concept of metallic bonding and practice their visual-spatial skills through the Interactive Multimedia 3D Metallic Bonding Modeling application (software).

The learning theory of this research is behavioristic. The theory focuses on the idea that all behaviors are learned through interaction with the environment that affects acquiring the knowledge. According to this theory, the behavior is entirely rule-determined, predictable, and determinable. Moreover, a person engages in certain behaviors because they have learned through previous experiences, to associate the behavior with gifts. Someone stops a behavior, perhaps because the behavior has not been rewarded or has been punished. All beneficial or destructive behaviors are learned behaviors (Fahyuni & Istikomah, 2016). The research aims to test the effectiveness of interactive multimedia 3D modeling of metallic bonding. The validity and practicality have been tested in the same research model. Multimedia is equipped with three-dimensional visualizations, explanations, and problems related to metallic bonding, and students can learn while moving the 3D modeling animation of metallic bonding. Multimedia is also equipped with two languages, namely Indonesian and English. In its application, multimedia is combined with a guided inquiry learning model with a scientific approach.

2. Research Method

2.1. Types of the Research

The type of research is research and development (R&D) that produce the specific products and test their effectiveness (Sugiyono, 2011). The product in this development research is an application software using Aurora 3D Presentation 2012.

2.2. Place and Time of Research

The research was conducted at the Universitas Negeri Surabaya on March 02nd-09th, 2020. The test implementation is three times, including initial knowledge test, small group test, and large group test.

2.3. Subjects of the Research

The research subjects were 25 students of undergraduate Chemistry Education at the Universitas Negeri Surabaya, Class of 2017.

2.4. Research and Development Procedures

The research uses a series of ADDIE model development, including analysis, design, development, implementation, and evaluation (Seel et al., 2017). The focus of the research is testing the effectiveness based on the implementation and evaluation process. Figure 1 shows the ADDIE model development of the research.

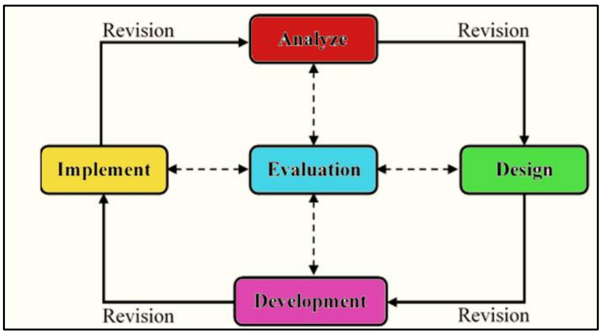

Figure 1. The ADDIE Model Development (Seel et al., 2017)

The systematic of the research are formulated as below:

1) Giving the questions to large group students without being accompanied by giving the metallic bonding theory.
2) Giving the metallic bonding theory accompanied by interactive multimedia three-dimensional modeling (3D) of metallic bonding in small and large groups students.
3) Analysis of the data
4) Formulation of the conclusions

2.5. Types of the Data

The research uses qualitative and quantitative data to demonstrate the effectiveness. The ordinal data that use are very great (VG = 5), great (G = 4), medium (M = 3), bad (B = 2), and very bad (VB = 1)

2.6. Data Analysis Technique

2.6.1. Effectiveness

The effectiveness analysis is based on the ability of visual-spatial students by analyzing the pre-test and post-test results in 15 questions with the same type.

Student learning completeness (DSS) determines using Eq. (1):

$$DSS = \frac{T}{T_t} \times 100\% \quad (1)$$

DSS = student learning completeness
T = number of scores obtained by students
T_t = total score

(Trianto, 2010)

The steps to quantitative analysis data as follow:

1) The completeness of student learning outcome (individually) determines using Eq. (2):

$$S = \frac{R}{N} \times 100 \quad (2)$$

S = expected value
R = scores obtained by students
N = maximum score
100 = constant

(Purwanto, 2008)

2) The average value of learning outcomes determines using Eq. (3):

$$\overline{X} = \frac{\sum x}{N} \quad (3)$$

$\overline{X}$: average value
$\sum x$: total score of all students
N : number of students

(Arikunto, 2010)

3) The classical learning completeness determines using Eq. (4):

$$P(\%) = \frac{\sum n}{N} \times 100\% \quad (4)$$

P = classical learning completeness
$\sum n$ = number of students completed

N = number of students

Individual completeness	:	If completeness of student ≥ 75%.
Classical learning completeness	:	If ≥ 60% completeness of all students ≥ 75%.

(Purwanto, 2008)

Recapitulation of student learning outcomes level is shown in Table 1.

Table 1. Recapitulation of Student Learning Outcomes Level (Riduwan, 2012)

Interval (%)	Category
> 80	Very high
60-79	High
40-59	Medium
20-39	Low
< 20	Very Low

2.7. Indicators of Student Success

Effectively interactive multimedia if ≥ 60% of all students achieve completeness ≥ 75% (Purwanto, 2008). Individual completeness is achieved if the correct answers of the student are ≥ 75%.

3. Result and Discussion

The design and features contained in interactive multimedia consist of one main page (homepage) and five additional pages, consisting of the competency page, introduction, metallic bonding theory, quizzes, and author profile. The background design uses the Adobe Photoshop CS6 and Adobe Illustrator CC 2017 applications, while the overall design and programming application use the Aurora 3D Presentation 2012. There are seven clickable icons in the main page display, as shown in Figure 2. Five of the seven icons are hyperlinks to other pages. One icon is for changing the language (two language options are available, namely Indonesian and English), and the exit button to close the program.

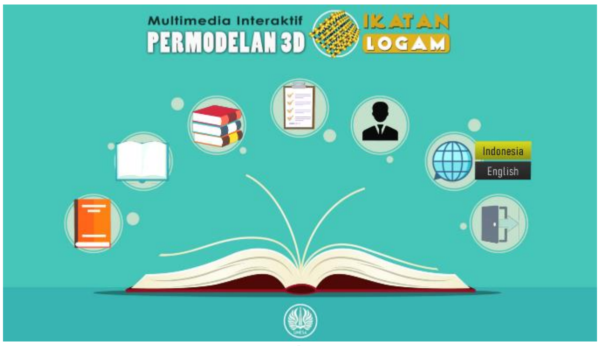

Figure 2. Main Page Display

The competency page consists of core competencies and basic competencies used in metallic bonding adjusted to the latest 2013 revised curriculum. Figure 3 shows the competency page display.

Figure 3. Competency Page Display

The theory page consists of a flash animation video, metallic bonding theory, and an image that can be played, paused, and looped. This page contains a 3D visualization of the metallic bonding compound that can rotate in any direction. Figure 4 shows the theory page display.

Figure 4. Theory Page Display

The quiz page consists of multiple-choice questions and submits button to lock the answer. Figure 5 shows the quiz page display.

Figure 5. Quiz Page Display

3.1. Effectiveness

Effectiveness is assessed based on 15 multiple choice questions that consist of ten metallic bonding test questions and five visual-spatial questions. The lecturer has validated those questions. The respondents of this research were 25 students of the class 2017 in Universitas Negeri Surabaya.

Table 2. Preliminary Knowledge Written Test Results

No	Subject	Individual completeness
1	Student 1	53.33%
2	Student 2	60.00%
3	Student 3	40.00%
4	Student 4	46.67%
5	Student 5	33.33%
6	Student 6	40.00%
7	Student 7	60.00%
8	Student 8	33.33%
9	Student 9	40.00%
10	Student 10	26.67%
11	Student 11	66.67%
12	Student 12	46.67%
13	Student 13	40.00%
14	Student 14	40.00%
15	Student 15	33.33%
16	Student 16	33.33%
17	Student 17	40.00%
18	Student 18	40.00%
19	Student 19	60.00%
20	Student 20	40.00%
21	Student 21	53.33%
22	Student 22	33.33%
23	Student 23	33.33%
24	Student 24	73.33%
25	Student 25	66.67%
Median		45.33%

There is a 20-minute limit to answer all those questions after getting the experience to use the media. The test was carried out three times with details: the preliminary knowledge test before being given theory and media interactive, the small group test, and the large group test. Table 2 shows the preliminary knowledge written test results.

The preliminary knowledge test aims to understand students' knowledge about metallic bonding theory before know about interactive multimedia 3D metallic bonding modeling. The test results showed an average value of 45.33%, lower than the completeness criteria (75.00%). Furthermore, after students learn about metallic bonding theory in the interactive multimedia 3D modeling of metallic bonding, the written test be solved in the small group students. Table 3 shows the small-group written test results.

Table 3. Small-Group Written Test Results

No	Subject	Score	Individual completeness
1	Student 1	12	80.00%
2	Student 2	13	86.67%
3	Student 3	11	73.33%
4	Student 4	12	80.00%
5	Student 5	13	86.67%
6	Student 6	11	73.33%
7	Student 7	12	80.00%
8	Student 8	12	80.00%
9	Student 9	13	86.67%
10	Student 10	11	73.33%
11	Student 11	12	80.00%
12	Student 11	13	86.67%
Mean			80.56%
Classical Learning Completeness			**75.00%**

The average value has increased to 80.56%, with the percentage of classical learning completeness is 75.00%. This value is classified into the high category based on the recapitulation of student learning outcomes level in Table 1. The test was tried on a large scale to determine that the media can be applied on a standard class scale (25 students). Table 4 shows the large-group written test results.

Table 4. Large-Group Written Test Results

No	Subject	Score	Individual completeness
1	Student 1	12	80.00%
2	Student 2	12	80.00%

No	Subject	Score	Individual completeness
3	Student 3	13	86.67%
4	Student 4	13	86.67%
5	Student 5	12	80.00%
6	Student 6	12	80.00%
7	Student 7	11	73.33%
8	Student 8	12	80.00%
9	Student 9	12	80.00%
10	Student 10	11	73.33%
11	Student 11	13	8..67%
12	Student 12	12	80.00%
13	Student 13	11	73.33%
14	Student 14	11	73.33%
15	Student 15	12	80.00%
16	Student 16	12	80.00%
17	Student 17	13	86.67%
18	Student 18	12	80.00%
19	Student 19	12	80.00%
20	Student 20	13	86.67%
21	Student 21	13	86.67%
22	Student 22	12	80.00%
23	Student 23	12	80.00%
24	Student 24	11	73.33%
25	Student 25	11	73.33%
	Mean		**80.00%**
Classical Learning Completeness			**76.00%**

Based on these results, the 19 students had a percentage above 75.00%. The mean value of individual completeness and classical learning completeness is 80.00% and 76.00%, respectively. This value is classified into the high category based on the recapitulation of student learning outcomes level in Table 1.

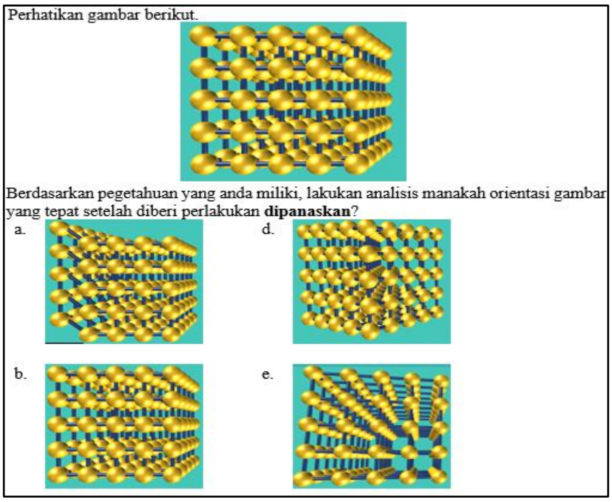

Figure 6. Examples of Visual-Spatial Test

Figure 6 shows the example of a visual-spatial test. Moreover, the written test about five visual-spatial questions be solved in the large-group students to know the visual-spatial intelligence. Table 5 shows the large-group written test results about spatial-visual.

Table 5. Large-Group Written Test Results About Spatial Visual

No	Subject	Score	Individual completeness
1	Student 1	3	60.00%
2	Student 2	3	60.00%
3	Student 3	4	80.00%
4	Student 4	4	80.00%
5	Student 5	4	80.00%
6	Student 6	3	60.00%
7	Student 7	4	80.00%
8	Student 8	4	80.00%
9	Student 9	4	80.00%
10	Student 10	4	80.00%
11	Student 11	4	80.00%
12	Student 12	5	100.00%
13	Student 13	4	80.00%
14	Student 14	4	80.00%
15	Student 15	4	80.00%
16	Student 16	4	80.00%
17	Student 17	5	100.00%
18	Student 18	5	100.00%
19	Student 19	3	60.00%
20	Student 20	3	60.00%
21	Student 21	5	100.00%
22	Student 22	5	100.00%
23	Student 23	4	80.00%
24	Student 24	3	60.00%
25	Student 25	5	100.00%
	Mean		80.00%
	Classical Learning Completeness		76.00%

Based on these results, the 19 students had a percentage above 75.00%. The mean value of individual completeness and classical learning completeness is 80.00% and 76.00%, respectively. This value is classified into the high category based on the recapitulation of student learning outcomes level in Table 1.

4. Conclusion

The interactive multimedia 3D metallic bonding modeling effective and can be used in the learning process with the classical learning completeness in the small and large group is 75.00% and 76.00%, respectively. This value is classified into the high category based on the recapitulation of student learning outcomes level.

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