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Enhancing Students' Critical Thinking through NASA Science as Interactive Multimedia in Learning Solar System

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ABSTRACT Science and technology advancement in the 21st Century requires several life skills that everyone must learn; critical thinking is one of them. Critical thinking is often defined as a process of metacognition that increases the chances of solving a problem. This research attempted to implement NASA Science as Interactive Multimedia to enhance students' critical thinking in learning Solar System. Interactive Multimedia is student-centered, allowing students to play an active role in learning to promote students' critical thinking skills. This study used a pre-experimental method with one group pretest-posttest design. The sampling used was convenience sampling, which participated in 42 7th grade students of a private school in Bandung. The Objective Test was used as a research instrument for both pretest and posttest. These test items were designed according to Facione's indicators of Critical Thinking Skills. Based on the analysis result, the value of <g> is 0.48. According to the Wilcoxon test, the hypothesis in this research is accepted. The value of Asymp. sig. (2-tailed) is 0.00, with a sig. α = 0.05. Thus, this research shows that: There is an enhancement of students' critical thinking after using NASA Science in learning Solar System.

Keywords Students' Critical Thinking Skills, NASA Science, Interactive Multimedia, Solar System, Solar System Exploration, Space Place

1. INTRODUCTION

Starting in 2000, Indonesia has actively participated in the Program for International Student Assessment (PISA). From 2000 until now, Indonesia's score in participating in the PISA test has never reached an average of the Organization for Economic Co-operation and Development (OECD) standard. This achievement can be proven by the average value of Science obtained by Indonesia in 2018, showing a score of 396 where the score is lower than the average value of the OECD in Science, 489. This result puts Indonesia in the 70th position out of 78 countries in Science (OECD, 2019). The ranking shows that the outcome of Science Learning in Indonesia is still relatively low.

Based on Indonesian Government Regulation No. 19 of 2005, groups of Science and Technology subjects in Junior High Schools or other equivalent levels are intended to obtain essential competencies in Science and Technology and cultivate thinking critically, creatively, and independently (Peraturan Pemerintah Republik Indonesia, 2005). The Indonesian Ministry of Education and Culture Regulation No. 20 of 2016 accurately explains that students' skills are thinking and acting. Those two skills include creativity, productivity, critical, independent, collaborative, and communicative (Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia, 2016).

Referring to the Government and Ministry of Education Regulation, the Head of Research and Development Officer of the Ministry of Education and Culture explained in more detail that in recent years, questions that measure Critical Thinking Skills had been tested in the National Examination (UN). The problem's composition is based on the cognitive level with a range of 10%-15% for reasoning, 50%-60% for applications, and 25%-30% for knowledge and understanding (Ministry of Education and Culture, 2019). However, unfortunately, with the composition of the questions that have been arranged, the average score of Science for Junior High

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School still occupies the low category. It is in line with the Education Assessment Center's data from the Ministry of Education and Culture, which shows an average value of Science in 2019 National Examination for Junior High School is only 48.79 with a minimum passing score of 55 (Education Assessment Center, 2019).

As mentioned earlier, the Ministry of Education and Culture has tested the National Examination questions, which measure Critical Thinking Skills. According to the Ministry of Education and Culture (2019), the assessment with this critical thinking model was carried out to catch up on Indonesia's backwardness in international surveys, precisely PISA results. In addition, a study examining 21st Century Skills (Binkley et al., 2012) discovered that science and technology advancement in the 21st Century requires several life skills that everyone must learn; Critical Thinking Skill is one of them.

Furthermore, Critical Thinking Skills are the key in educational settings. They allow individuals to go beyond merely retaining knowledge and gain a more sophisticated understanding of the information they receive (Dwyer, Hogan, & Stewart, 2014). Critical thinking also belongs to High-Order Thinking Skills (HOTS). It is synonymous with higher-level problem solving and reasoning as it is a crucial factor in Science's success (Lamb, Firestone, Schmitter-Edgecombe, & Hand, 2018). Besides, Facione (2015) defined critical thinking as a way of thinking that aims to prove a point, interpret something, or solve a problem. There are some indicators in Critical Thinking Skills stated by Facione (2015), which are interpretation, analysis, inference, evaluation, and explanation.

Critical thinking is closely related to learning Science. According to Tiruneh, de Cock, Weldeslassie, Elen, and Janssen, (2017), critical thought development has a vital role in science education's primary goal. Therefore, several education stakeholders have long called for comprehensive science curricula revisions focusing on student acquisition of Critical Thinking Skills (Halpern, 2014). The same concern is also shown in several Science curricula of different countries as it strengthens the need to encourage critical thought (Tiruneh et al., 2017). The Science Indonesian Curriculum for Secondary Level is no exception. It is proven based on the 2013 Curriculum, officially updated by the Indonesian Ministry of Education and Culture Regulation No. 24. of 2016. According to the Ministry of Education and Culture Regulation (2016), 51.5% of Basic Competencies in Science subjects for Junior High School are formulated as a word of "to analyze." Thus, it presents that the 2013 Indonesian Curriculum emphasizes the creation of critical thinking among students. Moreover, analyzing belongs to measuring the higher levels of thinking skills (HOTS) based on Bloom's Taxonomy with the two other more elevated levels, which are evaluating and creating (Saido, Siraj, Nordin, & Al-Amedy, 2018).

In Science, Critical Thinking Skills are essential since it is synonymous with research practices on issues ranging from observing, formulating questions, gathering data, analyzing data, and concluding (Bhakti et al., 2019). However, DiBiase & McDonald (2015) stated that Science classrooms are still firmly teacher-centered, where the teaching and learning process is primarily a form of knowledge transmission that does not promote critical thought. According to Barak (2015), many teachers still do not encourage thinking skills. In some cases, Science teachers lack the resources, one of which is technology-integrated learning as innovative teaching methods. Simultaneously, much of Science concerns abstractions and theoretical entities that cannot be easily observed or handled only through lecture-based instruction since they may be too large a scale (Ekanayake & Wishart, 2014). For instance, in learning Solar System. The Solar System phenomena could not be discussed and presented explicitly in the classroom, such as Solar System occurrences, day and night variation, moon phases, and eclipse. Accordingly, students only learn about the Solar System theories based on explanations from the teacher without obtaining an accurate illustration of actual phenomena that existed in the Solar System scope (Bhakti et al., 2019).

Swandi, Amin, and Muin (2018) stated that one alternative to enhance the Science learning process on abstract concepts is to involve relevant information technology such as interactive multimedia consisting of text, hypertext, sound, animation, video, and graphics. By using interactive animation and simulation, Science's particular concept is easily described. On the other hand, multimedia provides interactive ways of representing information and invokes learner thinking by explicitly presenting the abstract concept through learning processes of reasoning and critical thinking (Weay & Masood, 2015). Also, according to Djamas & Tinedi (2018), using interactive multimedia can improve critical thinking. Interactive Multimedia is student-centered, allowing students to play an active role in learning and promoting critical thinking.

Regarding the explanations above, previous researches have been conducted. For example, Djamas & Tinedi (2018) have researched developing media to improve students' critical thinking. However, the study focuses on Newton's Law and Accelerated Linear Motion topic. Meanwhile, the other researcher has also been concerned about the same research of interactive multimedia. Marina (2020) focuses on utilizing the Stellarium in Learning Solar System, which only measures students' understanding.

Thus, in this work, the researcher focuses on enhancing students' critical thinking in learning Solar System by applying NASA Science as Interactive Multimedia. This prior research will be conducted by designing and analyzing the lesson plan, the worksheet, and the objective test

Table 1 One group pretest-posttest design

Pretest	Implementation	Post-Test
Solar System Test Item based on Facione's Critical Thinking Indicators	Implementation of NASA Science	Solar System Test Item based on Facione's Critical Thinking Indicators

instrument of Facione's Critical Thinking on Solar System implemented to 7th-grade Junior High School Students.

2. METHOD

The research method that is used in this research is Pre-Experimental Method. With pre-experimental, the researcher studies a single group and provides an intervention during the experiment. This method does not have a control group to compare with the experimental group (Fraenkel, Wallen, & Hyun, 2012). In this research, the pre-experimental method was used to decide the effect of NASA Science implemented by the researcher to enhance students' critical thinking in learning the Solar System. Therefore, the researcher will know whether any change in students' Critical Thinking Skills occurred due to NASA Science's implementation in learning Solar System. The design used in this research was One Group Pretest-Posttest Design, as seen in Table 1.

The research was conducted at one of the private junior high schools in Bandung, which attended a 2019/2020 academic year. This research population was 7th-grade, which uses the 2013 Curriculum, which has not yet studied Solar System Topic. The research sample consisted of 42 students from two classes of 7th-grade at "X" Private Junior High School in Bandung. Convenience sampling was used as the sampling technique for this research. A convenience sample is the individuals' group available or convenient to be studied (Creswell, 2014).

There are three types of instruments used in this research: observation sheet, objective test, and questionnaire. First, the researcher used the observation sheet to determine whether the researcher has already done the learning activities according to the lesson plan. The science teacher at the school signed the observation sheet as the observer for this research. The observation sheet's outcome would inform the percentage result of activities according to the lesson plan. Second, the objective test is used to test students' critical thinking. In this research, the critical thinking test is based on Facione (2015), covering five aspects: explanation, interpretation, inference, analysis, and evaluation. The type of question is multiple choice, which consists of 26 items. The questions were constructed based on five aspects of Facione's Critical Thinking. Those aspects are tested through every question in the test item.

The test item was judged by the experts and tested on the students who have learned about Solar System. Second, the data were then analyzed using "ANATES" V.4 in terms of validity, level of difficulty, and discriminating power. Third, the questionnaire is used to know the students' impression after using NASA Science as interactive multimedia in learning Solar System, whether positive or negative. The questionnaire is adapted from Djamas & Tinedi (2018). Respond scale used for this questionnaire is the Likert Scale. In Likert Scale, the respondents are asked to respond to each statement with multiple answers consisted of strongly agree, agree, neutral, disagree, and strongly disagree. In this study, the "neutral" response was omitted to avoid doubting the students' impression of a negative or positive response.

3. RESULT AND DISCUSSION

The result shows quantitative and qualitative data. The pretest and the posttest are conducted to determine the students' critical thinking before and after treatments. Qualitative analysis will describe the students' impression during learning Solar System using NASA Science Multimedia.

3.1 NASA Science

NASA Science is an educational website that provides interactive learning of Space and Earth Science. This website was officially launched in 1998 by the Planetary Science Communications team at NASA's Jet Propulsion Laboratory (NASA, 2019). NASA Science provides several features of interactive learning. The features applied for this research are Solar System Exploration and Space Place. The further explanation about Solar System Exploration and Space Place is described below:

Solar System Exploration

Solar System Exploration provides realistic simulated views of planets, spacecraft, and other Solar System features. The orientation and position of planets and spacecraft on the website are based on accurate data (NASA, 2019). Solar System Exploration is used in this research for covering the topic of Characteristics of Solar System Components. While the rest of the issues learned in this research will be covered by NASA Space Place. The interface of Solar System Exploration is shown in Figure 1.

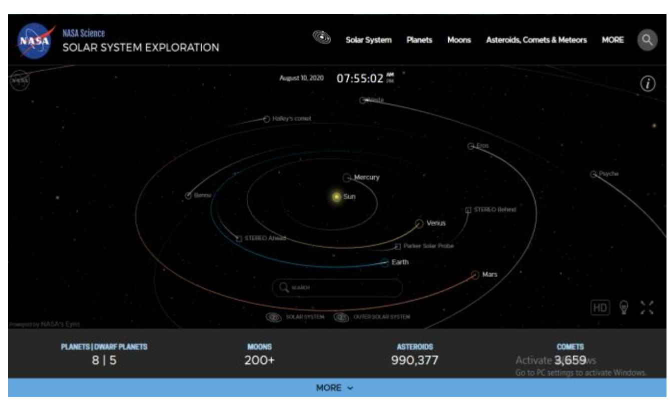

Figure 1 The interface of solar system exploration (Source: solarsystem.nasa.gov, 2019)

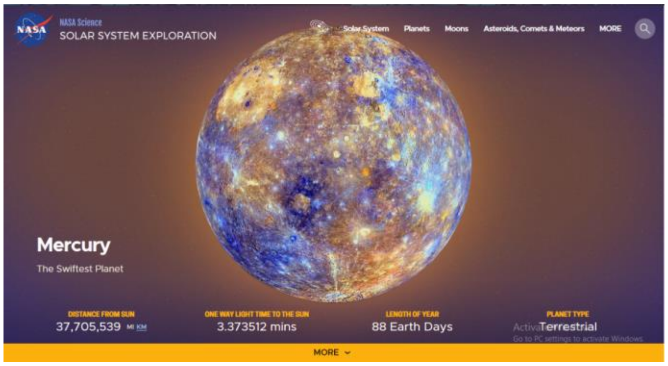

Figure 2 The overview of mercury by nasa science (Source: solarsystem.nasa.gov, 2019)

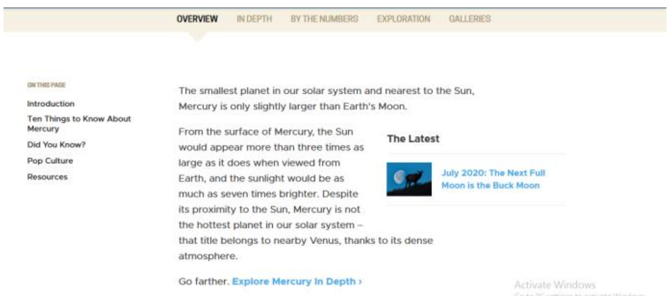

Figure 3 The information of mercury (Source: solarsystem.nasa.gov, 2019)

Figure 4 Things to know about mercury (Source: solarsystem.nasa.gov, 2019)

As seen in Figure 1, Solar System Exploration provides several interactive contents, including planets, moons, asteroids, comets, meteors, and many more, which users can freely explore (NASA, 2019). It also provides information regarding the exact number of planets, dwarf planets, moons, asteroids, and comets contained in this space. The user can further explore a planet if the user clicks on the illustration of the destination planet. For example, if the user clicks on the Mercury Planet as presented in Figure 1, the result will offer the interactive content shown in Figure 2.

As presented in Figure 2, the overview of Mercury by NASA Science has contents of Mercury's unique name, distance from Sun, one-way light time to the Sun, length of a year, and planet type. In more detail, if the user clicks on the "MORE" button at the bottom, there will be much

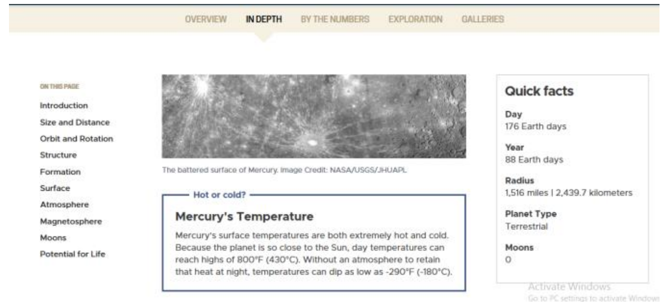

Figure 5 In-depth about mercury (Source: solarsystem.nasa.gov, 2019)

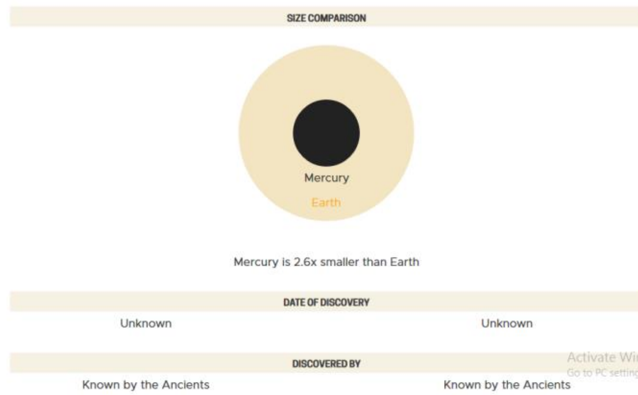

Figure 6 Size comparison of mercury (Source: solarsystem.nasa.gov, 2019)

information shown about Mercury, as presented in Figure 3.

Based on Figure 3, Mercury's information is divided into several sections: overview, in-depth, numbers, exploration, and galleries. In the “overview” section, the explanations derived into introduction, ten things to know about Mercury, "did you know?", pop culture, and resources. The overview section's most interesting ones are ten things to know about Mercury, presented in Figure 4.

As shown in Figure 4, NASA Solar System Exploration explains Mercury's information ranging from the size of planets, distance, rotation, revolution period until the atmosphere. For the “in-depth” section, the interface is presented in Figure 5. This section is contained a more in-depth explanation of the size and distance of Mercury, orbit and rotation, structure, formation, surface, atmosphere, magnetosphere, moons, and potential for life on Mercury. Finally, the "by the numbers" section informs the size of Mercury Planet compared to the Earth-size, as shown in Figure 6.

The contents described previously about Mercury Planet can also be accessed for the rest of the planets in this space.

Space Place

After exploring Solar System Exploration, we can also explore the other Web-Based Multimedia learning features; one chosen for this research is Space Place. Space Place is a very friendly multimedia learning and appropriate for

Figure 7 The interface of nasa space place (Source: spaceplace.nasa.gov, 2019)

Junior High School Students (NASA, 2019). The learning materials cover all about the Earth, Sun, Solar System until Universe is presented well in an attractive way supporting animation, figures, and video. The interface of Space Place can be seen in Figure 7. As explained previously, all the topics besides the Characteristics of Solar System Components will be covered by NASA Space Place. The issues consist of the Rotation and Revolution of Earth and Moon, Solar and Lunar Eclipse, and Moon Phase.

3.2 Students' Critical Thinking

The pretest and posttest results in this research were summarized using the 2013 version of MS. Word Excel, which is then analyzed through a Normality Test, Wilcoxon test, and Normalized Gain using SPSS Statistic version 26.0. Normality Test is conducted to measure the data distribution, whether it is normally distributed or not. If the data is categorized as normally distributed, then the data is analyzed by Parametric Test. However, on the contrary, Non-Parametric Test is used if the data is not normally distributed, which happened in this research. Therefore, the analysis is continued using Wilcoxon Test. The result of the Normality Test is shown in Table 2. The Shapiro-Wilk method is used to calculate the data distribution for this research because the sample of this research is less than 50 samples. The data is concluded to be normally distributed if a significance value of Shapiro-Wilk is greater than 0.05 (> 0.05) and vice versa. Based on the result of the Shapiro-Wilk test in Table 2, the pretest and posttest data for this research has a significance value of 0.036 and 0.020. Therefore, it can be determined that the significance value of both groups is less than 0.05, which means that the data is not normally distributed. Thus, the analysis is continued with Wilcoxon Test as a Non-Parametric statistical analysis approach. The detail of the Statistic Test of Students' Critical Thinking can be seen in Table 3.

Based on the result in Table 3, Asymp. Sig. (2-tailed) indicates the hypothesis test resulted from Wilcoxon Test. A Wilcoxon Statistical Test is used to determine whether the hypothesis is rejected or accepted for the data with no normalized distribution. Other than that, the Wilcoxon test is used if the data being compared are pretest and posttest in the class because it compares the means for two related groups. Two hypotheses of this research are stated as follows:

H0: There is no enhancement in students' critical thinking after applying NASA Science Multimedia in learning Solar System.

H1: There is an enhancement in students' critical thinking after applying NASA Science Multimedia in Learning Solar System.

The level of significance value used in this test is 0.05. It means that if the test result shows a significance value greater than 0.05 (>0.05), H0 is accepted. Meanwhile, H1 is accepted when the significance value is less than 0.05. The test results in Table 3 show that the significance value is 0.00, which is <0.05. Thus, it can be concluded that H1 is accepted where there is an enhancement on students' critical thinking after applying NASA Science in Learning Solar System.

Table 3 Statistic test of students' critical thinking

Details	Pretest	Post-Test
Mean	45.19	70.43
Std. Deviation	14.35	13.99
Highest Score	77	96
Lowest Score	23	46
Asymp. Sig. (2-tailed)	0.00*	
Negative Ranks	0	
Positive Ranks	42	
Ties	0	
Gain	25.24	
N-Gain	0.48	

*Asymp. Sig. (2-tailed) <0.05

Table 2 Result of normality test on students' critical thinking

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Group	Statistic	Df	Sig.	Statistic	Df	Sig.
Pre-Test	.154	42	.013	.943	42	.036
Post-Test	.131	42	.066	.936	42	.020

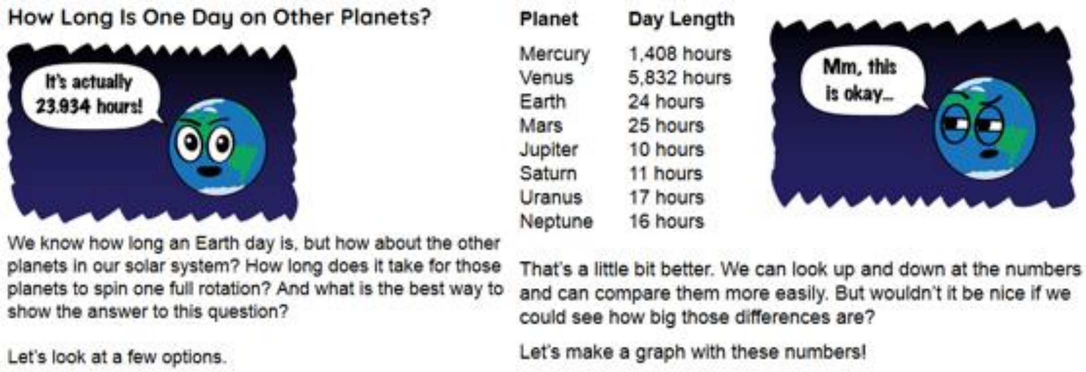

Figure 8 How NASA science formulated question to engage critical thinking (Source: spaceplace.nasa.gov, 2019)

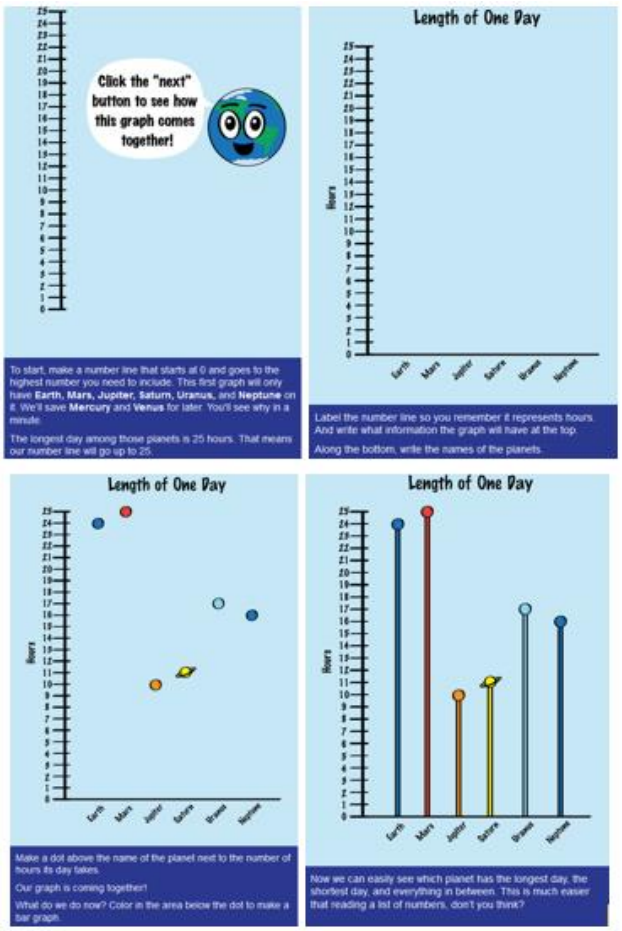

Figure 9 How NASA science involves students to inference data of rotational period into a graph (Source: spaceplace.nasa.gov, 2019)

The data obtained are also analyzed using the normalized gain test according to Hake's Rule (1999). The normalized gain score was determined to measure whether there is an enhancement or not on critical thinking among students in this research. Based on Table 3, the result shows that the average pretest score was 45.19 while the average score of the posttest was 70.43. It informs that there was an improvement of the posttest average score since it has a higher score than the pretest. The difference between posttest and pretest scores is calculated by gain and shows a value of 25.24.

Compared to the average score of pretest and posttest, the score has normalized again with the value of N-Gain 0.48. Therefore, the result is assumed as the medium enhancement according to Hake's normalization rule. Thus, it can be emphasized that students got Medium Improvement in critical thinking skills after implementing NASA Science as interactive multimedia in learning Solar System. This finding is supported by the previous research, which stated that using interactive multimedia can improve critical thinking (Djamas & Tinedi, 2018). More than that, several considerations are determined regarding this finding.

First, NASA Science is an educational website that provides an interactive way of learning Space and Earth Science. Using interactive animation and simulation, NASA Science describes a particular and large scale of the Solar System concept clearly, which then differentiates NASA Science from other interactive multimedia. It triggers and allows students to play an active role in exploring the accurate space simulation provided by NASA Science. According to Hsiao (2017), students' active role emphasizes student-centered learning and their learning ownership, giving them the chance to improve problem-solving and critical thinking skills. Since NASA Science is student-centered, it can be stated that it promotes students' critical thinking based on Hsiao's statement (2017).

Apart from that, the other consideration is that NASA Science engages students' critical thinking because it gives the students a role in utilizing this multimedia. However, also, the interactive content includes in this multimedia triggers the students' critical thinking. For instance, the concept derived by NASA Science is not just a straight explanation like the other multimedia does. Instead, it gives a chance for students to think critically by formulating a previous question related to the topic discussed. It also offers students the opportunity to infer, interpret, explain, analyze, and evaluate the Solar System concept. Figures 8 and 9 show how NASA Science formulates the question and inferences from the rotational period data.

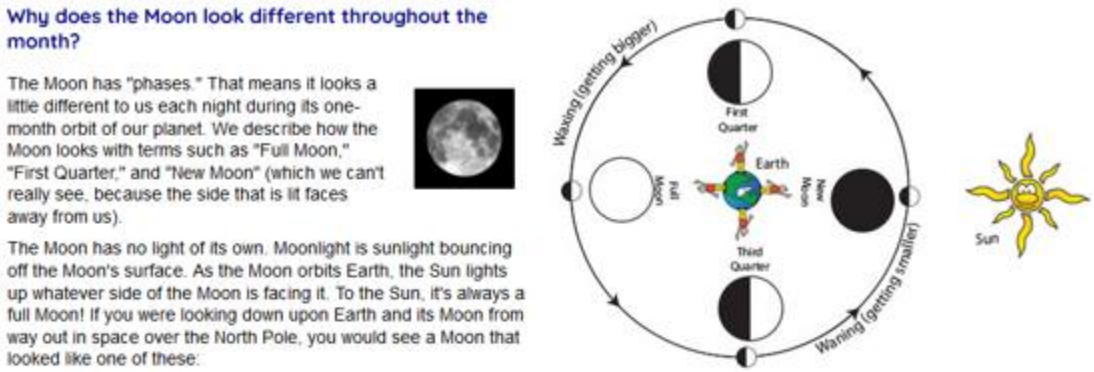

Figure 11 How NASA science involves students to interpret information from a diagram (Source: spaceplace.nasa.gov, 2019)

Table 4 N-gain score of critical thinking aspects

Critical Thinking Aspects	Average Score of Pretest	Average Score of Post-Test	N-Gain Score	Category
Interpretation	45.63	73.81	0.52	Medium
Analysis	41.07	51.19	0.14	Low
Inference	38.49	72.22	0.53	Medium
Evaluation	41.67	64.88	0.39	Medium
Explanation	56.75	81.75	0.51	Medium

From Figures 8 and 9, it can be seen that NASA Science represents learning processes to engage students' critical thinking. On the other hand, it is supported by the finding from Weay et al. (2015) that stated multimedia constructs critical thinking by providing interactive ways of representing information and invokes learner thinking by explicitly presenting the abstract concept through learning processes of reasoning and thinking critically.

In analyzing the students' critical thinking skills, the analysis was not only done in general result. In this research, the researcher has studied the five aspects of critical thinking based on Facione's (2015). The result of the pretest-posttest and N-Gain score of each Critical Thinking aspect are tabulated in Table 4. The score of normalized gain on Interpretation Aspect is 0.52, which is categorized as medium. For the Analysis Aspect, the normalized gain score is 0.14, which is classified as low. While the Inference Aspect shows the normalized gain score of 0.53, which is categorized as medium. Then the normalized score of Evaluation Aspect is 0.39, which is classified as medium. The last, the Explanation Aspect, shows the normalized gain score of 0.51, categorized as medium. The N-Gain Score of critical thinking aspects can also be seen in the following Figure 10.

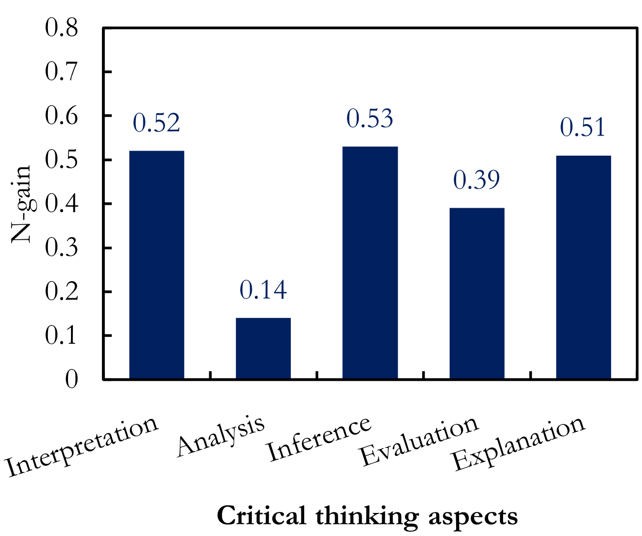

Figure 10 N-gain score of critical thinking aspects

According to the result presented in Figure 10, the interpretation, inference, evaluation, and explanation have a medium category. Therefore, it can be said that students got a medium improvement on those critical thinking aspects after the implementation of NASA Science as interactive multimedia in learning the Solar System. As explained based on Figures 8 and 9, NASA Science has already engaged students' critical thinking by giving students a chance to inference and explain a problem. It always begins with formulating a previous question as a bridge toward explaining the delivered topic.

Meanwhile, for Interpretation, here is the following Figure 11 as one example that describes how NASA Science engages students to interpret a problem. For example, from Figure 11, it is clearly described that NASA Science delivers a straight reason on how the Moon has different phases and is explained by interpreting the information content from a simulation diagram.

Although it is categorized as a medium category for evaluation, it still has a lower N-Gain score than the

Table 5 Students' impression in learning solar system by using NASA science

Aspect	Value	Interpretation
Media	3.32	Positive Impression
Learnability	3.23	Positive Impression
Satisfaction	4.09	Positive Impression
Average	3.55	Positive Impression

interpretation, inference, and explanation. The researcher found that the NASA Science content is not involved in stimulating the critical thinking evaluation aspect toward the Solar System Concept. The students could get the Medium Improvement of this aspect because it helps deliver clear concepts from NASA Science.

Unlike the other aspects, analysis is the aspect with a low categorized improvement, which means that NASA Science had only a negligible impact on improving Analysis on Students' Critical Thinking. In NASA Science Multimedia, the contents involved in it still lack engaging students to analyze a problem. Moreover, based on Facione (2015), analysis requires examining ideas, identifying arguments, and identifying reasons and claims. One of the examples is shown in Figure 12 regarding the revolution period.

Based on Figure 12, the answer to the question is "a". However, some of the students still choose "c" as the answer. In NASA Science, the content of moon phases is always delivered with an exact position of the Sun, which is on the right side, as seen in Figure 13.

From Figure 13, the students are not triggered to analyze the Moon Phase with the different positions of the Sun, so the students may have a misconception that the position of the New Moon is always on the right sight of the Earth. Whereas it depends on the position of the Sun when lighted up the Moon.

Overall, most of the normalized gain score was only the medium category which comes with different scores. Furthermore, the implementation of NASA Science Multimedia was carried out in online meetings without direct instruction on every teaching-learning process. Therefore, according to Ahn & McEachin (2017), fully online learning has not been successful in improving the achievement of students as well as their comprehension of science learning. Thus, the result would not be as maximum as it is directly implemented in the classroom.

3.3 Students' Impression

In this study, the students' impression is measured using a questionnaire consisting of three aspects: media, learnability, and satisfaction, divided into 13 sub aspects. Students' impression is processed using Likert Scale with four option responses: strongly agree, agree, disagree, and strongly disagree. According to Suherman (2003), students'

Table 6 Recapitulation of students' responses toward NASA science

Aspect	Statements	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
Satisfaction	I am satisfied using NASA Science Multimedia.	40.5	50.0	7.1	2.4
	I feel interested in learning about Solar System using NASA Science Multimedia.	50.0	40.5	7.1	2.4
	NASA Science Multimedia was fun and comfortable.	45.2	42.9	9.5	2.4
	I feel better to learn Solar System through NASA Science Multimedia than using Text Book.	35.7	50.0	11.9	2.4
Total Percentage		**42.9**	**45.8**	**8.9**	**2.4**
Media	NASA Science as interactive multimedia is easy to use.	35.7	54.8	9.5	0.0
	Images in NASA Science Multimedia are clear and easy to understand.	40.5	47.6	9.5	2.4
	Videos in NASA Science Multimedia are straightforward and easy to understand.	47.6	38.1	14.3	0.0
	Animations in NASA Science Multimedia are straightforward and easy to understand.	50.0	45.2	2.4	2.4
	Explanations in NASA Science Multimedia are clear and easy to understand.	47.6	40.5	9.5	2.4
Total Percentage		**44.3**	**45.2**	**9.0**	**1.4**
Learnability	I can easily understand the Solar System material using NASA Science Multimedia.	42.9	45.2	11.9	0.0
	NASA Science Multimedia was improving my	38.1	47.6	14.3	0.0

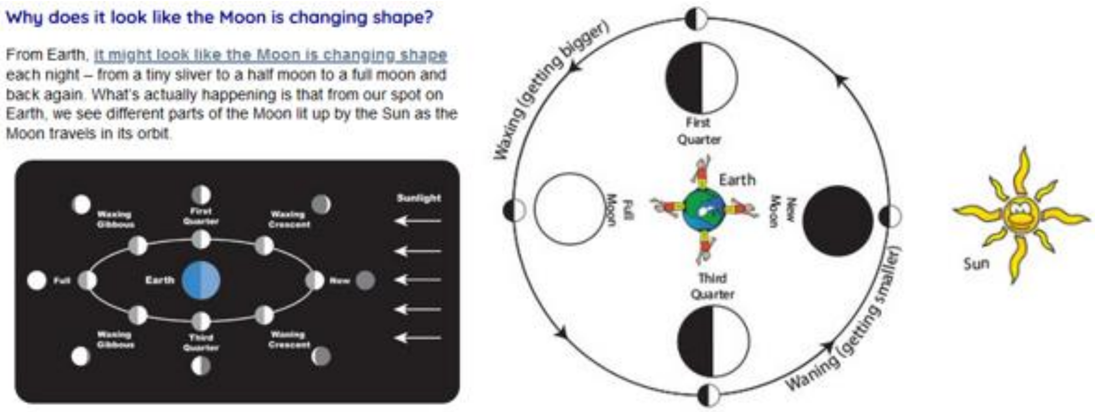

Figure 13 Moon phases on NASA science multimedia (Source: spaceplace.nasa.gov, 2019)

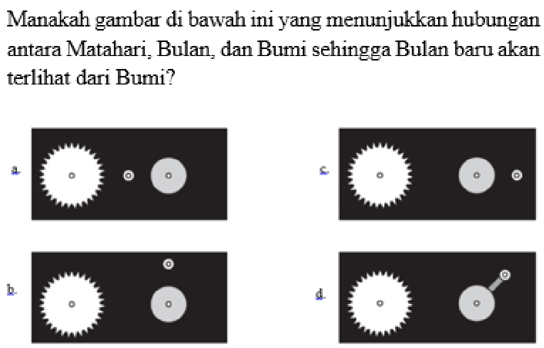

Figure 12 Test item question of analysis

impression value is interpreted as a positive impression if the value is more significant than 3.00 (>3.00), while a negative impression is interpreted if the value is less than 3.00 (<3.00). In measuring the value of students' impression, it was done based on (Suherman, 2003) by multiplying the total response score with the value of response and dividing it by the total number of respondents. The result of students' impression of NASA Science Multimedia is tabulated in Table 5.

Based on Table 5, students' impression results have a value of 3.55, categorized as a positive impression. Table 5 also shows that the student's impression in every aspect indicates a positive impression. The media aspect has a value of 3.32, the learnability aspect has a value of 3.23, and the satisfaction aspect has a value of 4.09. A further description of students' responses is provided in Table 6.

Based on Table 6, the percentage in students' satisfaction aspect shows that 42.9% strongly agree and 45.8% agree with the impression value of 4.09, which means that they get positive satisfaction from NASA Science Multimedia. This finding is supported by the previous research, which stated that students' satisfaction after utilizing multimedia shows high satisfaction, followed by a statement that learning using multimedia is not dull and gets some fun experiences (Kaewkiriya, 2013). Furthermore, Hsiao (2017) also found that students felt satisfied with multimedia and thought multimedia gives real-world circumstances that help the learning process.

The percentage result of media aspect shows 44.3% strongly agree and 45.2% agree, followed by the impression value of 3.32, which means that NASA Science has already presented a good media appearance. According to Sausan, Saputro, & Indriyanti (2020), the main factor that makes the students very interested in learning using multimedia is the attractiveness of multimedia appearances, such as bright colors of some figures, interactive video animations, and some realizations phenomena. It is also supported by Leow & Neo (2014), which stated that multimedia elements covered by an attractive figure, video, and animation help students to obtain more detailed and realistic information.

Last, the percentage in Learnability Aspect has a value of 34.5% strongly agree, and 54.2% agree with the impression value of 3.23, which means that students feel the positive impact of NASA Science in learning Solar System Concept. It is in line with the finding from Ercan (2014). The research found that students that use interactive multimedia can deepen their understanding. Interactive multimedia helps students learn more efficiently and effectively in their learning way and speed. Therefore, interactive multimedia can be used in learning environments for effective learning (Ercan, 2014).

4. CONCLUSION

In this study, the interactive multimedia used is NASA Science, which has been proved to be useful for students in learning the Solar System concept and can be one of the interactive multimedia for assessing students' critical thinking. Improving students' critical thinking after learning Solar System using NASA Science Multimedia is considered a medium improvement because it obtained the <g> score of 0.48. For each aspect of critical thinking, the analysis aspect has a low improvement, with the score of <g> shows 0.14. In contrast, the other elements such Interpretation, Inference, Evaluation, and Explanation, the <g> score is categorized as a medium with the score of

0.52, 0.53, 0.39, and 0.51. Thus, NASA Science gives the students a positive impression to the students. The three aspects: satisfaction, media, and learnability, gain a high value (>3.00) or positively impressed the students. The satisfaction aspect obtains the highest value, which shows 4.09, while learnability obtains the smallest value, which is 3.23.

REFERENCES

Ahn, J., & McEachin, A. (2017). Student enrollment patterns and achievement in Ohio's online charter schools. *Educational Researcher*, *46*(1), 44-57.

Bhakti, S. S., Setyadin, A. H., Hidayat, S. R., Zulfikar, A., Fratiwi, N. J., Amalia, S. A., & Siahaan, P. (2019). Enhancing Students' Critical Thinking Skills through Multimedia Based Integrated Instruction (MBI2) on Solar System Concept. In *Journal of Physics: Conference Series* (Vol. 1204, No. 1, p. 012034). IOP Publishing.

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). *Defining twenty-first-century skills. In assessment and teaching of 21st-century skills* (pp. 17-66). Springer, Dordrecht.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approach*. London: Sage publications.

DiBiase, W., & McDonald, J. R. (2015). Science teacher attitudes toward inquiry-based teaching and learning. *The Clearing House: A Journal of Educational Strategies, Issues, and Ideas*, *88*(2), 29-38.

Djamas, D., & Tinedi, V. (2018). Development of Interactive Multimedia Learning Materials for Improving Critical Thinking Skills. *International Journal of Information and Communication Technology Education (IJICTE)*, *14*(4), 66-84.

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An integrated critical thinking framework for the 21st Century. *Thinking skills and creativity*, *12*, 43-52.

Ekanayake, S. Y., & Wishart, J. (2014). Mobile phone images and video in science teaching and learning. *Learning, Media and Technology*, *39*(2), 229-249.

Ercan, O. (2014). The Effects of Multimedia Learning Material on Students' Academic Achievement and Attitudes towards Science Courses. *Journal of Baltic Science Education*, *13*(5), 608-621.

Facione, P. A. (2015). Critical thinking: What it is and why it counts. *Insight Assessment*, *2007*(1), 1-23.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education*. New York: McGraw-Hill Humanities/Social Sciences/Languages.

Hake, R. R. (1999). *American Educational Research Association's Division D, Measurement and Research Methodology: Analyzing Change/Gain Scores*. USA: Wooland Hills.

Halpern, D. F. (2014). *Critical thinking across the curriculum: A brief edition of thought & knowledge*. New York: Routledge.

Hsiao, E. (2017). A design case of scaffolding hybrid/online student-centered learning with multimedia. *Journal of Educators Online*, *14*(1), n1.

Kaewkiriya, T. (2013). A design and development of e-learning content for multimedia technology using a multimedia game. *International Journal of Software Engineering & Applications*, *4*(6), 61.

Lamb, R., Firestone, J., Schmitter-Edgecombe, M., & Hand, B. (2018). A computational model of student cognitive processes while solving a critical thinking problem in Science. *The Journal of Educational Research*, *112*(2), 243-254.

Leow, F. T., & Neo, M. (2014). Interactive multimedia learning: Innovating classroom education in a Malaysian university. *Turkish Online Journal of Educational Technology-TOJET*, *13*(2), 99-110.

Marina, R., & Prima, E. C. (2020). *Stellarium is an Interactive Multimedia to Enhance Students' Understanding and Motivation in Learning Solar System*. Proceedings of the Mathematics, Science, and Computer Science Education International Seminar. European Alliance for Innovation.

NASA Science. (2019). *About Us – NASA Solar System Exploration*. Retrieved from https://solarsystem.nasa.gov/about-us/

NASA Science. (2019). *NASA Solar System Exploration*. Retrieved from https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/

Organization for Economic Co-operation and Development. (2019). *Indonesia - Country Note - PISA 2018 Results*. Paris: OECD publishing.

Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia No. 20. (2016). *Standar Kompetensi Lulusan Pendidikan Dasar dan Menengah*.

Peraturan Pemerintah Republik Indonesia No. 19. (2005). *Standar Nasional Pendidikan (Cat. no. 41)*.

Saido, G. M., Siraj, S., Nordin, A. B. B., & Al-Amedy, O. S. (2018). Higher-order thinking skills among secondary school students in science learning. *MOJES: Malaysian Online Journal of Educational Sciences*, *3*(3), 13-20.

Sausan, I., Saputro, S., & Indriyanti, N. Y. (2020). A New Chemistry Multimedia: How Can It Help Junior High School Students Create a Good Impression. *International Journal of Instruction*, *13*(4).

Suherman, E. (2003). *Evaluasi pembelajaran matematika*. Bandung: JICA UPI.

Swandi, A., Amin, B. D., & Muin, F. (2018). 21st-century physics learning in senior high school through interactive computer simulation to enhance students' achievement. In *International Conference on Mathematics and Science Education of Universitas Pendidikan Indonesia* (Vol. 3, pp. 130-135).

Tiruneh, D. T., De Cock, M., Weldeslassie, A. G., Elen, J., & Janssen, R. (2017). Measuring critical thinking in physics: Development and validation of a critical thinking test in electricity and magnetism. *International Journal of Science and Mathematics Education*, *15*(4), 663-682.

Weay, A. L., & Masood, M. (2015). The "Big Picture" of Thematic Multimedia Information Representation in Enhancing Learners' Critical Thinking and History Reasoning. *Procedia-Social and Behavioral Sciences*, *197*, 2058-2065.