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The Volcano Simulation Software Implementation in Integrated Physics Learning Disaster Mitigation to Develop Critical Thinking Skills

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Abstract

This research aimeds to analyze the students' learning results in the critical thinking skills using volcano simulation software. In addition, students' response to the volcano software integration into physics learning is also described in the current research. The research samples are students of SMA Tamansiswa Mojokerto consisting of two classes, namely XI MIPA 1 and XI MIPA 2, with 65 students. This research is included in quantitative research by using One Group Pretest – Posttest Design. The pre-test was given first, and at the end of the learning, the samples were given a post-test. The data collection instruments used in this research are the critical thinking ability test and student response questionnaire sheet. The data were analyzed descriptively (n-gain) and statistically (t-test). The results showed (1) an increase in the critical thinking skills with an average score of n-gain of 0,87 and 0,83 with the high criteria and (2) there is no difference in the average score of n-gain between both classes ($p > 0.05$). It can be concluded that physics learning by using volcano simulation software effectively increases the students' learning results and critical thinking skills. The average percentage of students' responses is 82% with a very good category. The use of volcano simulation software on the critical thinking skills obtained results that it being more interesting and easier for students to understand better the taught concepts as well as can practice the critical thinking skills of students.

Keywords: Volcano Simulation Software, Viscosity, Critical Thinking Skills

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INTRODUCTION

Indonesia has many volcanoes. Volcanic phenomena have become an inseparable part of Indonesian people's lives (Hariyono et al., 2020). There are many active volcanoes spread all over Indonesia. The impacts caused by natural volcanic disasters caused an increase in the number of fatalities and damages caused by the extreme event. National Board for Disaster Management (NBDM) also listed, throughout 2015 to 2021, 121 volcanic eruptions occurred in Indonesia. In the range between 2015 to 2021, most volcanic eruptions were recorded in 2018, with a total of 63 eruptions. The number is the highest in the last decade. The deceased and injured people reach thousands of people. The data described the community's vulnerability to disasters. One of the factors suspected as the cause of the high disaster victims is skill and low knowledge society's minimizing disaster risk (Hariyono et al., 2020).

According to the information public education is needed regarding volcanoes and their mitigation. Many students do not understand the educational volcanic disasters and preparedness. Disasters education is implemented by integrating disaster material into suitable material with volcanic volcano material, namely Physics subject. Physics is a science that studies natural phenomen and their causes relevant to everyday life. The volcano is one of a natural phenomenon. Physics material can be integrated with volcano material. The

government has provided learning resources for physics subjects in school, However, the learning resources have not been integrated with volcano material (Fauzi, 2020). Physics learning increases the physics principle critical thinking skills to explain several natural events and solve problems (Anisa et al., 2020). One of the low activities of students in critical thinking is in physics.

One of the media that can provide convenience for students is virtual laboratory simulation, the description of a system or process through demonstration or unrealistic role. In the virtual simulation learning process, it is possible to use the help of a computer to explain and present material that is difficult to present in front of the class such as natural phenomenon, microscopic and macroscopic objects and materials. Other events which are difficult to present in real terms and other activities which can cause a danger in class (Anisa et al., 2020).

Volcano Learning Project (VLP) media is an interactive virtual software simulation that invites students to learn. Volcano Learning Project is more of an effort to virtualize various information related to the volcano and their activities. The use of virtual simulation media makes it easier for teachers to convey a lot of material with one place and thus more efficient use of time. Moreover, virtual simulation media makes the learning process more fun to watch, read, digest and remember (Ramadani & Nana, 2020). Volcano Learning Project software is a suitable simulation for physics students in learning the volcano phenomenon and is recommended as a medium to educate the public about volcanoes (Hariyono, 2017). Volcano simulation software consists of volcano simulation, mentoring technique, exploration, disaster mitigation, and reference. Menu of the volcano simulation software consists of eruption type, silica content, volcano type, rock type, pressure, seismograph, lava viscosity, and lava temperature. The exploration menu consists of the choice of gas and viscosity when operated to explain the volcano, magma viscosity, and description (Mahfudin & Hariyono, 2020).

The current research aimed to students' response to the volcano simulation software integration into physics learning and the application of volcanic simulation software in viscosity physics learning using, students are considered to have indications in developing critical thinking skills because there are mentoring techniques in volcano simulation software. Critical thinking is one of the things that is important for the continuity of student learning because students' critical thinking will increase understanding in the material of viscosity physics. In addition, this study aims to identify students' ability to improve critical thinking by using volcanic simulations in learning viscosity physics with VLP media. The interactive learning process contained in VLP media makes it easier for students to receive understanding of the material with a pleasant impression while exploring volcanoes. Indicators critical thinking skills according Triyanto (2014) Ability to state facts, be able to express the facts contained in the problem, be able to choose logical and relevant arguments for the problem at hand, able to detect bias in point of view able to predict or determine an effect that will result from making decisions on a problem. Based on these critical thinking indicators, volcano simulation software with VLP media is considered very appropriate for the development of students' critical thinking because it includes all indicators in it.

METHOD

This research is included in the quantitative research using One Group Pretest – Posttest Design research (Indra, 2021). This research is conducted by giving treatments to experiment and control class.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
XI MIPA 1	O_1	X	O_2
XI MIPA 2	O_1		O_2

Description :
O_1 : *Pretest* before treatment
X : Treatment using volcano simulation software
O_2 : *Posttest* after treatment

The research was conducted at SMA Tamansiswa Mojokerto. The class taken as a research object is the XI MIPA. The populations in this research are students of SMA Tamansiswa Mojokerto. The research subjects are 65 students. XI MIPA class consists of two classes, XI MIPA 1 and XI MIPA 2. The samples used in this research are XI MIPA 1, as many as 33 students' (experimental class) and XI MIPA 2, as many as 32 students' (control class).

The instruments data collection used in this research were are student response questionnaire and critical thinking ability test, which consisted of five essay questions using four critical thinking skills indicators: interpretation, inference, analysis, and evaluation. Students' response the questionnaire using the Likert scale. Students' response questionnaire are distributed after the whole learning process done to see how students' respond to using volcano simulation software learning physics.

The analysis of the increase in the level of students' critical thinking skills ability is calculated by using N-gain calculation with the equation:

$$\text{N} - \text{gain (g)} = \frac{S_{post} - S_{Pre}}{S_{max} - S_{pre}}$$

Then the N-gain result is converted to high, moderate, and low criteria according to **Table 2**.

Table 2. N-gain Category

Score	N-gain Category
0.7 < N-gain	High
0.3 < N-gain < 0.7	Moderate
N-gain < 0.3	Low

(Hake, 1999)

The technique data analysis used was quantitative-descriptive to describe the facts that happened in school. The research procedures used are as follows.

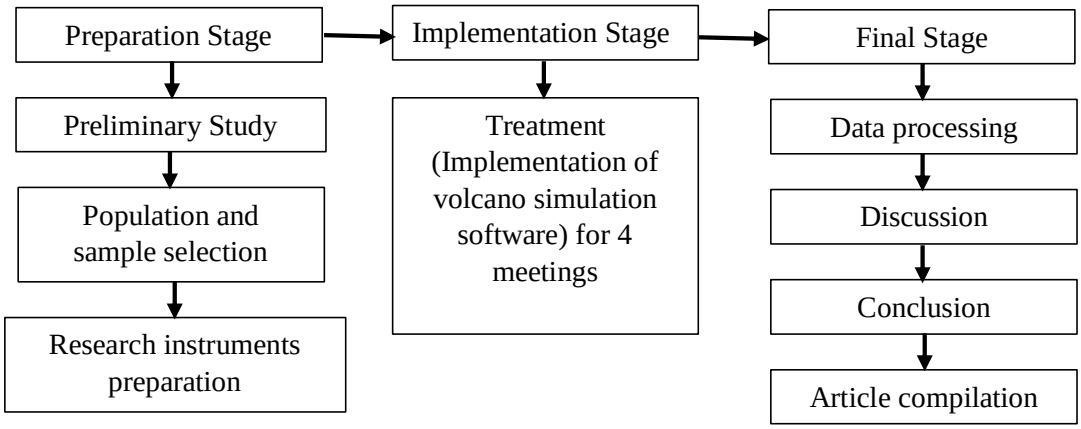

Figure 1. Research Procedures Diagram

Table 3. Aspects of Critical Thinking Skills Assessed

Critical Thinking Skills	Explanation
Interpretation	Interpret the meaning of each element that exists
Explaining	State the reasoning results in the form of arguments by including the pieces of evidence

Analysis	Analyze the available information to determine the pattern/relationship between some elements
Conclude	Provide provisional guesses based on information, provide an assessment of the given information, and draw conclusions correctly

Source from Facione, 2015

The learning process carried out using volcanic simulation software carried out at SMA Tamansiswa Kota Mojokerto using descriptive statistical analysis techniques provides an overview of the data viewed with the mean, standard deviation, maximum, minimum and range. In the statistical analysis technique, there is a validity of the instrument which was validated by two lecturers department physics and a physics teacher at SMA Tamansiswa Mojokerto. The results statistical analysis technique: Test of Normality, Test of Homogeneity of Variance, and N-gain.

RESULTS AND DISCUSSION

The learning process conducted using volcano simulation software carried out in SMA Tamansiswa Mojokerto, the learning device instruments used have been validated by two lecturers in physics major of Surabaya State University and physics teacher in SMA Tamansiswa Mojokerto. The physics learning device validation test results using volcano simulation software are shown in **Table 4**.

Table 4. The Learning Device Validation Score

Research Aspect	Average Score	Criteria
Syllabus	3.5	Valid
RPP	3.6	Valid
LKPD	3.7	Valid
Handout	3.6	Valid
Test Questions	3.5	Valid
Questionnaire	3.9	Valid

Based on **Table 4**, the average score of learning device instruments including syllabus, LKPD, RPP, Handout, and critical thinking test questions, all of which have valid criteria can be used. Therefore, the learning device using volcano simulation software is suitable and can be used in viscosity physics learning in SMA Tamansiswa Mojokerto.

Before process learning is conducted, are given pre-test questions to determine the initial ability. Furthermore, the learning process of viscosity physics using volcano simulation software was carried out in the lab class. At the end of the learning process, post-test questions are asked to determine the student's final ability. Pre-test and post-test scores are used to measure differences in students' critical thinking skills before and after learning by using volcano simulation software in the static fluid material viscosity subject.

It can be known that before learning physics using volcano simulation software, both XI MIPA 1 and XI MIPA 2 students' scored lower on the critical thinking skills. After the learning process using volcano simulation software is conducted, average scores of students' XI MIPA 1 and XI MIPA 2 critical thinking skills increased. Based on the five valid question items test, analysis prerequisite test is conducted by using the of normality to measure data is normally distributed or not. The test of normality in this research used Kolmogorov-Smirnov test with a significance value > 0,05. The following is the result of the calculation of the normality test as shown in **Table 5.**

Table 5. Test of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Class	Statistic	df	Sig.	Statistic	df	Sig.
KBK	Pretest A1	.147	33	.069	.951	33	.138

	Posttest A1	.144	33	.082	.937	33	.055
	Pretest A2	.150	32	.065	.948	32	.124
	Posttest A2	.143	32	.093	.919	32	.020

a. Lilliefors Significance Correction

Based on **Table 5**. It is known that the pre-test and post-test in XI MIPA 1 class with sig. value of 0.069 and 0.082. Pre-test and post-test in XI MIPA 2 class with sig. value of 0.065 and 0.093 using the Kolmogorov-Smirnov test, which means that significance value is higher than 0.05. It concluded that the pre-test and post-test for XI MIPA 1 and XI MIPA 2 class come from a normally distributed population.

Moreover, the data are tested for homogeneity that are normally distributed. The test of homogeneity of variance test is used to determine whether both classes or all samples homogeneous or not. The following is the result of the calculation of the test of homogeneity test as shown in **Table 6a (pretest)** and **Table 6b (posttest).**

Table 6a. Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
KBK	Based on Mean	1.976	1	63	.165
	Based on Median	1.808	1	63	.184
	Based on Median & with adjusted df	1.808	1	62.130	.184
	Based on trimmed mean	1.887	1	63	.174

Based on **Table** 6a, the pre-test homogeneity test results of XI MIPA 1 and XI MIPA 2 class with sig can be known value 0.165 using SPSS 25 calculation, the significance value > 0,05. It can be concluded that all classes or samples have homogeneous variance.

Table 6b. Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
KBK	Based on Mean	1.980	1	63	.164
	Based on Median	1.919	1	63	.171
	Based on Median & with adjusted df	1.919	1	51.678	.172
	Based on trimmed mean	1.962	1	63	.166

Based on **Table 6b**. It can be known that the post-test homogeneity test results of XI MIPA 1 and XI MIPA 2 classes with sig. value 0,164 using SPSS 25 calculation, the significance value > 0,05. It can be concluded that all classes or samples have homogeneous variance.

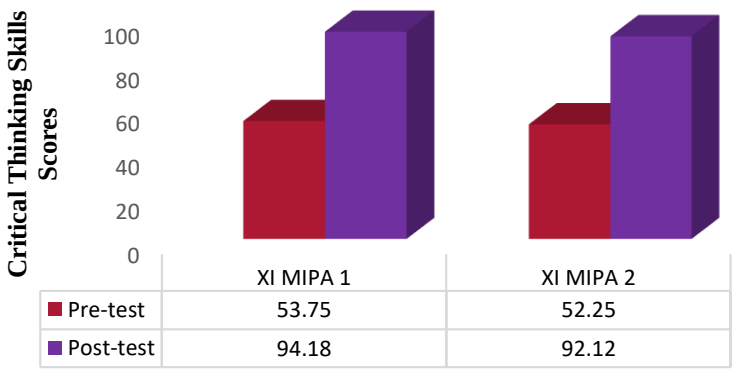

Figure 2. Critical Thinking Skills Test Results Diagram

Based on **Figure 2**, before the problem-based physics learning using volcano simulation software viscosity static fluid material, the critical thinking skills of students XI MIPA 1 and XI MIPA 2 class obtained low average scores. After using volcano simulation software is conducted, the scores critical thinking skills of students' XI MIPA 1 and XI MIPA 2 increased.

Moreover, to determine increase in the critical thinking skills students', the paired samples t-test is conducted by using post-test and pre-test data in students of XI MIPA 1 and XI MIPA 2 classes in SMA Tamansiswa Mojokerto. The following is the paired samples t-test results data, as shown in **Table 7.**

Table 7. Paired Samples Test

	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
PRE A1 - POST A1	-40.424	1.786	.311	-41.057	-39.791	-130.030	32	.000
PRE A2 - POST A2	-39.875	4.818	.852	-41.612	-38.138	-46.821	31	.000

Based on **Table 7.** That the H_0 is rejected for all classes. It means that, post-test score was significantly higher than pre-test score statistically calculated with SPSS 25 for all classes. This showed that the increase in the critical thinking skills ability of students by using volcano simulation software happened significantly. Furthermore, to determine criteria of critical thinking ability, the n-gain analysis of pre-test and post-test scores was used. The N Gain analysis results data, as shown in **Table 8.**

Table 8. N Gain Analysis Results

Class	<g>	Criteria
XI MIPA 1	0.87	High
XI MIPA 2	0.83	High

Based on **Table 8.** It known that the n-gain analysis results scores of both classes are high, therefore it physics learning process using volcano simulation software is effective in increasing the learning ability and critical thinking ability of students. It is known that n-gain results of experiment and control class 0,87 and 0,83 and both are classified as high which means that there is no difference significant in both classes when given treatment using volcano simulation software.

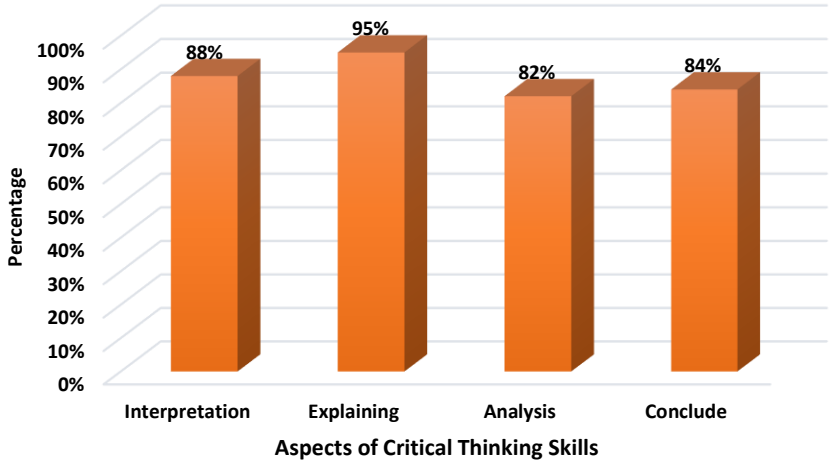

Figure 3. Critical Thinking Skills Results Diagram

In **Figure 3**, the acquisition of the percentage of critical thinking skills students' in each aspect obtained a very good category. The aspect Interpreting obtained a percentage of 88%. The critical thinking skills interpreting aspect is trained when students can correctly interpret the elements available in the software and answer the questions in the interpreting category test sheet. In the explaining aspect obtained a percentage of 95%. The critical thinking skills explaining aspect is trained when students can correctly explain and answer the questions in the explaining category. In the analyzing aspect obtained a percentage of 82%. The critical thinking skills analyzing aspect is trained when students can analyze answer the question of the relationship between volcanic lava and flow rate obtained by analyzing category correctly. The analysis aspect obtained the lowest percentage compared to other aspects. This is because the analyzing aspect has the highest level of difficulty compared to other aspects, and thus students experienced difficulty in answering the questions in analyzing aspect. In the concluding aspect obtained a percentage of 84%. The critical thinking skills concluding aspect is trained when students can make a conclusion from some things found and answer the questions in the concluding category correctly. The results obtained are in accordance with previous research conducted by Mahfudin & Hariyono (2020) regarding the efforts in training the critical thinking skills through volcano simulation software learning media is considered feasible and effective in increasing the critical thinking skills of students. And the research by Ngurahrai et al. (2019) regarding the learning media to train the critical thinking shown good implementation and helped improve critical thinking.

The students' responses are obtained through the questionnaire of all students who received physics learning based on volcano simulation software as many as 65 students of XI MIPA class SMA Tamansiswa Mojokerto. The questionnaire sheet used consists of 15 question points asked with description, 1 = Disagree; 2 = Less agree; 3 = Agree; and 4 = Strongly agree. As for some sample percentage of student responses contained in Table 9 below.

Table 9. Students' Responses Percentage Data

No.	Statement	Percentage %
1.	I feel happy and interested in taking physics subject static fluid material with the problem-based learning model	82.30
2.	I am more skilled and active in physics subjects by using problem-based learning with volcano simulation software laboratory virtual	80.76
3.	I find it easier to think critically in solving questions through problem-based learning using volcano simulation software laboratory virtual	82.69
4.	I can be trained to solve a problem with many solutions or ways in the problem-based learning	80.38
5.	I better understand the benefits and technology of physics in daily life in the problem-based learning using volcano simulation software laboratory virtual	81.15

The data in the Table 9 above showed that as many as 82.69% of students felt that they admit that it is easier to think critically, this can be used by students when solving problems studied. According to Hurley & Hurley (2013), ways to train the critical thinking skills is by learning with media or virtual oriented on learning and teaching approach activities for students. The results of using volcano simulation software can increase the students' thinking skills as one of the demands of learning in the 21st century. According to ŽivkoviĿ (2016) in this 21st century, it is important for students to increase critical thinking skills in education solve problems in the real world.

There are 80.38% of respondents stated that the volcano simulation software as learning in school help them in solve a problem with several solutions. According to Fisher (2008),

there are 6 critical thinking characteristics: problem identification, recording the latest information, create alternative solutions to a problem, drawing conclusions, arguing, and evaluating arguments. The six characteristics can be increased through a learning system using virtual laboratorium simulation which requires students to think directly as a problem simulation in real world. SSG learning media (Volcano simulation software) is considered important in solving student problems in critical thinking.

Then, 81.15% of respondents stated that the understanding the benefits and technology of physics in problem-based learning by using simulation software is considered more understandable. The research conducted by Rahmawati & Wiyatmo (2018) showed that in physics learning has an education integration in more effective volcanic eruption disasters compared to physics learning using conventional media, this is the result of a review of the readiness for volcanic disasters and mastery of the material by students. According to Hendrawati et al. (2019), a significant change in the interaction effect in learning used contextual approach and critical thinking skills in students.

As many as 80.76% respondents stated that they feel more skilled and active in physics subject by using problem-based learning with laboratory virtual simulation software. According to Nirwana (2011) there are several benefits in learning using laboratory virtual namely 1) Reduction of time constraints in teaching students until they understand, 2) Geographical barriers are reduced if there is a student located far from the learning center, 3) This simulation is considered cost-effective or economical because does not need a laboratory building in physical form and simple tools, 4) The safety and security of students can be guaranteed with the use of this method because it is only virtual on screen. From the benefits certainly the students will be more skilled in thinking critically because of the benefits produced from laboratory virtual simulation software are very diverse.

82.30% respondents stated that they feel happy and interested in taking physics subject static fluid material with problem-based learning model. According to Nurvitasari et al. (2019) also showed that virtually learning media is considered to be able to increase the effectiveness of the use and learning of physics, moreover, students have a high interest in physics. This also made students better understand the material given in physics learning because interest in an object will lead the students to curiosity to learn deeper regarding the volcanic disaster in Indonesia. Based on the explanation, a media development is necessary in physics learning, especially viscosity material related to volcano phenomenon, and can train students' critical thinking. This is viewed from the overall research results data in the form of the feasibility of volcano simulation software learning media in terms of validity and effectiveness of the volcano simulation software (Nieveen, 1999). The use of media in the form of interactive multimedia towards concept and critical thinking skills obtained results that interactive multimedia is more interested and makes it easy for students to better understand the concepts taught and can train students critical thinking skills.

CONCLUSION

Based on the research results, it can be concluded that physics learning using volcano simulation software effectively and significantly can increase students' critical thinking in viscosity material in SMA Tamansiswa Mojokerto. This volcano simulation software is feasible because it has fulfilled the validity criteria, and the effectiveness of the high level of critical thinking skills improvement. In learning process used the help of volcano simulation software. With the volcano simulation software, students are active in practicing critical thinking skills and actively discussing. Therefore, the students learning results are increased when using the volcano simulation software in physics learning.

RECOMMENDATION

The aspects measured in this research are the students' critical thinking. For this reason, further research needed to measure other aspects, such as mastery of students' concepts and

science process skills. This research is in small sample. The next research is to facilitate in large sample.

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