The Students’ Voice of Volcanology in Education for Sustainable Development Context

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Abstract. The aim of this study is to identify college students’ conception regarding to volcanic phenomena. This study was possessed the conception profile of freshmen in volcanology using questions instrument about volcanology concept and making decision skills instrument test which created by the researchers. A descriptive quantitative approach was used, which included 32 physics students at Surabaya State University as the participants. The result indicated that the physics students have a little understanding about volcanology concept. From all questions provided, they answered correctly less than 50% only. In line with this, their making decision skills need to be trained. Meanwhile, as science teachers must have a good understanding of this subject matter. Therefore it can be concluded that the evaluated geoscience learning curriculum for pre-service science teachers needs to be evaluated.

1. Introduction
For the past several years, geoscience learning has been of considerable interest to science educators in this subject and researchers working on the relevant field, as addressed by [1] who claimed that good knowledge of earth-related science education relevant to disasters is important for university students. The science of disasters can be introduced to the students in either classroom settings or final projects. The quality of learning depends on the teacher's understanding of the geoscience subject matter, which reflects the quality of education. Education is one of the main vehicles for intellectual and professional development of human resources and plays a very important role in supporting a stronger and globally competitive Indonesia. Thus, it is the most powerful weapon used to change the world [2]. To realize good quality education, science teachers, curriculum developers, and resource researchers must be organized and have easy access to overcome geoscience misconceptions [3].

A conception about geoscience is very important for humanity to successfully respond to these challenges and develop in the coming decades. Several supporting factors are (1) global finance depends on access to reliable and safe energy sources, most of which depend on geoscience knowledge; (2) air, soil, and mineral resources become very scarce in some areas due to the increase in human population and global industrialization; and (3) there are many questions in terms of sea level rise, drought, forest fires, desertification and intensification of storms as a result of global climate change widely accepted [4].

Geoscience is important to enhance the disaster mitigation of Indonesian society. The science curriculum for junior high school in Indonesia has some content to prepare students to understand the layers of the earth, volcanoes, earthquakes, and risk reduction actions before, during, and post-disaster.
according to the threat of disasters in the area. Thus, this understanding can increase his/her knowledge and concepts of science that are useful in everyday life as well as to develop skills, to investigate the environment, and solve problems [5].

The science curriculum that has been formulated is very suitable with the conditions of the earth in Indonesia, because the events of the disaster and associated social and economic impacts are currently increasing. It is undeniable that Indonesia have many natural disasters [6]. In the last decade it showed the highest number and impact of disasters, while 2015 was declared the hottest year ever. The Asia Pacific region has become the most frequent place for this disaster, while Indonesia is one of the most at risk of disasters and the effects of climate change [7].

In fact, there were 350 natural disasters occurred in 2016 worldwide, killing 10,273 people and affecting over 204 million people. The estimated amount of economic damage came close to US$147.4 billion [8]. Based on Emergency Event Database data it is known that more disasters that occur are from non-geophysical disasters (hydrology, meteorology, and climatology) than those originating from geophysical disasters. Therefore, the total damage and total losses resulting are more. However, the number of deaths is significantly caused by geophysics disasters, namely earthquakes and volcanic activity [7].

Volcanic phenomena become an inseparable part of the lives of Indonesian people [9]. Geographically, almost all Indonesia regions are prone to natural disasters, especially volcanic disasters. Indonesia has many volcanoes [10]. There are 147 volcanoes, and 76 of them are active volcanoes and spread along the islands of Sumatra, Java, Sulawesi and the Lesser Sunda [11]. This condition brings consequences or impacts both positive and negative for Indonesia society, especially those who live in the volcanic region. The positive impact is the potential of natural resources (fertile land, beautiful landscapes, many deposits of metals, non-metals, oil and gas) caused by the presence of volcanoes. Negative impacts are dangerous or vulnerable to geological disasters such as earthquakes, volcanic eruptions and landslides [10].

On the other fact, the weakness of the disaster preparedness system and the low understanding of disaster risk to the surrounding community caused the increasing number of deaths because volcanic disasters. Indonesia is the fifth country with the largest population in the world where 60 % of the population lives on volcanic area, but that number has not been balanced with a good level of understanding of disaster preparedness [12]. The National Disaster Management Agency (BNPB) also noted that from 2010 to 2014, there were 36 eruptions with a total of 432 people had died, and 2217 people had injured. These data illustrate the vulnerability of the society for disasters. If we cannot prevent and reduce significantly, the damage caused by extreme events is a major disaster for life [9].

One of the factors predicted as the cause of the high disaster victims is the low knowledge and skill of the society in minimizing disaster risk. The ability to reduce disaster risk greatly helps them to protect people and economic assets [13]. Certainly, it cannot be done spontaneously to manage the disaster, but must be planned in good long-term management before a disaster can occur through a process called disaster management [14]. This disaster management can be integrated into the geoscience learning in school. Therefore, knowledge related to disaster mitigation and response techniques needs to be shared by every Indonesian society, so as to minimize the risk of disasters that occur [12].

Geoscience teachers give large contribution to make to universal education by offering place-based, locally relevant science education on topics of critical importance to society [15]. The science teacher should be creative in applying geoscience learning by integrating various kinds of values that apply in society. For example, the implementation of the learning of Science, Environment, Technology and Society (SETS) was integrated with local wisdom that was able to reconstruct and increase the disaster management knowledge [16, 17]. Education of sustainable development (ESD) skills contributes in many ways to quality education in primary and secondary schools through the sustainable content and the ESD pedagogy promotes the learning of the skills, perspectives, and values needed to grow a sustainable society [18].

Education of sustainable development (ESD) based learning is action-oriented learning, which supports independent learning, participation and collaboration, problem orientation, inter-and
transdisciplinary and connects formal and informal learning. One of the main competencies in continuing education is the "self-awareness competency", which is the ability to reflect on one's own role in the local community and (global) community, to continuously evaluate and motivate one's actions further, and to deal with one's feelings and desires. This competency is nothing but a skill to make decisions about the problems faced [19].

This paper is intended to identify the physics students' understanding of volcanology concepts and their decision-making skills. The function of this identified is to find out the needed curriculum development in the geoscience subject matter for the college students. So that, they will be the expert science teachers in sustainable earth issues for the future.

2. Method
Participants of the study included 32 physics’ students at Physics Department State University of Surabaya, Indonesia. The research used a descriptive quantitative approach by using written test (paper and ballpoint) that created by researchers, which consist of ten (10) questions to volcanology concepts, and five (5) questions to decision-making skill.

Basic competence that supporting the instruments are mastering the structured study of the dynamics and the role of the Earth as a physical system in human life and living creatures; understand aspects of interdependence between earth and humans; understand the various potential natural disasters; including hydro-meteorological disasters in Indonesia; understand the role of physics in shaping awareness, response and alertness to earth disasters. This study focused on the study of volcanoes, which consists three (3) sub materials (the volcano concept, volcanic eruption, and volcano-related mitigation). In addition to that, it also measures students' decision-making skills in volcanic earth issues.

The volcanology concept test used two-tier test, the answer' components consist possible answers (1st tier) and open reasons (2nd tier). The instrument tests were arranged based on the volcanology concept indicators. Table 1 gives the indicators of volcanology sub materials.

| Sub material | Indicators |
|--------------|------------|
| Volcano concept | Applying tectonic plate theory in explaining the process of volcanic formation. |
| | Describing various types of volcanoes based on the formation process. |
| Volcano eruption | Understanding the material of volcanic eruptions. |
| | Explaining the type of eruption based on the rheological properties of magma and lava and based on the nature of the magma viscosity and gas pressure in the magma chamber. |
| Volcano-related mitigation | Utilizing natural signs as an early warning of volcano disaster to determine volcanic activity and develop decision-making skills. |
| | Understanding volcanic eruption parameters to determine volcanic activity and develop decision-making skills. |

The ten questions of volcanology concepts will assess using rubrics the following Table 2.

| Tier | Score | Description |
|------|-------|-------------|
| Possible answer (1st tier) | 1 | Correct |
| | 0 | Un-correct |
| Reasons (2nd tier) | 4 | The reason is correct, complete, and relevant with the question. |
| | 3 | The reason is correct and relevant with the question, but it not complete. |
| Tier | Score | Description |
|------|-------|-------------|
| 2    | The reason is not relevant with the question, but the statement is correct. |
| 1    | The reason is un-correct and also not relevant with the question |
| 0    | No reason |

While the decision-making skill test consists of five (5) indicators, i.e. (1) identify the problems based on given issues, (2) determine information needed in making decisions, (3) identify alternative actions, (4) consider in making decisions, and (5) making decisions. The making decision skill test used open test. The five indicators will assess by using rubrics the following Table 3.

### Table 3. The rubric of decision-making skill.

| Indicators                                    | Score | Description                                                                 |
|-----------------------------------------------|-------|-----------------------------------------------------------------------------|
| Ability to identify problems (1)              | 4     | The identified problems are true, specific, and relevant to the problems faced by the society. |
|                                               | 3     | The identified problems are true, but it is less specific and relevant to the problems faced by the society. |
|                                               | 2     | The identified problems are wrong, but it is still relevant to the problem faced by the society. |
|                                               | 1     | The identified problems are not relevant to the problems faced by the society. |
| Information needed in making decisions (2)    | 4     | There are four correct identified information. |
|                                               | 3     | There are three correct identified information. |
|                                               | 2     | There are two correct identified information. |
|                                               | 1     | An identified information is correct. |
| Alternative actions (3)                       | 4     | All alternative actions are appropriate to the situation. |
|                                               | 3     | Two alternative actions according to the situation. |
|                                               | 2     | One alternative action that suits the situation. |
|                                               | 1     | Alternative actions are not appropriate to the situation. |
| Consideration in making decisions (4)         | 4     | All considerations are related to the potential for the eruption, community conditions, and the impact of eruptions. |
|                                               | 3     | Two considerations relate to the potential for the eruption, community conditions, and the impact of eruptions. |
|                                               | 2     | One consideration relates to the potential for the eruption, community conditions, and the impact of eruptions. |
|                                               | 1     | All considerations are not related to the potential for the eruption, community conditions, and the impact of eruptions. |
| Decision-making (5)                           | 4     | The right decision and in accordance with alternative actions. |
|                                               | 3     | The decision is not right, but it is still relevant to alternative actions. |
|                                               | 2     | The right decision is right but still relevant to alternative actions. |
|                                               | 1     | Decisions are not related to alternative actions. |

Table 1 and 2 show “indicators” used in two types of written test specifically designed for analysing level of understanding of volcanology concept and grading of decision-making skill. However, the method doesn't provide clearly the 10 questions for analysis of volcanology concept and the other 5 questions for decision-making skill treatment. Based on the rubric assessment in Table 2 and 3, it will be obtained the students’ score about their understanding of volcanology concept and their decision-making skill.
The data will be analyzed using percentage descriptive analysis to determine the student’s conception of volcanology concept, and how their decision-making skills as the education of sustainable development’ competencies. In other hand, also will be identified the correlation between students understanding of volcanology concept and their decision-making skill. The correlation analysis is using “Pearson Correlation” through Statistical Product and Service Solution (SPSS) software.

3. Results and Discussion

3.1. Volcanology Concept

The volcanology concept consists of three sub materials, i.e. volcano concept (VC), volcanic eruption (VE), and volcano-related mitigation (VM). Table 4 give the students’ score of volcanology concept test based on the sub material.

| Student | Sub material | Final score |
|---------|--------------|-------------|
|         | VC | VE | VM |
| 1       | 2  | 5  | 6  | 26 |
| 2       | 4  | 7  | 5  | 32 |
| 3       | 6  | 5  | 6  | 34 |
| 4       | 7  | 6  | 4  | 34 |
| 5       | 1  | 6  | 9  | 32 |
| 6       | 3  | 6  | 1  | 20 |
| 7       | 9  | 10 | 4  | 46 |
| 8       | 3  | 7  | 8  | 36 |
| 9       | 2  | 2  | 4  | 16 |
| 10      | 3  | 7  | 8  | 36 |
| 11      | 2  | 2  | 4  | 16 |
| 12      | 5  | 5  | 5  | 30 |
| 13      | 3  | 6  | 4  | 26 |
| 14      | 3  | 3  | 8  | 28 |
| 15      | 2  | 1  | 4  | 14 |
| 16      | 2  | 4  | 5  | 22 |
| 17      | 2  | 4  | 7  | 26 |
| 18      | 3  | 2  | 3  | 16 |
| 19      | 3  | 2  | 4  | 18 |
| 20      | 3  | 5  | 8  | 32 |
| 21      | 3  | 9  | 5  | 34 |
| 22      | 3  | 5  | 3  | 22 |
| 23      | 1  | 2  | 3  | 12 |
| 24      | 2  | 4  | 4  | 20 |
| 25      | 2  | 6  | 6  | 28 |
| 26      | 1  | 6  | 4  | 22 |
| 27      | 3  | 5  | 4  | 24 |
| 28      | 4  | 5  | 4  | 26 |
| 29      | 2  | 3  | 7  | 24 |
| 30      | 2  | 4  | 3  | 18 |
| 31      | 2  | 3  | 6  | 22 |
| 32      | 3  | 5  | 4  | 24 |
Based on the Table 4 above, the students’ conception is a low understanding of the volcanology concept. It can be seen through Table 4 above that the higher score is just forty-six, whereas the lower score is twelve. So that the students’ understanding of volcanology concept need to trained. Table 5 gives the correlation among these sub materials.

Table 5. The correlation of students’ conception of volcanology concept for each sub material.

| Sub material | VC   | VE   | VM   |
|--------------|------|------|------|
| VC           | -    | 0.04 | 0.534* |
| VE           | 0.04 | -    | 0.388* |
| VM           | 0.534* | 0.388* | -    |

*p>0.05

Table 5 show that just sub material volcano concept and volcanic eruption have correlation with volcanic mitigation. In other hand, volcanic eruption sub material was not correlate with volcano concept. Based on research conducted by [9] in the Department of Physics, Surabaya State University, it is known that prospective physics teachers have a low understanding of volcanic material and there are several problems associated with the concept of volcanoes. Another fact is that learning geoscience does not support the formation of geoscience’ knowledge and skills, is dominated by theoretical studies and lacks focus on efforts to prepare students for disasters especially volcanic eruptions [9]. In another study conducted by [10] it was also found that teachers had difficulty in evaluating student achievement in disaster preparedness.

3.2. Decision-making skill
The making decision skill consists of five indicators, i.e. ability to identify problems, Information needed in making decisions, Alternative actions, Consideration in making decisions, and Decision-making. Using the open instrument test, it obtained a result based on the rubric assessment (Table 3) for each participant given by Table 6.

Table 6. The students’ score of decision-making skill.

| Student | Indicators | Final score |
|---------|------------|-------------|
| 1       | 1 2 3 4 5  | 40          |
| 2       | 3 1 2 1 2  | 45          |
| 3       | 3 1 1 1 3  | 40          |
| 4       | 3 1 2 0 2  | 40          |
| 5       | 2 1 1 1 1  | 30          |
| 6       | 1 0 2 2 1  | 30          |
| 7       | 2 0 1 2 2  | 35          |
| 8       | 3 1 1 1 1  | 35          |
| 9       | 3 1 2 2 4  | 60          |
| 10      | 2 0 1 1 1  | 25          |
| 11      | 2 1 1 1 3  | 40          |
| 12      | 1 0 2 1 2  | 30          |
| 13      | 2 0 1 1 1  | 25          |
| 14      | 1 0 1 1 2  | 25          |
| 15      | 1 1 2 1 3  | 40          |
| 16      | 2 0 1 1 2  | 30          |
| 17      | 3 1 2 2 2  | 40          |
| 18      | 2 0 1 2 3  | 40          |
Based on the Table 6 above, it is known that the most students got a poor score (less than 50). It can be known that the students’ making decision skills need to trained. If viewed from each indicator, it is known that the skills of indicator 1 are better than the other indicators.

Figure 1 above give information that the students’ skills on each indicator are different. The higher score is on the indicator 1 (54% only). But their decision making is good enough with a little score for indicator 2, 3, and 4. It can be known that they are less able to determine alternative actions on the issue and consider it to make the right decision. Meanwhile, to determining the alternative actions is important because one action is not necessarily the best decision. Table 7 gives the correlation among the decision-making indicators.

Table 7. The correlation of students’ decision-making skill for each indicator.

| Decision-making indicator | (1) | (2) | (3) | (4) | (5) |
|---------------------------|-----|-----|-----|-----|-----|
| (1)                       | -   |     |     |     |     |
| (2)                       | 0.226 | - |     |     |     |
| (3)                       | 0.532 | 0.849 | - |     |     |
| (4)                       | 0.583 | 0.985 | 0.076 | - |     |
| (5)                       | 0.934 | 0.893 | 0.237 | 0.409 | - |
Table 7 shows that all of decision-making indicators are correlated each other. So that, every indicator is dependent each other. Furthermore, also can be determined the relationship between the students’ volcanology concept [VC] and decision-making skill [DM] (Table 8).

Table 8. The relationship between the students’ volcanology concept and decision-making skill.

|      | VC  | DM  |
|------|-----|-----|
| VC   | -   | 0.686 |
| DM   | 0.686 | -   |

*p>0.05

Based on Table 8, the relationships between the students’ volcanology concept and decision-making skill presented the same results. There was relationship between the students’ volcanology concept and their decision-making skill. The students who have good understanding of volcanology concept, their decision-making skill are necessarily good either.

Based analysis above, we know that the students’ volcanology concept as well as their decision-making skill is low. Then, these variables have relationship each other. So that, we need to evaluate the geoscience learning to increase the students’ volcanology concept and decision-making skill.

One way to solve this case is reconstructing the sustainable learning. The integration model of sustainability perspective in learning spermatophyte based on local wisdom is considered proven to be effective in raising sustainability’s awareness of high school students [17]. Therefore, it should be applied for geoscience learning so the students will have good sustainability’s awareness for geoscience issues.

4. Conclusion

Based on the research results, it can be concluded that the students have a poor understanding of volcanology concepts. In parallel with this, their skills in education of sustainable development (ESD) competencies are also low. It can be known through the most them got making decision skills score less than or equal to fifty percent (≤50 %), that is their decision-making skill need to be trained. So that, their education of sustainable development (ESD) skills are still low. The developed geosciences learning curriculum based on education of sustainable development for the physics students needs to be developed. The aims are to train the physics students' understanding of volcanology concepts and their decision-making skill.

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