Jurnal Ilmu Pendidikan (JIP)
Vol. 27, Issue 1, June 2021, pp. 1-7
ISSN: 0215-9643 e-ISSN: 2442-8655

Students' Science Process Skill in Volcanoes Eruption Disaster Preparedness and Mitigation

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ARTICLE INFO

Article history
Received 04, 19, 2021
Revised 8, 10, 2021
Accepted 10, 22, 2021

Keywords
Science process skill
Volcanoes eruption
Disaster preparedness
Mitigation

ABSTRACT

Students' Science Process Skill in Volcanoes Eruption Disaster Preparedness and Mitigation. This study aims to determine the mastery of science process skills of students who are trained in integrated disaster risk reduction learning. This research is experimental research with one sample control group design. The sample in this study were 60 7th grade students from State Junior High School 2 Cangkringan, Yogyakarta, Indonesia. This school is in the Merapi Mountain area. The science process skills data were obtained using a process skills observation sheet filled in by the observer. Meanwhile, the data analysis was performed descriptively. The results show that the students' scientific process skills profile increases in every meeting after they have been trained with the volcanic eruption disaster mitigation course. The most significant improvement is identified in the skills of observing, followed by predicting, communicating, and drawing conclusions skills.

I. Introduction

One of the national education goals is facilitating students to develop experience through experiments in formulating problems; proposing and testing hypotheses; designing and assembling instruments; collecting, processing, and interpreting data, and communicating verbally and in writing. These skills belong to science process skills. The purpose of science education is to train individuals to be adaptive to different conditions, creative, think critically, and capable of solving problems by considering scientific perspectives (Aktamış & Yenice, 2010). Wijaya et al., (2019) also revealed that related to skills, Team Games Tournament-based learning was proven to be able to increase student competency achievement and become a creative, innovative, and interesting method.

Chiapetta & Koballa (2010) divide science process skills into basic process skills and integrated process skills. Basic process skills represent simple skills, while integrated process skills are more complex skills. Turiman et al., (2012) mention the elements of basic science process skills, including observing, classifying, measuring, and using numbers, making conclusions, predicting, communicating, and using space and time relationships. Additionally, integrated science process skills consist of data interpretation, operational definitions, control variables, hypotheses creation, and experiments. The division of basic and integrated science process skills' aspects from several experts is presented in Table 1.

Table 1. The Classification Category of Science Process Skills

	(Abruscato, 2010)	**(Collette & Chiappetta, 2010)**	**(Martin, 2012)**
Basic – Science Process Skills	Observing Classifying Predicting Using Numbers Measuring Drawing Conclusion Using Space and Time Relationships Communicating	Observing Classifying Predicting Using Numbers Measuring Drawing Conclusion Using Space and Time Relationships	Observing Classifying Predicting Using Numbers Measuring Communicating Asking
Integrated – Science Process Skills	Interpreting Data Controlling Variables Making a Hypothesis	Interpreting Data Controlling Variables Making a Hypothesis	Interpreting Data Controlling Variables Making a Hypothesis

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	(Abruscato, 2010)	**(Collette & Chiappetta, 2010)**	**(Martin, 2012)**
	Defining Operationally	Defining Operationally	Defining Operationally
	Conducting Experiments	Conducting Experiments	Conducting Experiments
		Formulating the Model	Formulating the Model
			Drawing Conclusion

Science process skills encourage students to find concepts and also boost students to think critically so that they master the science content and process skills simultaneously, to be able to apply them in everyday life (Jeenthong et al., 2014). Through science process skills, students use their minds to apply various concepts or principles. In the discovery process, students perform various activities such as observing, measuring, predicting, analyzing, and concluding so that they can form basic concepts (prior knowledge) in their minds (Ratnasari et al., 2017).

Science process skills are defined as cognitive processes classified into concrete steps used as thinking guides (Mundilarto, 2015). Learning that is integrated with daily life facilitates students to make observations and classifications easily. Besides combining the atmosphere of everyday life, learners can access a meaningful learning atmosphere. Meaningfulness reflects the opportunity for students to learn the current contextual ideas. In addition, integrated learning is very effective to be carried out, viewed from several aspects of natural science skills, such as process skills, general skills, critical thinking skills, and scientific attitude to science. Thus, students can be conveniently trained to improve their science process skills (Wilujeng & Suryadarma, 2017).

Practically, science process skills cannot be separated from conceptual understanding involved in learning and science application (Faqih, 2017). Learning that emphasizes real experiences through things closely related to daily life grows students' enthusiasm in participating in teaching and learning activities, as well as to improve their science process skills (Rahardini et al., 2017). One of the natural scientific phenomena closely related to students' daily life is natural disasters. As an area located at the confluence of the world's three lithosphere plates, Indonesia has 17% of all volcanoes in the world, with 129 active volcanoes (Verstappen, 2010). Consequently, Indonesia has a very high volcanic eruption potential. One effort to reduce the possible negative impact of volcanic eruption is implementing integrated disaster risk reduction courses at the elementary or secondary school level. The subject that accommodates that course is the natural sciences. In its implementation, science learning is integrated with volcanic eruption disaster and its mitigation material. It reflects various science process skills, both primary and integrated.

However, only some aspects of science process skills were measured because only those elements can be unified with disaster mitigation training. The selected elements of the science process skills were combined with the aspects of volcanic eruption disaster mitigation. Sopaheluwakan, (2006) defines that individual and household preparedness in anticipating natural disasters consists of knowledge and attitudes towards disaster risk, early warning systems, plans for disaster emergencies, and resource mobilization. Based on these aspects, four elements of science process skills were integrated with volcanic eruption disaster mitigation. The relationship between aspects of process skills and volcanic eruption disaster mitigation is shown in Table 2.

Table 2. Relationship Between Science Process Skill and Disaster Mitigation Aspects

Science Process Skills Aspects	**Disaster Mitigation Aspects**
Observing	Knowledge and Attitudes Toward Disaster Risk
Predicting	Early Warning System
Drawing Conclusion	Plan for Disaster Emergency
Communicating	Resource Mobilization

This study aims to determine the science process skills profile of students who have been undergone volcano eruption disaster mitigation training. The findings from this research are expected to bring inputs for education to reduce disaster risk through learning so that teachers and learning practitioners can continue to improve disaster mitigation training through various aspects of science skills.

II. Method

This research was experimental research with one sample control group design. The study facilitated a large group to attain the same learning treatment intending to know the developments at each meeting. The research sample consisted of 60 7th grade students at State Junior High School 2 Cangkringan, Yogyakarta, Indonesia. The school was chosen because located close to one of the active volcanoes in Indonesia, namely Mount Merapi.

The science process skills data were obtained through an observation using science process skills observation sheet instruments. The process skills observation sheet was filled in during the three meetings of the teaching and learning process. The material at each session focused on the integration of science learning with efforts to reduce the risk of volcanic eruption disaster. Students were asked to recognize the structure of the earth, plate shifts, the theory of volcanic formation, and the characteristics of volcanoes. Besides, they were asked to recognize the signs and stages of volcanic eruption, identify disaster risk reduction efforts, and the actions to save them-selves whenever a volcanic eruption occurs.

The evaluation using the observation sheet was carried out by the observer. The process skills observation sheets adopted a nominal scale of yes and no. The observation sheet of students' process skills consisted of four aspects, namely observing, predicting, drawing conclusions, and communicating. Indicators for each aspect were developed into several behavioral items. The observation sheets for each meeting were designed differently. They were adapted to the characteristics and ongoing learning activities. The indicators of each aspect of science process skills are described in Table 3.

Table 3. Science Process Skill Indicators

No	Aspects	Indicators
1	Observing	Use some or all of the senses to gather information from objects
2	Predicting	Express what would have been possible Use patterns or relationships to make predictions
3	Drawing Conclusion	Make conclusions based on observational data and be associated with theory
4	Communicating	Conveying observations systematically Report systematic observations

In addition, the data analysis was per-formed to determine the students' average mastery of each indicator of science process skills, both primary and integrated science process skills. The observation sheet of science process skills was assessed by the observer during the teaching and learning activities, referring to the assessment on the rubric provided by the researcher. They filled the observation sheets by giving a checklist (√) to the proper score. The results on each aspect were analyzed using the average formula below.

$$\bar{x} = \frac{\Sigma n}{\Sigma f} \times 100 \qquad (1)$$

$\bar{x}$: Average score in every aspect

Σn : Total score obtained

Σf : Number of students respondents

III. Results and Discussion

This study measures four aspects of science process skills taught in three learning meetings. The chosen aspects are observing, predicting, drawing conclusions, and communicating. The instrument used was a science process skill observation sheet consisting of 11 observation aspects. The data analysis results are presented in Table 4.

Table 4. Assessments of Science Process Skill Results.

No	Science Process Skill Aspects	Meeting Observation Result		
		1	*2*	*3*
1	Observing Skills	41,07	55,36	83,04
2	Predicting Skills	40,48	47,62	66,67
3	Drawing Conclusion Skills	23,21	32,14	35,71
4	Communicating Skills	17,86	44,64	46,43

The data in Table 4 shows improvements on each aspect of process skills at each meeting. The element with the most significant improvement is observation skills. It indicates that students have started to learn and exercise integrated science process skills in volcano risk reduction efforts. Selby & Kagawa, (2012) mention several learning models appropriate for teaching disaster risk reduction efforts in schools, including interactive learning, affective learning, inquiry learning, surrogate experiential learning, and experiential learning. The learning model used in this study was discovery learning, which is part of inquiry learning.

The aspects of science process skills measured in this study are observing, predicting, drawing conclusions, and communicating. These aspects were selected because they have similarities with science, which cannot be realized without a process. The scientific process in science has been carried out through several stages of experimentation, consisting of observation, formulation of problems, formulation of hypotheses, testing hypotheses, making conclusions, and communicating (Kementrian Pendidikan dan Kebudayaan, 2013).

Bati et al., (2010) define science process skills as internalized skills through teaching and learning activities, such as simulation and experimental activities. The simulations and experiments aim to find new knowledge. This is in line with the objectives of discovery learning models that aim to find new learning concepts so that the students obtain more imprinted knowledge (Flick & Lederman, 2004). Listyawati, (2012) argues that science is related to knowledge in the form of concepts, facts, or principles, as well as a process of discovery. Therefore, process skills must be trained in learning. Science

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process skills are beneficial for students in realizing student participation in learning activities.

A. Observation Skills

Martin., (2012) states that students who have observational skills must meet four indicators, namely can use one or more senses to gather information about objects or events, feel the differences and similarities between objects, match observational things with descriptions, and identify characteristics of the object. This study used the discovery learning model. Observing skills are facilitated by the teacher by asking questions, suggesting reading books, showing video shows, and other learning activities that lead to problems. Additionally, students are also given the opportunity to identify as many problems as possible related to learning material can be seen in Fig. 1.

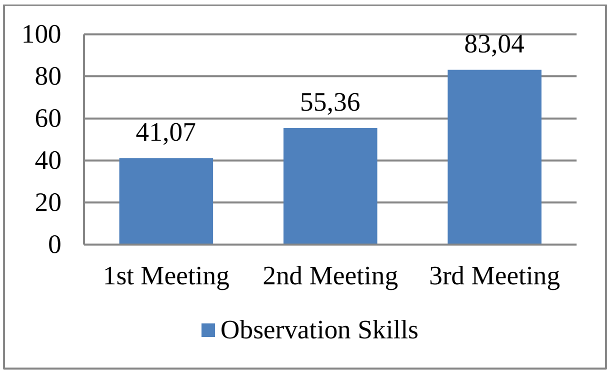

Fig. 1. Graph of Observation Skills Assessment Results

Based on Fig. 1, there is an increase in students' observing skills at each meeting. Students are given problems that have been engineered by the teacher so that they do not need to exert all their thoughts and abilities to get findings in the issues presented (Widiadnyana et al., 2014). In addition, teachers present problems related to volcanic eruptions that are close to students' daily lives to ease students from carrying out observations. Thus, it can be a supporting factor to increase students' observing skills.

Observation activities in this learning are facilitated by various stimuli. Students may still need adaptation at the first meeting because they are not accustomed to learning with student-cantered learning models. Concerning efforts to reduce disaster risk, students are trained to observe the animation related to the material for each meeting. Then, students are asked to ask questions and identify problems because the discovery learning model requires students to find their own learning concepts. Consequently, they must have the skills to observe the teacher's explanation to verify the results of their work because the teacher only acts as a learning facilitator. In addition, observing skills are also trained by letting them identify the earth's structure, volcanic characteristics, eruption stages, and efforts to reduce disaster risk.

In relation to knowledge and attitudes towards disaster risk, observation skills are required. Knowledge is a significant factor and the key to preparedness. Accelerated knowledge on hazardous risks leads to better understanding, improved management, with the ultimate goal to reduce the disaster risk (Spiekermann et al., 2015). Additionally, the possessed knowledge possessed influences the attitudes and concerns of the community to be ready and alert in anticipating disasters, especially for those who live in disaster-prone areas (Shreve & Kelman, 2014). By having observing skills, students know how to act during a disaster, have knowledge about disaster management, and attitudes towards disaster risk. This is undoubtedly very beneficial for disaster risk reduction efforts.

B. Prediction Skills

Martin, (2012); Padilla, (1990) stated three indicators for students with predictive skills. Students with predictive skills can use facts to formulate the following process and stages, use patterns or relationships to calculate cases, and predict events based on previous observations or experiences. The development of students' prediction skills is facilitated by teachers in constructing hypotheses. Based on Fig. 2, a significant increase has been observed in each meeting. Research conducted by Elvanisi et al., (2018) shows that the predicting skill is found to attain the highest score. This highest score is obtained because students are trained to find knowledge independently (Ayadiya & Sumarni, 2015).

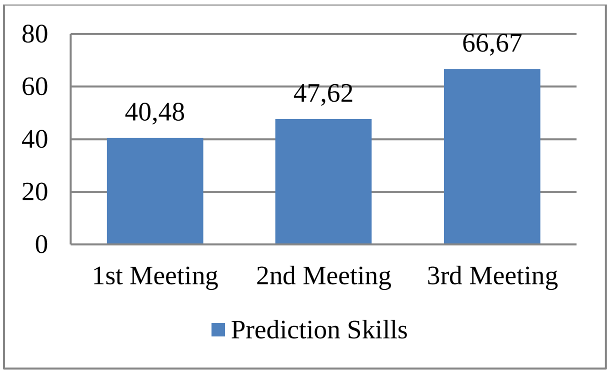

Fig. 2. Results of Prediction Skills Assessment

Science process skills in predicting aspects can be trained with discussion learning methods and practicum. In line with this, Siska et al., (2013) argue that high predicting skills appear because students are trained to discover concepts and principles through experimental or practicum activities. Elfeky et al., (2019) also found high predictive aspects besides identifying, controlling variables, experimenting, and interpreting data.

Naturally, the predictive skill score is low in the first meeting because students are rarely or even never invited to do practical activities. After conducting teaching and learning activities, students' predictive skills at the second and third meetings experienced a significant increase. Predicting skills in learning activities is improved by assisting students' activity sheets. After obtaining preliminary information on previous observing activities, students are ready to construct a hypothesis. Armed with the obtained data and information, students can solve questions relating to the volcanoes, the stages, and signs of eruption, also carry out practicum and simulation as an effort to reduce the risk of the volcanic eruption.

Predicting skills are needed to predict signs and symptoms of volcanic eruptions. In addition, it predicts a series of notifications about the appearance of natural phenomena and their relation to the early warning system (Sangkala & Gerdtz, 2018). By having good knowledge in predicting symptoms of volcanic eruptions, students can take steps to avoid or reduce risks and prepare themselves to make an effective emergency response (Gall et al., 2015).

C. *Drawing Conclusion Skills*

Martin, (2012); McCormack, (1992) explain four indicators of students with proper drawing conclusions. Those indicators consist of making conclusions based on observational data, inferring known facts, concepts, and principles, concluding empirical data on the results of experiments or observations with graphs, tables, or diagrams, and linking the results of experiments or experiments activities with existing theories. In this study, the skills to draw conclusions are trained when students conduct a careful examination to prove whether the hypothesis has been verified or not, following the results of data processing that has been done. A thorough inspection is carried out on the results of their work from beginning to end. Besides, they are trained to draw conclusions in various forms, namely tables, sentences, presented in Fig. 3.

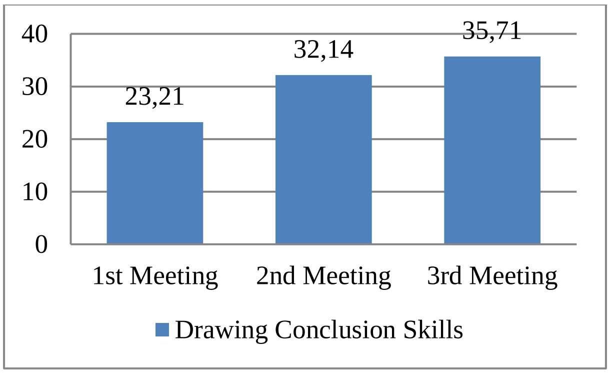

Fig. 3. Results of Drawing Conclusion Skills Assessment

Based on Fig. 3, students' ability to draw conclusions has been accelerated in each meeting. However, compared with the other three aspects, the aspect of drawing conclusions attains the lowest score. Lati et al., (2012) also discovers that the ability to draw conclusions gets the lowest scores between many aspects of science process skills. It may be influenced by students' lack of attention. Drawing conclusions is carried out at the end of the learning period when the students are not focused and want to end the lesson immediately. In addition, students consider that they only need to understand the concepts taught previously. They do not see the essence of drawing conclusions by processing data from the concept map into a conclusion that answers the learning objectives. Thus, students need to be habituated so that they are familiar with writing learning conclusions at each meeting, which also supports the achievement of discovery-based learning goals.

Conclusion drawing skills are required to prepare plans for disaster emergencies. Plans for disaster emergencies represent the activities carried out immediately as the response to a disaster to minimize the adverse effects caused by the disaster (Sadeka et al., 2020). Planning for a disaster emergency is based on a disaster risk analysis and mitigation efforts. The plan includes the introduction and assessment of hazards, recognition of vulnerability, analysis of the likelihood of disaster impacts, choice of disaster management measures, disaster impact management mechanisms, and the division of tasks and roles of agencies (Said & Chiang, 2020). By having a good plan, students will be able to have a family rescue plan (a division of tasks) if an emergency occurs. An evacuation plan includes the availability of a map, a place for family evacuation routes, and a place for families to gather during a disaster. Besides, it also involves finding a relative, family, or friends who provide temporary displacement place in an emergency, first aid, rescue, safety and security, fulfillment of basic needs, equipment and supplies, essential facilities that have access to disasters, and training and simulation or rehearsal.

D. *Communication Skills*

Martin, (2012) mentions four indicators of communication skills mastery. Those indicators include conveying the results of observations systematically, changing information in other forms, such as graphs, tables, and diagrams, reading the information provided in the form of graphs and tables, while also deciding the best steps of the information that displays type. Good communication skills represent students' ability to convey something coherently, both orally and in writing (Elvanisi et al., 2018). Verbal communication skills also involve students' speaking abilities in choosing and using sentences. The communication skills in writing are the ability to transfer and present knowledge consistently, both in the paper, pictures, and data in the form of tables or graphs. In this research, communication skills are trained by writing down information obtained from direct observations and interviews.

Fig. 3 shows that at the first meeting, the students' communicating skills score is deficient. In the second and third meetings, the increase is not significant, although the figure was still higher than the skill of concluding. The low improvement in students' communication skills may be caused by students' difficulty in understanding abstract and complicated concepts if they are not accompanied by concrete examples during the learning process (Rahmazani et al., 2017). Communication skills are closely connected with practical or simulation activities. To reduce disaster risk, this can be applied in the mobilization of resources. The indicator of the success of resource mobilization is assessed from the community's collective action and the role of several groups to mobilize other groups (Rañeses et al., 2018). With good knowledge and skills, students will have skills related to disaster preparedness.

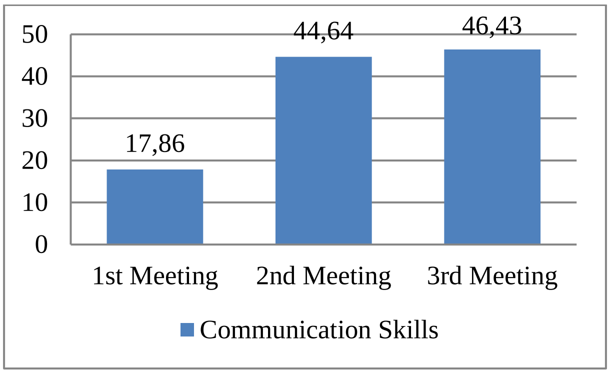

Fig. 4. Results of Communication Skills Assessment

IV. Conclusion

This research indicates that the integration of science learning in junior high school with disaster risk reduction efforts improves the students' science process skills. The most significant improvement of science process skills aspects has been observed in observing abilities, followed by predicting, communicating, and drawing conclusions skills. The efforts of disaster risk reduction in early educational institutions can facilitate the development of generation with excellent disaster mitigation. The measure requires integration to a subject. One of the subjects that can be used is science learning in junior high school. Science learning cannot be separated from science process skills. Thus, the integration of aspects of science process skills with disaster preparedness elements is valuable. It is supported with this research results, showing the increase of four aspects in science process skills in line with the training and implementation of learning-based disaster risk reduction efforts.

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