Science Subject Specific Pedagogy to Support Disaster Risk Reduction in Education: Its Feasibility and Influence

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Abstract

As a country with a high level of vulnerability to volcanic disasters, Indonesia must have good preparedness in dealing with these disasters. One of the efforts to improve preparedness is through learning in schools so that the community has been introduced to disaster mitigation from an early age. This study aims to (1) produce a science subject-specific pedagogy that is integrated with volcanic eruption disasters and (2) find out the effectiveness of the use of integrated science subject-specific pedagogy of volcanic eruption disasters to students' disaster concept mastery and preparedness in disaster mitigation. This research is R&D research with a 4-D model consisting of define, design, develop, and disseminate. The subject of this study was 7th-grade students whose school is located in a disaster-prone area for the eruption of Mount Merapi, Yogyakarta. Data were obtained from tests and non-tests, including concept mastery tests, preparedness tests, questionnaires, and performance observations. The data were analyzed descriptively using MANOVA's gain score and inferential statistics using the SPSS 22.0 program. The results of this study show that (1) the science subject-specific pedagogy product developed is included in the very good category based on validation results from expert and learning practitioners, and (2) science subject-specific pedagogy is effective for improving students' disaster concept mastery and student preparedness in facing disasters. Overall, this science subject-specific pedagogy product is feasible for science learning and has been proven to improve students' preparedness and mastery of concepts regarding volcanic eruption disasters.
Keywords: Disaster Risk Reduction; Science; Subject Specific Pedagogy

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INTRODUCTION

Indonesia is the country with the highest natural disaster risk factor in the world (Haerudin et al., 2019; Verstappen, 2010, 2013). From January to March 2023, volcanic eruption has occurred twice (Badan Nasional Penanggulangan Bencana, 2023). One of the most active volcanoes in Indonesia is Mount Merapi which is located in Sleman Regency, Yogyakarta, with four vulnerable areas, namely in Cangkringan, Pakem, Turi, and Ngemplak Districts (Badan Nasional Penanggulangan Bencana, 2011).

The disaster-prone area on Mount Merapi is a densely populated settlement. This adds to the high susceptibility factor to the eruption of Mount Merapi. The high-risk factor should be directly proportional to the level of community preparedness. However, in reality, not all people living in disaster-prone areas understand what to do when there is an increase in the status of Mount Merapi. This is shown by people who continue to carry out activities as usual, for example, looking for grass on the slopes of Mount Merapi, mining sand, and continuing to do activities around disaster-prone areas. As the world's fifth largest population country, the Indonesian people's knowledge and attitudes do not reflect a society that is aware and resilient in the face of disasters (Hidayati, 2012; Kenny, 2012). In Indonesia, the role of education in efforts to recognize disaster risk, preparedness, and mitigation is still very low, it is also natural that the community has low knowledge and attention to disaster management (Dwiningrum et al., 2017; Hidayati, 2012). Knowledge about disaster management must be given to all elements of society, including children. The most effective insertion of knowledge about disaster management for children is through the integration of the disaster curriculum into the school curriculum, especially for schools located in disaster-prone areas (Suarmika & Utama, 2017). By integrating diversity into the curriculum in schools, children will consciously have preparedness, care, and sensitivity to their environment (Medina, 2015; Selby & Kagawa, 2012).

Natural Sciences is a collection of knowledge about natural phenomena that are arranged systematically. Science objects include the universe and its contents. Natural science is a branch of knowledge that studies natural phenomena and phenomena that occur in daily life (Lund & Cyvin, 2022; Sangsa-ard & Thathong, 2014). One example of a natural phenomenon in science is volcanic eruption (Dwianto et al., 2017; McNutt et al., 2000). Science learning at the secondary education level should be presented holistically, but it is still taught separately from each other (Tillery et al., 2013; Trefil & Hazen, 2016). The availability of integrated teaching materials is needed to support integrated science learning activities in junior high schools (Hewitt et al., 2007; Trefil & Hazen, 2016). Integrated sciences' teaching material and subject-specific pedagogy have not been developed based on related materials following integrated basic competencies (Hekmah et al., 2019; Wilujeng, 2017). Integrated science teaching materials are needed so that science learning can take place in an integrated manner. The reality that occurs in the field is very far from the understanding of integrated science (Jeenthong et al., 2014). Science teachers teach all physics, chemistry, and biology subjects without connecting the three as a form of cohesiveness (Dewi et al., 2017).

To support integrated science learning, science subject-specific pedagogy is needed, a learning tool that can facilitate the implementation of integrated science learning, no longer being disaggregated between physics, chemistry, and biology, which one of the

sciences' field studies is earth structure and volcanoes (Dwianto et al., 2017; Riezqia et al., 2017). Thus, students can comprehensively understand science. As a follow-up, various learning needs to be developed to facilitate the integration of disaster learning at the school level, bearing in mind that schools are formal educational institutions in the community. It is intended to give students an understanding of the natural phenomena of volcanoes and an attitude of being alert in implementing disaster mitigation. Research conducted by Adiyoso & Kanegae (2013) shows that the effect of schools adopting curriculum-based disaster issues on school children related to disaster risk reduction is effective in increasing disaster knowledge and improving risk perception and preparedness. While, Arianda (2018) and Nikmah & Binadja (2015), in their research about the Discovery Learning model, show that the model effectively improves learners' affective, cognitive, and psychomotor aspects. This research seeks to combine these two things. The novelty of this research is integrating the discovery learning model and the disaster preparedness approach.

Based on the description above, the development of science subject-specific pedagogy that can facilitate the implementation of learning that integrates disaster education is deemed necessary. This research develops science subject-specific pedagogy using an integrated discovery learning model for volcanic eruption disasters. The discovery learning model was chosen because it has a learning syntax that is believed to support the achievement of student preparedness competencies, namely stimulation, problem statements, data collection, data procession, verification, and generalization. With the development of these devices, it is hoped

that it can improve the understanding of concepts, and the preparedness of students, especially in the implementation of disaster mitigation.

METHOD

This research was a research and development with the 4-D model with four stages: define, design, develop, and disseminate (Thiagarajan et al., 1974). The science subject-specific pedagogy consists of a syllabus, lesson plan, students' worksheet, and handout. The feasibility of the developed science subject-specific pedagogy is assessed based on the results of the assessment of learning experts and learning practitioners using the product feasibility assessment sheet. The flowchart of this research is shown in Figure 1.

The average assessment score from the learning expert is then classified by category level according to Widoyoko, as in Table 1.

Table 1 Product Rating Category Classification (Widoyoko, 2017)

No	Average Interval Score	Category
1	$3.25 < x \leq 4.00$	*Very good*
2	$2.50 < x \leq 3.25$	*Good*
3	$1.75 < x \leq 2.50$	*Low*
4	$1.00 < x \leq 1.75$	*Very low*

After an expert assesses the developed product, the learning device product is implemented in learning to determine the effectiveness of using the product to increase mastery of concepts and student preparedness. The implementation was carried out in two pilot classes, where one class used the Science Subject Specific Pedagogy developed while the other class used the Science Subject Specific Pedagogy in the school, then the measurement of mastery of concepts and preparedness before and after learning used questionnaires in Table 2.

Table 2 Field testing design

Group	Pre-test	Treatment	Post-test
Experiment	$O_{1.1}$	X_a	$O_{2.1}$
Control	$O_{1.2}$	X_b	$O_{2.2}$

$O_{1.1}$: Experiment before treatment
$O_{1.2}$: Control before treatment

X_a : Learning with developed SSP

X_b : Learning with schools' SSP
$O_{2.1}$: Experiment after treatment
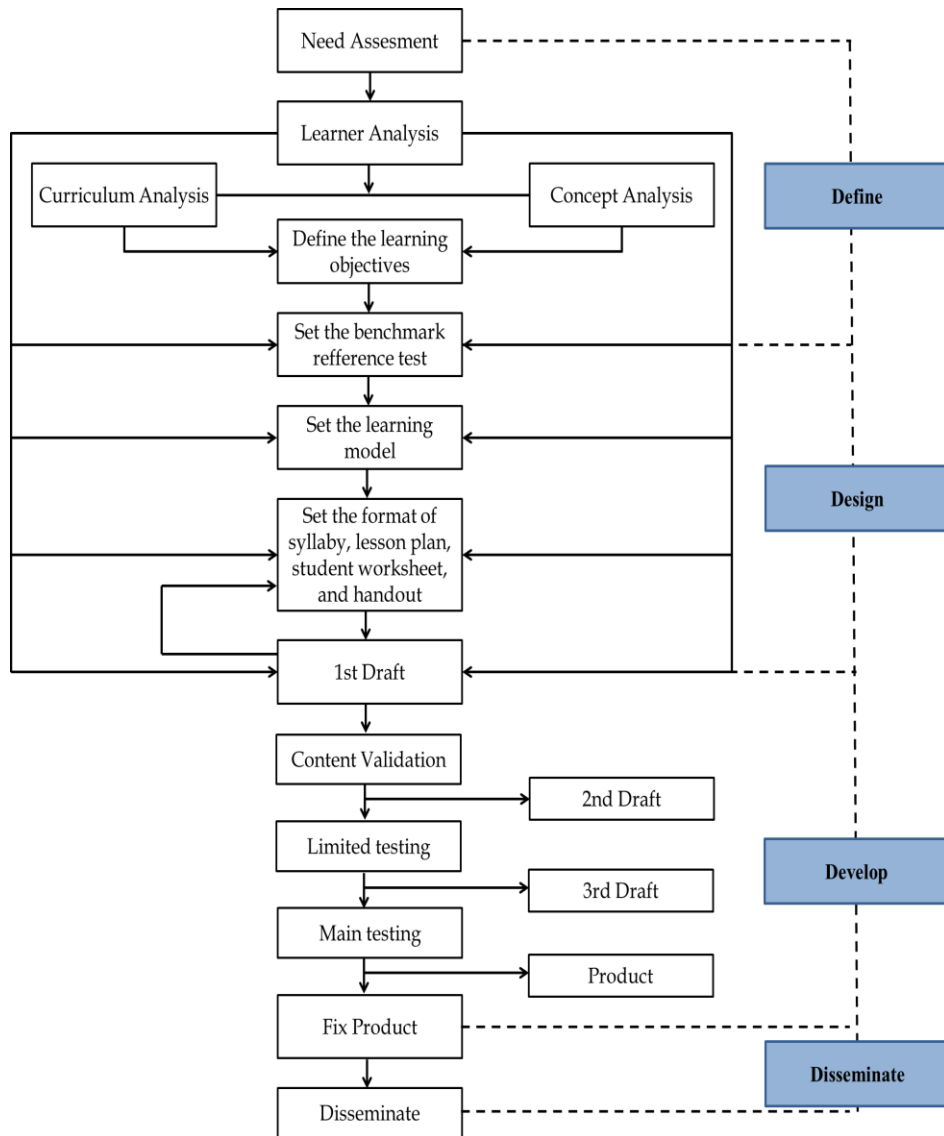$O_{2.2}$: Control after treatment

Figure 1 Development of science subject-specific pedagogy with 4-D models

The data obtained is then processed using descriptive statistics to determine the gain score increase. The gain score categories were obtained according to Hake (2002), as in Table 3.

Table 3 Gain score category

No	Gain Score	Category
1	$\langle g \rangle \leq 0{,}3$	Low
2	$0{,}3 < \langle g \rangle \leq 0{,}7$	Moderate
3	$\langle g \rangle > 0{,}7$	High

After obtaining an increase in gain score data, an inferential statistical analysis was carried out using Multivariate ANOVA (MANOVA) test using the SPSS 22.0 program to determine the effect of developed science subject-specific pedagogy on students' concept mastery and disaster preparedness.

RESULT AND DISCUSSION
Product Feasibility
Two learning experts and three learning practitioners assessed the feasibility of the syllabus, lesson plans, students' worksheets, and handouts. The results of the product feasibility assessment by learning experts and learning practitioners are in Figure 2.
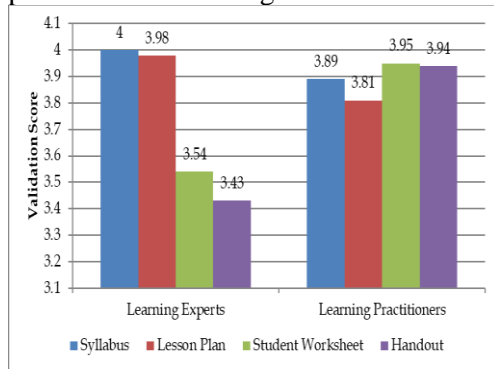

Figure 2 Product feasibility assessment chart

Based on Figure 2, it is concluded that the products developed obtain a feasibility assessment from learning experts and practitioners with very good categories and are suitable to use in the learning process.

Product Influence on Students' Mastery Concept
Thirty-five numbers of multiple-choice pre and posttest is used to measure the students' concept mastery. The results obtained are then analyzed descriptively using Microsoft Excel, which is then categorized according to the gain score increase category. The pre and post-assessment results of students' concept mastery from the experimental and control classes are in Figure 3.
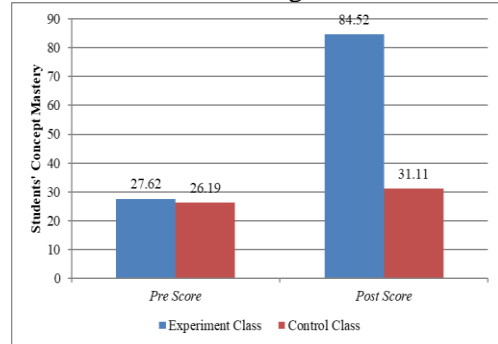

Figure 3 Assessment of students' mastery concepts

Based on the result in Figure 3, it can be concluded that students in the experimental class have higher concept mastery than the control class. The increase in pre and post-test scores in the experimental class is also much more significant. The activities carried out by students in the experimental class are discussions, practicum, and simulations whose focus is student-centered.

Learning that supports the stimulation and formation of intellectual abilities is proven to increase students' concept mastery. Implementing specific teaching materials can help increase students' mastery of concepts (Maulidar et al., 2016; Syar, 2017; Widiadnyana et al., 2014). In line with Indriasari (2016) mentions that the provision of earthquake disaster preparedness simulation methods positively influences students' disaster preparedness. The experimental class that used handouts with disaster mitigation load experienced a very significant increase in scores than the control class that did not use developed handouts. This shows the handout to be one product that improves students' mastery of concepts.

Discovery-based science learning is very demanding of student activity, so it can indirectly train improved three main

learning competencies, such as affective, cognitive, and psychomotor. Discovery's learning syntax supports students to be more active in learning activities, so it can hone students' ability to explore and discover their knowledge (Belton, 2016; Limbong et al., 2019).

The learning activity such as discussions, practicum, and presentations also can encourage students' ability to understand the concept. Besides that, it can support the students' centered learning (Kumullah et al., 2018). Students that are given more freedom to solve their problems, and to find their knowledge by themselves, are proven to increase their concept mastery because the concept is built by their understanding, of course, with the assistance and direction of the teacher. The teacher only acts as a facilitator who provides feedback and input on concepts that students themselves have discovered. Besides that, the existence of a phenomenon inherent in daily life, students can stimulate the development of their thinking skills in problem-solving so that students will get a deeper understanding (Marlina et al., 2017).

Product Influence on Students' Disaster Preparedness

Preparedness is measured using questions and questionnaires given before and after learning and preparedness observation sheets on implementing unplanned simulations as supporting data. The results obtained are then weighted to obtain the final score and then analyzed descriptively using Microsoft Excel, which is then categorized according to the category of gain increase. The pre and post-test results from the experimental and control classes are in Figure 4.
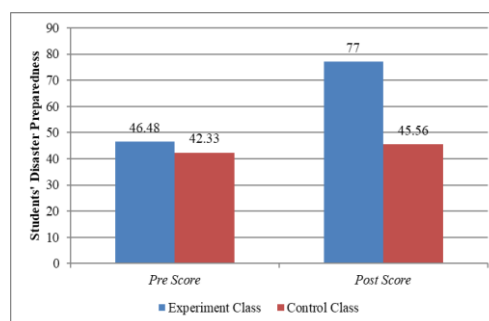

Figure 4 Assessment of students' preparedness

Based on the result of the gain score analysis supported by Figure 4, it can be concluded that students' disaster preparedness in the experiment class with the developed subject-specific pedagogy is higher than in the control class. The pre and post score also significantly increased. The aspect of disaster preparedness measured are knowledge and attitudes toward disaster risk, early warning systems, plans for disaster emergencies, and resource mobilization.

Schools are one of the communities that are vulnerable to disasters; therefore, efforts to improve community-based disaster management programs need to be done in schools, one of which is with the participation of students in carrying out disaster risk reduction activities that are integrated into teaching and learning activities in schools (Astuti & Yuliyanto, 2015; Sangkala & Gerdtz, 2018). Science is a very appropriate subject considering that disaster is a natural phenomenon that can cause damage and endanger life (Almukarramah et al., 2013; Said & Chiang, 2020).

Students from one of the junior high schools in Cangkringan derived from Merapi eruption disaster-prone areas also indirectly have provisions and resilience in the face of volcanic eruption disasters. The still-thick nuances of local wisdom

and the customs of the people on the slopes of Mount Merapi evidence this. The flow of modernization does not erode citizens, and they continue to heed the local wisdom they trust. However, local wisdom is not directly taught by parents to their children, so it is possible that this attitude naturally arises from the environment in the area (Tyas et al., 2021; Widodo & Hastuti, 2019). The use of specific learning tools integrated with disaster education can direct students directly to the attitude of preparedness that must be possessed.

Product Effectivity to Student's Mastery Concept and Disaster Preparedness

The multivariate test aims to determine whether there is a significant difference between the gain score of process skills, mastery of concepts, and preparedness in both the experimental and control classes. Levene's value for each variable is 0,981 for concept mastery and 0,419 for disaster preparedness. It states that the data is ready to analyze with multivariate tests. Multivariate test results are shown in Table 4.

Table 4 Multivariate test analysis result

Effect		Value
Science Subject Specific Pedagogy	Pillai's Trace	0,923
	Wilks' Lambda	0,077
	Hotelling Trace	12,055
	Roys' Largest Root	12,055

Based on the result in Table 4, it can be concluded that the influence of the independent variable on the dependent variable is getting greater. The significance values for the four analyzes are 0,000. The significance level is set at 0.05 if the significance value is smaller than 0.05, so the hypotheses in this study are accepted, which means that there are significant differences in the concept mastery and preparedness in disaster mitigation between students that use

developed science subject-specific pedagogy with students participating in learning without using the product developed.

Students' preparedness to face a volcanic eruption disaster can be realized if all aspects of learning competence are trained, both aspects of knowledge (cognitive), attitude (affective), as well as skills or psychomotor (Fitrissani et al., 2014; Krathwahl, 2002; Omar et al., 2012). Integrating disaster education in schools prone to disasters with appropriate learning models is very effective in increasing students' preparedness for natural disasters (Rambau et al., 2012; Septikasari & Ayriza, 2018; Teo et al., 2019). The use of real objects learning media by bringing students to objects directly; in this case, learning is carried out using objects that are attached to the daily lives of students who are facilitated with appropriate learning media, it is also very effective in increasing student preparedness (Amaliya et al., 2011; Labibah et al., 2019).

Science subject-specific pedagogy based on discovery learning integrated with the volcano eruption that was developed facilitates the three domains of competence, where when students have the skills in this process in participating in learning activities, it will improve the mastery of the concept. Improved concept mastery will impact the formation of a good preparedness attitude for students. Unfortunately, the subject of this study was limited to students who lived in the environment around the Merapi volcano eruption disaster in Yogyakarta.

CONCLUSION

The research and development results are products in the form of science subject-specific pedagogy, consisting of a syllabus, lesson plan, students'

worksheet, and handout. Those products are integrated with volcanic eruption disasters and delivered in discovery learning syntax. According to experts and learning practitioners, the whole science subject-specific pedagogy reaches a very good category in its feasibility. After being implemented in the learning process, it can be concluded that the science subject-specific pedagogy with discovery integrated volcanic eruption disaster effectively improves students' mastery of the concept and preparedness in disaster mitigation. Further development research is still needed to complete the findings, for example, on the other types of disasters such as landslides, earthquakes, floods, etc. In addition, the subject can also be extended to those students who live in areas with other active volcanoes, such as Mount Semeru or Mount Sinabung.

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