JPPIPA 12 (7) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Interactive Media Requirements for Volcano Education and Student Creativity Development in Disaster-Prone Areas

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Received: May 15, 2026
Revised: June 16, 2026
Accepted: July 25, 2026
Published: July 31, 2026

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DOI: 10.29303/jppipa.v12i7.15312

Abstract: This needs assessment study reveals a significant gap between the demands of the Merdeka Curriculum and the actual conditions of disaster-related learning about volcanoes in schools located in high-risk eruption areas of West Sumatra. Although the learning outcomes require students to design simple mitigation strategies, most schools have not achieved these competencies due to students' low understanding of evacuation procedures and disaster preparedness. This situation is exacerbated by limited infrastructure: the majority of schools lack functional science laboratories and have very restricted internet access. However, there is strong potential shown by students' high enthusiasm for creative project-based learning. Therefore, the development of low-cost, low-tech, fully offline interactive project media using local or recycled materials is urgently needed. Such media are expected to improve students' scientific understanding of volcanic hazards, enhance disaster literacy, and foster creativity, critical thinking, and the competencies mandated in the Pancasila Student Profile. Thus, this media development serves as a strategic solution to support sustainable education in disaster-prone regions.

Keywords: Creativity development; Disaster preparedness education; Interactive project media; Low-cost offline learning media; Volcanic hazard learning

Introduction

Education is a fundamental process in the formation of quality human resources and is a major pillar of a nation's development. According to UNESCO 2015 in its report Incheon Declaration and Framework for Action, education is a human right and a means to achieve sustainable development. In Indonesia, the constitutional mandate in the Preamble to the 1945 Constitution, paragraph four, and Article 31, paragraph (1), affirms that every citizen has the right to education and that the government is obliged to finance basic education.

In fact, empirical evidence shows that there are still significant gaps in the quality of education. Indonesia's Human Development Index (HDI) in 2024 ranks 114th out of 193 countries, with an average of 8.56 years of schooling up to the age of 13.69 years (UNDP, 2025). This gap became even more apparent during the Covid-19 pandemic, which forced the education system to switch to online learning, thereby widening the gap in access to and quality of education between regions and between socio-economic groups (Gultom et al., 2020; Widjaja et al., 2021).

Several recent studies in Indonesia show that the quality of education is influenced by multiple factors, including teacher competence, infrastructure, curriculum, and parental involvement (Hartanto et al., 2023; Jamaluddin et al., 2025). In addition, the implementation of Merdeka Belajar (Freedom of Learning), which was launched in 2019 by the Ministry of Education, Culture, Research, and Technology, has not been fully able to address 21st-century challenges such as digital literacy, critical thinking skills, and

How to Cite:
Suzry, T. G., Fauzi, A., Mufit, F., & Novitra, F. (2026). Analysis of Interactive Media Requirements for Volcano Education and Student Creativity Development in Disaster-Prone Areas. *Jurnal Penelitian Pendidikan IPA*, *12*(7), 724–732. https://doi.org/10.29303/jppipa.v12i7.15312

national character (Doyan et al., 2024; Hasanah et al., 2026; Hidayati, 2022; Muliyadi et al., 2026). Therefore, comprehensive studies and evidence-based solutions are needed to improve the quality of national education. This study aims to analyze interactive projects as a contributory effort in developing an Indonesian education system that is more inclusive, of higher quality, and relevant to the demands of the times.

Indonesia is known as one of the most disaster-prone countries in the world. Geographically, Indonesia is located at the meeting point of three major tectonic plates, namely Indo-Australia, Eurasia, and Pacific. In addition, Indonesia is located in the Pacific Ring of Fire. These conditions make Indonesia highly prone to disasters such as earthquakes, tsunamis, volcanic eruptions, floods, landslides, and tornadoes (BNPB, 2024, 2025).

Based on data from the National Disaster Management Agency (BNPB) in December 2025, in the last 10 years from 2015 to 2024, Indonesia has experienced more than 32,000 disaster events with tens of thousands of fatalities and economic losses of more than Rp 250 trillion (BNPB, 2025). The 2024 Indonesia Disaster Risk Index (IRBI) ranks Indonesia 1st in the world for tsunami risk, 5th for earthquake risk, and 9th for overall disaster risk (World Risk Index, 2024).

According to data from the National Disaster Management Agency (BNPB), Indonesia has more than 129 active volcanoes, which make the surrounding areas prone to disasters. This not only poses physical threats such as lava, volcanic ash, and volcanic earthquakes, but also has an impact on the social, economic, and educational aspects of the community, especially children and students in the region. In disaster-prone areas such as those around volcanoes located in several provinces in West Sumatra, Central Java, and Yogyakarta, students often face challenges in the learning process, where knowledge about disaster mitigation is crucial to improving preparedness and reducing the risk of casualties.

In volcanic disaster-prone areas in Indonesia, needs analysis is important to identify the gap between ideal conditions and reality in the field. These areas often face challenges of unequal access to education, where the curriculum, media, and teaching materials are not yet fully integrated with disaster mitigation education. Based on data from the study, there are several active volcanoes in Indonesia, with eruptions affecting thousands of students every year. This study focuses on three aspects to be analyzed, namely the curriculum, learning media, and teaching materials, with an emphasis on existing gaps (Nagata et al., 2024).

The province of West Sumatra is located in the Bukit Barisan mountain range, which is part of the Pacific Ring of Fire. There are 11 active and potentially active volcanoes in this region, including Mount Marapi, Talang, Tandikat, Kerinci, and Sorik Marapi. Mount Marapi, located in Agam and Tanah Datar Regencies, is the most active volcano in West Sumatra, with more than 50 eruptions since the 18th century and significant eruptions from December 2023 to 2025, which caused 23 fatalities and damage to hundreds of schools. BNPB notes that in 2025, hydrometeorological and geological disasters in West Sumatra damaged 314 school units and disrupted the learning process, affecting more than 141,800 students. This data is consistent with BNPB's statement on the condition of volcanoes in West Sumatra Province, as shown in the table below.

Table 1. Summary of Data on Eruption Activity, Fatalities, and Impacts of Volcanoes in West Sumatra

Year	Volcano	Number of Eruptions	Fatalities	Main Impact
2000–2010	Marapi	5 significant eruptions (2004, 2005, 2009)	<10	Ashfall in Agam & Tanah Datar; disruption to agriculture.
2011–2020	Marapi & Kerinci	8 eruptions (2011, 2015, 2017, 2018)	5–10	2017 eruption: ash up to 300 m; flight cancellations.
2021–2023	Marapi	10+ eruptions (2023: 63 eruptions in December)	24 (hikers)	Eruption on 3/12/2023: ash 3–5 km; 11 initially missing.
2024–2025	Marapi	5 eruptions (March 2024: 5 eruptions + 13 ash plumes)	0 (no significant casualties yet)	Ash up to 1,500 m; canceled 10+ flights.

Source: BNPB (2024), PVMBG (2025). Data from 2025 to December shows low activity, Alert status (Level II)

According to historical records, Marapi has been erupting since 1807, with an average rest period of 3.5 years for eruptions in the shortest period of approximately less than 1 year and the longest period of approximately 17 years. The eruptions of Marapi are explosive and effusive in nature, often accompanied by rumbling sounds, ejection of incandescent rocks, and ash rain. The main impacts include volcanic ashfall, cold lava flows, and flight disruptions. These impacts occur in several areas in West Sumatra, namely Tanah Datar, Padang Panjang, and Bukittinggi. The following data is obtained from official data as of December 2025, historical data up to 2024, with the latest updates from PVMBG and BNPB.

Table 2. Data on Areas Affected by the Volcanic Eruption in West Sumatra

District/City	KRB III (≤3 km)	KRB II (3–5 km)	KRB I (5–7 km)	Total Vulnerable Population
Agam	12,500	48,000	22,000	82,500
Tanah Datar	18,000	52,000	18,000	88,000
Bukittinggi	2,800	15,000	8,500	26,300
Padang Panjang	1,200	9,500	5,000	15,700
Total	34,500	124,500	53,500	212,500

Source: Marapi KRB Map 2023 (updated 2024) – PVMBG

This condition makes West Sumatra one of the provinces with the highest level of disaster vulnerability in Indonesia. Amidst these threats, science education about volcanoes and disaster mitigation in West Sumatra schools is still dominated by conventional methods based on lectures and textbooks (Kartika et al., 2023).

In the context of education, learning about volcanoes is not only intended to convey scientific information, but also to develop students' creativity. However, conventional learning methods are often ineffective because they are passive and do not actively involve students. Based on preliminary data from the West Sumatra Provincial Education Office and a 2025 field survey, more than 72% of junior high schools in volcano-prone areas (Agam, Tanah Datar, and Padang Panjang districts) do not have functional science laboratories and have less than 25 school laptops/computers that can be used for project activities, with an average of around 400 students. This situation causes teachers and students to be highly dependent on low-cost, locally sourced media that does not require electricity or stable internet, making the development of simple yet effective interactive project media urgently needed. The limitation of functional science laboratories in disaster-prone schools, with only 28% having adequate labs, and the lack of technological devices in schools on volcanic slopes further reinforce the urgency of developing interactive project media that is inexpensive, easy to make from local materials, and can be run without electricity and the internet (Suherly et al., 2022).

Data from the West Sumatra Education Office in 2024 shows that only 22-30% of schools in disaster-prone areas have integrated contextual disaster education into the Merdeka Curriculum, particularly through the Pancasila Student Profile Strengthening Project (P5). More than 80% of science teachers admit that they do not have interactive learning media that is relevant to local conditions, such as eruption simulations, evacuation route maps based on simple technology, or media based on Minangkabau wisdom. As a result, students' understanding of evacuation procedures and disaster preparedness is still low, ranging from only 24-50% (Benardi et al., 2025; Etnawati, 2022; Munandar et al., 2024; Syafira et al., 2024).

The Merdeka Curriculum provides ample space for the development of student creativity through problem-based projects and contextual themes (P5). However, in practice, these projects are still ceremonial in nature and do not produce tangible products that can be used by students or the surrounding community.

The development of interactive media is the process of designing learning tools that transform students from passive observers into active participants through two-way interaction, direct feedback, and multi-sensory engagement. This media not only conveys information but also allows students to experiment, make choices, and see the real consequences of their actions, thereby deepening and reinforcing their understanding of scientific concepts (such as volcanic eruptions). By utilizing inexpensive local materials or simple technology, the development process also trains creativity in recycling, critical thinking when designing scientifically accurate mechanisms, independence in completing prototypes, and cooperation in dividing group tasks. The final results, ranging from button/Arduino-based eruption miniatures, stop-motion videos, 3D pop-up books, digital story maps, to simple AR, are not only teaching aids but also authentic projects that cultivate the six dimensions of the Pancasila Student Profile at once, in line with the spirit of the Merdeka Curriculum, which is based on phenomena and profile-strengthening projects (Mustofa et al., 2023).

The science curriculum consists of two main elements: science comprehension focusing on concepts and applications, and process skills (dynamic inquiry cycle). Essential material is grouped into 7–14 main subtopics arranged from concrete to abstract (solar system), with scaffolding between phases (Hasbi et al., 2015; Hudhana et al., 2025; Maryulis et al., 2018). P5 integration is carried out through dimensions such as creativity (model design), critical thinking (data analysis), and cooperation (group projects), with an emphasis on meaningful learning (connections to real issues such as disasters) and awareness (environmental ethics reflection).

Effective science learning must shift from passive knowledge transmission to the stimulation of higher-order thinking skills, one of which is creativity. Creativity is particularly important for students in disaster-prone areas, as it enables them to formulate

innovative and adaptive solutions to unexpected challenges in emergency situations. However, preliminary research shows that conventional teaching methods in secondary schools often fail to stimulate these skills, leaving students to merely receive information without being able to process it into concrete actions or new ideas.

There is still a gap in the development of interactive learning media in disaster-prone areas. Needs analysis is an essential first step to identify what students, teachers, and local communities need. Previous studies show that interactive media can increase learning motivation and preparedness, especially in early childhood and secondary school students. Therefore, this analysis aims to explore the need for interactive media in volcano education, with a focus on developing student creativity in disaster-prone areas (Sigarimbun, 2024). The results of the analysis are expected to form the basis for the development of more adaptive and effective media, thereby contributing to sustainable education and disaster risk reduction in Indonesia.

Method

This study uses a descriptive qualitative approach to the ADDIE model of development (needs assessment) at the Analysis stage (Branch, 2009). The study was only conducted up to the Analysis stage because its purpose was to identify the need for interactive media projects for volcano learning and the development of student creativity in disaster-prone areas, so it did not produce a final product. The research subjects were science teachers at junior high schools/MTs in disaster-prone areas in West Sumatra, namely Tanah Datar, Padang Panjang, Bukittingi, Solok, and eighth-grade students at eight schools in volcanic disaster-prone areas. The eight schools to be studied were in Tanah Datar district, namely MTsN 3, MTsN 7, MTsN 8, MTsN 5; in Padang Panjang district, MTsN 1; in the Bukittingi area, MTsN 2; and in the Solok area, MTsN 3 Alahan Panjang and MTsN 1 in Solok city. Data collection was conducted through a questionnaire with 34 statements, semi-structured interviews, observation of laboratory facilities, and documentation studies (Purwasih et al., 2022; Sari et al., 2022). Quantitative data analysis used percentages and averages, while qualitative data was analyzed using interactive techniques (Miles et al., 1994).

Result and Discussion

Curriculum Analysis Results

The Natural Sciences (IPA) curriculum for junior high schools (SMP) in West Sumatra follows the national framework established by the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2024) and the Ministry of Religious Affairs. Currently, the main implementation is the Merdeka Curriculum, which has been gradually implemented since the 2022/2023 academic year, replacing the previously dominant 2013 Curriculum (K13) (Simatupang, 2019). In 2024 (BPS Sumatera Barat, 2025), it will emphasize science education to support human resource development in the tourism and agriculture sectors. Junior high school science is focused on developing science literacy, critical thinking skills, and integration with local issues such as disaster mitigation, including earthquakes and volcanoes. The shift to the Merdeka Curriculum aims to make learning more flexible and project-oriented, in accordance with the Junior High School Science Learning Outcomes (CP) Phase D Regulation, which includes: 1). Understanding basic science concepts covering matter, energy, living things, earth and space, 2) Developing scientific attitudes through experiments and projects, 3) Integration with the Pancasila Student Profile (P5) which is faithful, responsible, creative, and independent. The results of the science curriculum analysis in the eight schools observed.

Table 3. Data from Curriculum Analysis in Several Schools and in Accordance with the 2024 Ministry of Education and Culture Regulation

Aspects Analyzed	In line with the Merdeka Curriculum	Reality	Main Gaps
Learning Outcomes (CP)	Students are able to explain the volcanic process, the impact of eruptions, and simple mitigation strategies (Permendikbudristek No. 12/2024)	Volcanism material is taught, but mitigation is only covered in 1–2 sessions and is not mandatory. This applies to all schools observed.	78% of schools did not achieve the mitigation Los
Example Activities/Projects	Problem-based projects are recommended: eruption simulations, evacuation route maps, preparedness campaigns	80% of teachers still use lecture methods + photocopied worksheets; projects are limited to posters.	Lack of contextual project examples for the West Sumatra region on Mount Marapi, Talang
Integration of P5 & SPAB	The themes "Sustainable Lifestyle" and "Local Wisdom" must be included, covering disasters	8% of the schools studied integrate P5 with the concept of disaster-safe schools	92% have not been integrated with disaster-safe schools

Aspects Analyzed	In line with the Merdeka Curriculum	Reality	Main Gaps
Local Content	Schools may add local content such as traditional stories and community customs.	No schools have implemented regional stories or community customs into the context of this material in accordance with existing CP	Loss of local wisdom potential
Time Allocation	Minimum of 4–6 JP for disaster topics with a total of 80–120 JP for P5 per semester	Many schools reduce science class hours due to disasters or building renovations.	Effective time is only 40–50% of what was planned, with actual implementation not reaching 30%.
Media & Learning Resources	Use of interactive media, simulations, and simple technology	72% of schools in the Marapi disaster-prone area do not have functional science labs, and internet technology per school is less than 50%. This is because these schools are located in areas with difficult access.	Available media are limited to textbooks, YouTube videos, and worksheets

The Merdeka Curriculum Permendikbudristek No. 12 of 2024 explicitly provides ample space for contextual, creative, and project-based learning about volcanoes and disaster mitigation. Learning Outcomes (CP) Phase D clearly state that junior high school students must be able to explain the volcanic process, the impact of eruptions, and design simple mitigation strategies. However, the reality on the ground, especially in schools in the red zone of Mount Marapi and Talang, shows a very significant gap. This gap clearly shows that although the Merdeka Curriculum has provided ideal and flexible policies, its implementation in disaster-prone areas is still hampered by infrastructure limitations, a lack of practical examples, and the suboptimal competence of teachers in utilizing local content and project-based approaches

Interview Results

From in-depth interviews with science teachers, principals, and students in eight educational units located in the red zone threatened by the eruption of Mount Marapi and Talang, it can be concluded that there is an urgent need for low-cost, low-tech, locally sourced, and 100% offline interactive project media. Teachers realize that conventional methods based on lectures and textbooks are no longer able to build a deep understanding of the volcanic process and disaster preparedness among students who live directly under the threat of eruptions and hot clouds. Students showed great enthusiasm when given space to be creative, while the principal emphasized that the limitations of laboratory infrastructure, most of which was damaged by the 2023–2025 eruptions, unstable electricity, and minimal internet access made high-tech media almost impossible to implement (Wiratma, 2015).

Some excerpts from the interviews: "From an interview with one of the teachers, Mr. Yoki, who works at one of the MTsNs in Tanah Datar, he explained that our school is the closest school to Mount Marapi. In 2023, when a major eruption occurred with an ash column reaching 3000 m, our school received the most volcanic ash, making visibility difficult. We required our students to wear masks to reduce the impact of air pollution. Additionally, the volcanic eruption in 2024 severely damaged our school due to cold lava from the mountain causing flash floods in the Jambu River area. The classrooms where learning took place were swept away by the strong river current." In P5, we once tried the theme of Sustainable Living, but it only became a poster. The children got bored. If there were media that they could hold, turn around, and assemble themselves, such as miniature erupting mountains or 3D evacuation maps made of cardboard, they would definitely be more enthusiastic and creative. From Ibu Yulismar in Solok "In our P5 activities, we once tried the theme of Sustainable Lifestyle, but it only ended up as a poster. The children got bored. If there were media that they could hold, turn around, and assemble themselves, such as a miniature erupting volcano or a 3D evacuation map made of cardboard, they would definitely be more enthusiastic and creative." These are some of the insights from the interviews that call for changes in media development to enhance students' potential and creativity in the concept of volcanoes. The most desired media are those that can be designed and produced by students and teachers themselves using recycled materials and Minangkabau local wisdom, such as clay, used cardboard, betel leaves, bamboo, or elements of traditional stories so that it not only improves scientific literacy about volcanoes and disaster mitigation, but also simultaneously hones creativity, critical thinking, independence, and a spirit of mutual cooperation in accordance with the six dimensions of the Pancasila Student Profile (Anam et al., 2026; Anggraini, 2025). The existence of such media is seen as a strategic solution to bridge the gap in the implementation of the Merdeka

Curriculum in disaster-prone areas, while strengthening the resilience of education and communities on the slopes of volcanoes in West Sumatra Province.

Results of Laboratory Equipment Observations

The results of the questionnaire analysis filled out by 8 science teachers and direct observation of laboratory facilities in eight junior high schools show a very clear picture of the limitations of infrastructure and science learning resources in disaster-prone areas of West Sumatra Province (Dewi et al., 2019; Kancono, 2010). A total of 87.5% of schools do not have science laboratories that function optimally, 100% do not have basic equipment for lava simulation (pumps/hoses), and only 12.5% have stable internet access. This situation is exacerbated by damage to facilities caused by repeated eruptions of Mount Marapi from 2023 to 2025. In addition, the questionnaire results included several suggestions from students who said, "Ma'am, when are we going to make a real volcano that spews red lava? There are many on YouTube, but never at school. If we had the equipment, we would make it ourselves, then invite the villagers to see it. This demonstrates high enthusiasm and creative potential when is given the opportunity to create interactive learning media. Therefore, this data clearly indicates that the interactive project media to be developed must meet four main criteria that were repeatedly mentioned by respondents, namely low-cost with an estimated cost of approximately Rp50,000 per group, low-tech without electricity and internet, made from local/recycled materials, and 100% offline, but still able to provide an active, creative, and relevant learning experience with local disaster risks. The following is a summary of the main findings in the form of tables and graphs that illustrate the real conditions of science laboratories and the urgent need for interactive project media in target schools.

Table 4. Data from Student Questionnaires at Eight Schools in West Sumatra Province

Observation & Questionnaire Items	Number of Schools (n=8)	Percentage	Description
There is a fully functional science laboratory	1 school	12.5	7 schools are only warehouses/damaged after the Marapi eruption
Practical tables and chairs for at least 4 groups	2 schools	25	6 schools do not have any
Sink + running water in the lab	0 schools	0	All schools do not have
Measuring cups/beakers/chemical glasses (at least 10 pieces)	2 schools	25	6 schools damaged or missing
Dropper pipette	3 schools	37.5	5 schools none
Digital scale or kitchen scale	1 school	12.5	7 schools do not have
Small aquarium pump / plastic hose	0 schools	0%	No school has
Food coloring / baking soda / vinegar	4 schools	50	Teachers usually buy it themselves
School laptops/computers that are still in working condition	Average of 3.1 units	< 5 units in all schools	2 schools only have 1 unit
Projectors/LCDs that are still functional	3 schools	37.5	5 schools damaged
Stable electricity throughout school hours	4 schools	50	4 schools often experience power outages during ash rain
Stable internet (can open YouTube without interruption)	1 school	12.5	7 schools are slow/nonexistent
Have conducted a volcanic eruption simulation at school	2 schools	25	Only posters, not simulations
Teachers stated that they "really need" low-cost and low-tech media.	8 schools	100	All teachers agree

This data was obtained from observations at eight schools that were studied as a basic needs analysis to obtain data on laboratory equipment that is in line with the reality of schools in the field (Mahtari et al., 2025). Many school laboratories do not function as places for practical work; they have been turned into classrooms due to the lack of learning spaces in schools in these areas. This means that equipment that should be stored properly is no longer known to be located. The use of laboratories is no longer a learning tool that encourages students to work together to complete a project in their studies.

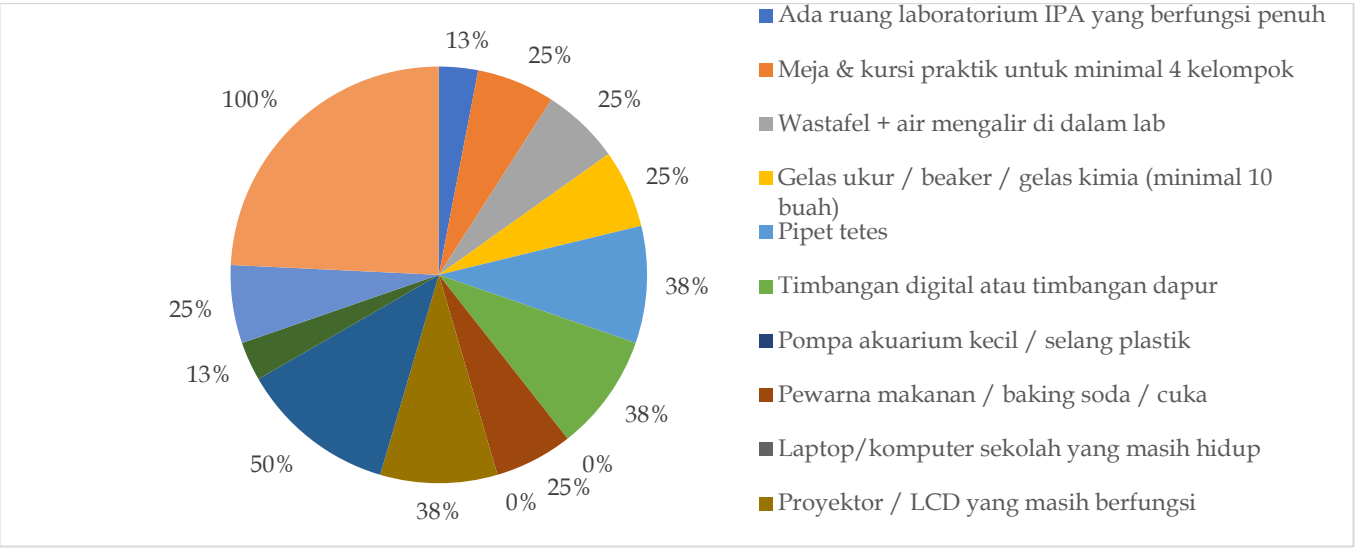

Figure 1. Data from observations of science laboratories in schools

Observation Results with Students

Based on questionnaires filled out by 129 eighth grade students in eight sample schools, it was revealed that 92% of students said they would be very enthusiastic if volcano learning was done by making their own media (miniature eruptions, 3D evacuation maps, or stop-motion videos). A total of 87% of students felt that the volcanic material taught so far was boring because it only consisted of lectures and pictures in textbooks, so their understanding of the eruption process and evacuation routes was still low (only 38% really understood). Students explicitly stated that they really need media that they can assemble themselves from used items, with an average score of 3.78 out of 4, such as used bottles, cardboard, clay, or leaves around the school, because such media makes them feel like "real scientists" and makes it easier for them to remember the material (Jafar et al., 2025; Solfiah et al., 2020).

Furthermore, 94% of students admitted to often feeling worried when Mount Marapi emits volcanic ash or rumbling sounds, but they do not know where to run if a major eruption occurs. They hope for project materials that not only teach the eruption process but also the evacuation routes for their school and village in an engaging format (e.g., a 3D map that can be disassembled or a pop-up book). Students also showed high creativity: 89% had tried to make a volcano erupt at home using baking soda and vinegar, and 100% said they were ready to work on group projects if the materials were cheap and easy to obtain. Overall, the students' responses confirm that low-tech, locally-based interactive project media are not only needed but also highly desired to improve students' understanding of volcanic concepts, creativity, and disaster preparedness among students living under the shadow of active volcanoes in West Sumatra.

Conclusion

This needs analysis research, which was carried out up to the Analysis stage of the ADDIE model, clearly identified the urgent need to develop low-cost and low-tech interactive project media based on local wisdom in volcano learning and disaster mitigation in junior high schools (SMP) in disaster-prone areas of West Sumatra Province (Wahyuni et al., 2023). Although the Merdeka Curriculum (Permendikbudristek No. 12/2024) mandates that students be able to design simple mitigation strategies, the reality in the field shows that 78% of schools do not achieve the Learning Outcomes (CP) for mitigation. Students' level of understanding of evacuation procedures and disaster preparedness is still low, ranging from 24-50%. Students are very enthusiastic about learning by creating their own media, but 87% of students feel that the material taught so far is boring lectures and textbooks. The condition of infrastructure in disaster-prone areas, especially the red zones of Mount Marapi and Talang, is very concerning and requires further attention. The most desirable media are those that can be designed and produced by students and teachers themselves using recycled materials and local wisdom, such as clay, used cardboard, and bamboo. The development of interactive project media, such as miniature eruptions or 3D evacuation maps made from cardboard, is seen as a strategic solution to bridge the gap in the implementation of the Merdeka Curriculum, improve understanding of science concepts, and simultaneously hone students' creativity, critical thinking, and disaster preparedness in West Sumatra

Acknowledgments
On this occasion, the researchers would like to express their gratitude to the relevant parties who have assisted in the completion of this research. Author 1 designed the research and research products. Author 2 designed the research, research products, and instrument validation. Authors 3 and 4 reviewed the instruments and validated the research products.

Author Contributions
All authors contributed to writing this article.

Funding
No external funding.

Conflicts of Interest
No conflict interest.

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