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Philosophical Review in Disaster Mitigation-Based Science Education

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ABSTRACT

The study of Natural Sciences (IPA) plays a crucial role in building students' scientific knowledge, critical thinking skills, and environmental awareness, especially in Indonesia, which is prone to natural disasters. This research analyzes disaster mitigation-based science education through a philosophical approach encompassing the dimensions of ontology, epistemology, and axiology. The method employed is a literature review of 14 articles relevant to the period from 2016 to 2024. The results indicate that, ontologically, this education emphasizes students' understanding of the interaction between natural phenomena and human activities. Epistemologically, experience-based, simulation, and technology-driven approaches have been shown to enhance disaster literacy and mitigation skills. Axiologically, this education instills values of social responsibility, environmental awareness, and solidarity in facing disasters. This integration supports Education for Sustainable Development (ESD) and fosters a generation that is responsive and adaptive to global challenges, including climate change and disaster risks.

Keywords: Disaster Mitigation, Philosophy of Education, Ontology, Epistemology, Axiology

INTRODUCTION

Natural Science (IPA) education plays a vital role in building students' scientific knowledge, critical thinking skills, and environmental awareness (Handayani, 2020; Shutaleva, 2023). In Indonesia, a country prone to various natural disasters such as earthquakes, floods, volcanic eruptions, and tsunamis, integrating science education with disaster mitigation has become an urgent necessity (Maknun, 2015; Yunus et al., 2024). This approach not only enriches students' scientific understanding but also develops disaster responsiveness and adaptive skills in emergency situations.

From the perspective of the philosophy of education, disaster mitigation-based learning can be examined through several approaches, such as pragmatism, which emphasizes the relevance of education to real-world needs (Garrison, 1994), constructivism, which prioritizes experience-based learning (Mughal & Zafar, 2011), And humanism, which emphasizes the development of moral awareness (Aloni, 2011). In this context, experience-based learning, such as disaster simulations, has proven effective in helping students understand rescue steps more comprehensively. (Dhohirrobbi, Islamudin, Chamidah, & Amin, 2025; Maryati, 2024).

Research shows that project-based learning approaches on natural disaster mitigation can strengthen students' understanding of the relationship between science and environmental safety (Rukanda et al., 2024). In addition, the use of educational media such as pop-up books and animated videos has proven effective in enhancing students' logical thinking skills and disaster literacy (Pambudi, 2019).

Disaster mitigation-based science education is also relevant within the framework of Education for Sustainable Development (ESD)(Rahma, 2018), It aims to equip students with the knowledge and skills needed to address global challenges, including climate change and disaster risks (Septiani, 2023). The integration of science education and disaster literacy not only enriches students' academic understanding but also enhances community resilience (Rukanda et al., 2024).

This urgency is further emphasized by the fact that disaster literacy among the Indonesian population remains relatively low. The BNPB (2020) report highlights that a lack of understanding and awareness of disaster mitigation often exacerbates the impacts of disasters. In this regard, disaster mitigation education based on local wisdom can be integrated into the 2013 Curriculum to enhance students' awareness of disaster risks (Arif, 2024; Suarmika, Arnyana, Suastra, & Margunayasa, 2022; Suarmika & Utama, 2017). In addition, disaster mitigation learning models in disaster-prone areas such as the slopes of Mount Slamet can also enhance students' environmental literacy and preparedness (Hidayat & Ermawati, 2022).

Furthermore, the development of educational technology, such as disaster mitigation-based edu-games, has proven to enhance students' awareness and skills in dealing with disasters (Sari, Dayurni, & Nur, 2023). Other interactive media, such as "Lift the Flap Books," also help young children understand disaster mitigation concepts through engaging visualizations (Huntington, 2005).

Against this background, a philosophical study of disaster mitigation-based science education becomes relevant to explore the fundamental principles, theoretical foundations, and practical implications of this approach. This aims not only to improve the effectiveness of learning but also to ensure that science education can serve as a means to shape a society that is responsive, adaptive, and responsible in facing future disaster risks. Based on this premise, this literature review study aims to examine the philosophical perspectives on disaster mitigation-based science education.

METHOD

This article discusses a philosophical review of disaster mitigation-based science education. The study employs a literature review analysis method. The sources for the literature review are obtained from reputable international journals and nationally indexed SINTA articles published between 2016 and 2024, relevant to the research discussion. These references were gathered through an online search using Google Scholar. The keywords used were "Disaster Mitigation in Science Education" and "Philosophical Review of Disaster Mitigation," resulting in 860 relevant articles. However, only 14 articles were deemed suitable for the study and were used as references for writing this literature review.

Peneliti menggabungkan artikel-artikel yang berkaitan dengan pembelajaran IPA berbasis mitigasi bencana. Kemudian jenis dan hasil penelitianya disusun dalam bentuk tabel yang mencakup peneliti, tahun terbit, judul dan metode penelitian. Kemudian, penulis mereview artikel tersebut secara menyeluruh khususnya terkait hasil dan kesimpulan.

DISCUSSION

The analysis of the articles can be seen in Table 1.

Tabel 1
Article Analysis

Researcher	Year	Article Title	Research Method
Indarti Komala Dewi, Elly Sukmanasa	2016	Mitigasi Bencana sebagai Bahan Pembelajaran IPA dan IPS pada Kurikulum 2013	Deskriptif kualitatif
Hurriyah, Lufri, Asrizal	2023	Meta Analisis Pengaruh Pembelajaran Terintegrasi Bencana Alam dengan Visi SETS	Meta-analisis
Puyanti, Susanti, Elza Heryenzi, Diah Suprihatin, Henny Johan	2022	Desain Pembelajaran Terintegrasi Mitigasi Bencana Banjir dengan Pendekatan STEMS dan PjBL	Deskriptif kualitatif
Syubhan Annur, Ani Rusilowati, Suprijadi, Woro Sumarni	2019	Pengajaran IPA, Pendekatan STEM dan Kearifan Lokal dalam Mitigasi Bencana	Studi review
Hanifa Sekar Ayunda, Desy Safitri, Sujarwo	2024	Mitigasi Bencana Berbasis Kearifan Lokal Nyabuk Gunung	Studi literatur
Lativa Qurrotaini, Novita Nuryanto	2020	Implementasi Pendidikan Mitigasi Bencana Alam Gempa Bumi dalam Pembelajaran IPS SD	Deskriptif kualitatif
Susi Mahmudah, Farah Fauzia	2022	Penerapan Model Simulasi tentang Pembelajaran Mitigasi Bencana Alam Gempa Bumi Berbasis Video Animasi	Eksperimen
Syarifuddin, Junaidi Fery Efendi, Faiz Azmi Fauzia	2023	Pemahaman Mitigasi Bencana Alam Siswa Berbasis Permainan Tradisional pada Pembelajaran Matematika	Pre-eksperimental
Iswatul Hasanah, Sri Wahyuni, Rayendra Wahyu Bachtiar	2016	Pengembangan Modul Mitigasi Bencana Berbasis Potensi Lokal yang Terintegrasi dalam Pelajaran IPA di SMP	Model 4-D
Nelly Wedyawati, Yasinta Lisa, Sara Selimayati	2017	Pengaruh Model Pembelajaran IPA Terintegrasi Mitigasi Bencana terhadap Hasil Belajar	Quasi-eksperimen
Hidayatul Umahatun Qismawa, Sri Jumini	2020	Pengembangan Komik Berbasis Mitigasi Bencana sebagai Sumber Belajar IPA	Library Research
Encep Andriana, Trian Pamungkas Alamsyah, Injilya Tambun	2020	Pengembangan Lembar Kerja Peserta Didik Berbasis Saintifik Kontekstual Materi Peristiwa Alam	Research and Development (3D Model)
Fatwa Al'afani, Unggul Wahyono, Miftah	2022	Penerapan Modul Mitigasi Bencana yang Terintegrasi dalam Pelajaran IPA di SMP Terdampak Tsunami	Pre-eksperimental
Desti Rahmayani, Henny Johan, Sutarno, Deni Parlindungan, Aprina Defianti	2024	Analisis Keterlaksanaan Pendidikan Mitigasi Bencana dalam Pembelajaran IPA di Wilayah Pesisir Kota Bengkulu	Deskriptif
Sri Wahyuni	2019	Pembelajaran Rain Water Harvesting sebagai Upaya Mitigasi Bencana Berbasis Kearifan Lokal	Wawancara, studi pustaka, studi lapangan

Based on the results of the 14 articles reviewed as comparative studies, the researchers concluded that philosophical perspectives can be applied to the science learning process grounded in disaster mitigation.

Philosophy originates from the Greek word philosophia, derived from philo, meaning love, and sophia, meaning wisdom. Thus, in a literal sense, philosophy means "love of wisdom." According to Istikhomah & Wachid, philosophy is defined as a genuine desire for ultimate truth. In Indonesian, the term philosophia is translated as filsafat. The adjective form is filsafat, not filosofis, while a person who practices philosophy is called a filsuf, not a filosof. (Fadli, 2021; Ruslan, Nilawati, Marjuni, & Achruh, 2024).

Philosophy is the study of events or phenomena in life, rooted in critical human thought and elaborated into fundamental concepts. Philosophy is an effort to seek and discover truth about the nature of existence using reason and optimal intellectual capabilities. Therefore, the goal of philosophy is to understand valid truths. When these truths are structured systematically, they form a systematic philosophy. Philosophy is divided into three theoretical branches: the theory of essence (ontology), the theory of knowledge (epistemology), and the theory of aesthetics and values (axiology) (Ningsih, Nurwahidin, & Sudjarwo, 2022) That explains the purpose of the disaster mitigation concept in science education at schools.

Ontology in Disaster Mitigation-Based Science Education

The ontology of disaster mitigation-based science education is rooted in the reality that natural disasters, such as earthquakes, floods, and landslides, are phenomena that can be studied, predicted, and managed through scientific approaches. In this context, science education is not limited to theoretical understanding of natural phenomena but also integrates disaster mitigation concepts as part of the curriculum. The goal is to shape students with scientific awareness to understand, confront, and minimize disaster risks (Dewi & Sukmanasa, 2016).

Disaster phenomena, such as floods, can be explained through scientific concepts like the water cycle, climate change, and watershed management. In practice, a rainwater harvesting-based approach serves as a concrete example of how biology can be applied to reduce the risks of flooding and drought (Wahyuni, 2019). This approach demonstrates that science can bridge theory with real-world practice in disaster mitigation efforts.

In addition, earthquakes as tectonic phenomena serve as another focus in disaster mitigation-based science education. Through animation-based video simulations, students can understand the process of earthquakes, their impact on the environment, and the necessary safety measures. This approach not only provides cognitive understanding but also instills early preparedness, enabling students to be better equipped to face disaster risks (Mahmudah & Fauzia, 2022).

The integration of the STEM (Science, Technology, Engineering, Mathematics) approach in science education also plays a crucial role in enhancing students' skills. For instance, students are encouraged to design practical solutions, such as flood-resistant houses, using scientific and technological principles. This approach helps students understand the tangible relationship between science and mitigation efforts while also fostering their ability to become innovative problem solvers (Puyanti, Susanti, Heryenzi, Suprihatin, & Johan, 2022).

Local wisdom is a crucial aspect of disaster mitigation-based science education, showcasing how traditional practices like Nyabuk Gunung or terracing reflect a profound

ecological understanding. These approaches effectively reduce risks such as landslides and floods while highlighting the importance of integrating traditional knowledge with modern scientific principles in the learning process (Ayunda & Safitri, 2024).

Disaster mitigation-based science education not only focuses on mastering academic content but also emphasizes practical applications relevant to daily life. Modules, Student Worksheets (LKPD), and educational media such as disaster mitigation comics are designed to encourage student engagement in simulations, experiments, or community-based projects. This approach enhances students' critical thinking skills and builds their confidence in dealing with emergency situations (Qismawa & Jumini, 2020).

Overall, the ontology of disaster mitigation-based science education emphasizes the importance of education as a means to build a society that is responsive to disaster risks. By integrating scientific knowledge, practical skills, and social values, this approach aims to create a generation that is scientifically aware, proactive, and capable of minimizing the impact of future disasters. This underscores that science education is not only academically relevant but also has practical implications in real-life contexts (Rahmayani, Johan, Sutarno, Parlindungan, & Defianti, 2024).

Epistemology in Disaster Mitigation-Based Science Education

The epistemology of disaster mitigation-based science education is rooted in the scientific method, involving observation, experimentation, and data analysis to understand natural disaster phenomena. The knowledge taught is derived from scientific research and empirically validated data, as well as local knowledge based on the experiences of local communities. For instance, communities in tsunami-prone areas possess traditional knowledge about early signs of tsunamis, which can be combined with scientific understanding. This integration provides students with a relevant context, enabling them to comprehend and apply this knowledge in their daily lives.

Knowledge of disaster mitigation is acquired, studied, and taught through a scientific approach that combines theory, experimentation, and practical applications. Natural science serves as the foundation for understanding disaster phenomena, their mechanisms, and effective mitigation strategies. For example, learning about earthquakes can be conducted through animation-based video simulations that provide students with a concrete experience of how earthquakes occur, evacuation procedures, and self-rescue efforts. These simulations use valid scientific data, enabling students to realistically understand the impacts of disasters and mitigation measures (Mahmudah & Fauzia, 2022).

The STEM (Science, Technology, Engineering, Mathematics) approach is a vital component of disaster mitigation-based science education, aimed at improving students' comprehension. Through this method, students delve into concepts like the water cycle, climate change, and soil dynamics via experiments and problem-solving projects. For example, students may create a project on flood-resistant houses by utilizing physics and engineering principles. This methodology fosters problem-solving abilities while delivering practical and applicable solutions to disaster mitigation challenges (Puyanti, Susanti, Elza, Diah, & Henny, 2022).

In addition to scientific knowledge, disaster mitigation-based science education also utilizes local wisdom as a source of knowledge. For instance, the Nyabuk Gunung practice, which involves creating terracing, provides students with insights into how traditional communities develop ecological solutions to prevent landslides and floods. By integrating local wisdom with modern scientific knowledge, students are taught that disaster mitigation

solutions can be adaptive and contextual, tailored to the specific needs of local communities (Ayunda & Safitri, 2024).

Knowledge about disaster mitigation is also developed through direct observation, literature studies, and the analysis of natural phenomena. For example, the concept of rainwater harvesting in biology education teaches students to utilize rainwater efficiently based on rainfall data and water needs in specific regions. This knowledge is acquired through field research and environmental observation, which are then applied in designing effective water management systems (Wahyuni, 2019)

Disaster mitigation-based science education is also integrated into formal education curricula, such as the 2013 Curriculum, which directs science learning to connect scientific concepts with social and environmental issues. For instance, students are taught to understand disaster risks in coastal areas and develop mitigation strategies based on relevant scientific knowledge (Dewi & Sukmanasa, 2016).

By combining scientific and local knowledge, disaster mitigation-based science education provides students with a holistic understanding. This learning process is designed not only to enhance conceptual understanding but also to develop students' critical thinking and practical skills. Students are encouraged to become agents of change who can implement disaster mitigation solutions in their communities, making this education both academically relevant and socially meaningful (Rahmayani et al., 2024).

This epistemology emphasizes that knowledge about disaster mitigation is acquired through a combination of theoretical approaches, practical experiments, direct observation, and the integration of local wisdom. Through this integrated method, disaster mitigation-based science education creates individuals who are not only responsive to disaster risks but also committed to environmental sustainability. This approach empowers them to become agents of change capable of making a positive impact on their communities and the environment (Al'afani et al., 2022; Qismawa & Jumini, 2020).

Axiology in Disaster Mitigation-Based Science Education

The axiology of disaster mitigation-based science education emphasizes the values and practical benefits aimed to be achieved through education, particularly in fostering students' awareness, preparedness, and responsibility toward disaster risks. One of the key values is developing students' awareness of disaster risks in their environment, such as earthquakes, floods, and landslides. Through animation-based video simulations, students not only gain scientific understanding of disasters but are also trained to take effective evacuation measures, thereby enhancing their preparedness for emergency situationst (Mahmudah & Fauzia, 2022).

In addition to fostering awareness, this learning approach aims to develop students' practical skills through the STEM (Science, Technology, Engineering, Mathematics) framework. For example, students are encouraged to design technical solutions such as flood-resistant houses, allowing them to apply scientific knowledge in real-life contexts while enhancing their critical and creative thinking skills (Puyanti, Susanti, Heryenzi, et al., 2022). The value of environmental conservation is also a key focus, exemplified through teaching the concept of rainwater harvesting in biology. Students are taught to understand the importance of water conservation as a step toward mitigating floods and droughts, directly linking scientific knowledge with environmental preservation practices. (Wahyuni, 2019).

Local wisdom is also an essential element of this learning approach. Practices such as Nyabuk Gunung, which involves creating terracing to prevent landslides and floods, teach

students the importance of adaptive solutions based on local culture. By understanding and appreciating local wisdom, students not only learn practical disaster risk management but also develop respect for cultural values passed down by local communities (Ayunda & Safitri, 2024).

The value of social responsibility is emphasized in this learning approach, where students are trained to become agents of change within their communities. The knowledge and skills acquired at school can be shared with their families and communities, fostering a more disaster-responsive society. For example, students are taught to recognize early warning signs of disasters and create evacuation plans that involve their families and surrounding environments (Dewi & Sukmanasa, 2016). This approach strengthens students' roles in building a community that is resilient to disaster risks.

The axiology of this learning approach is also oriented toward developing practical skills through community-based projects and simulations. Students are encouraged to create disaster risk maps of their surroundings, simulate mitigation steps, or design early warning systems. These activities not only enhance students' critical thinking and problem-solving skills but also boost their confidence in facing real-world challenges (Al'afani, Wahyono, & Miftah, 2022).

Overall, the axiology of disaster mitigation-based science education provides not only academic benefits but also contributes to shaping students' character. This education instills values of humanity, care, and sustainability that are highly relevant to current global challenges. By integrating knowledge, skills, and values, this approach creates a generation that not only understands disaster risks but is also capable of taking an active role in disaster mitigation efforts at both local and global levels (Qismawa & Jumini, 2020; Andriana et al., 2020).

Therefore, this education becomes a long-term investment in shaping a generation that is environmentally conscious, proactive, and responsible, while also capable of contributing to the creation of a safer and more sustainable community.

CONCLUSION

In general, disaster mitigation-based science education plays a significant role in developing students' understanding of the natural world and their potential roles in disaster management. The ontology of this learning approach emphasizes that nature is not merely an object of study but something intrinsically connected to human life. Consequently, students learn to perceive disasters not as unavoidable events but as phenomena that can be managed through appropriate action.

From an epistemological perspective, this learning approach teaches students to connect scientific knowledge with the practical application of disaster mitigation. Students not only study scientific theories related to disasters but also learn practical methods to reduce disaster impacts, as demonstrated through the use of effective learning models. This enables students to acquire applicable knowledge that can be utilized in their daily lives.

The axiology of this learning approach emphasizes the importance of developing values that benefit society and the environment. Disaster mitigation-based science education focuses not only on academic achievements but also on fostering social awareness and ecological responsibility. By engaging students in real-world projects or activities related to disaster mitigation, this approach provides opportunities for students to apply the knowledge they have gained to protect communities and the environment from the impacts of disasters.

Overall, disaster mitigation-based science education integrates these three dimensions of the philosophy of education to create a more holistic and applicable learning experience. This approach not only enriches students' scientific knowledge but also equips them with skills and values that are valuable for their future lives.

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