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Development of Early Landslide Detection Tool as Optimization of Disaster Mitigation Understanding for Early Childhood in Wonosobo

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Abstract
Early childhood is a crucial period with immense potential and high vulnerability to natural disasters. In Wonosobo Regency, landslides pose a serious threat, necessitating concrete efforts to enhance the preparedness of young children. This study aims to develop an early landslide detection tool to improve disaster mitigation understanding among early childhood children. The research method employed is Research and Development (R&D) using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. Data collection techniques include observation, interviews, and documentation, which were subsequently analyzed. The study results indicate that the developed early detection tool is highly feasible, with an expert media evaluation score of 100%, making the product suitable for further testing. Trials showed that this tool could provide fast and accurate warnings about potential landslides, significantly enhancing preparedness and disaster mitigation understanding among young children in the Wonosobo Regency. The implications of this research highlight the importance of integrating early detection technology into disaster mitigation education, which can improve the safety and understanding of young children regarding future disasters.

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Introduction

Early childhood education encompasses all efforts made by teachers and parents to create a safe environment where children can learn through play. They are given ample opportunities to reflect on and internalize lessons learned from their surroundings through repeated exposure to the learning process, engaging their full potential and intelligence (Septantiningtyas, N., Fajri, Z., & Wardani, 2024). Early childhood education in disaster mitigation includes various activities, such as storytelling or games that teach children to recognize early signs of landslides, evacuation drills, and introducing the developed early detection tool (Kurniati et al., 2021). This approach aims to equip children with knowledge and skills to enhance their safety when facing disaster threats like landslides.

The Indonesian archipelago is rich in natural resources but is also highly vulnerable to hazards such as floods, cyclones, earthquakes, and landslides (Septikasari et al., 2024). Events or series of events that threaten and disrupt the lives and livelihoods of people due to natural and/or non-natural factors, as well as human factors, resulting in loss of life, environmental damage, property loss, and psychological impact, are defined under the Indonesian Law No. 24 of 2007 on Disaster Management. Natural disasters result from one or more occurrences caused by nature, such as earthquakes, tsunamis, volcanic eruptions, floods, droughts, cyclones, and landslides (Hantoro et al., 2024). Given Indonesia's geological and geographical conditions, nearly all regions are potentially vulnerable to landslides, including Central Java (Ismowati et al., 2023). The stability of soil or rock on slopes is disrupted, leading to landslides, which are movements of masses of soil, rock, or a combination of down or out of the slope. These events

often result in significant losses, including casualties, environmental destruction, economic losses, and profound psychological impacts. This highlights the critical importance of effective disaster management as a form of disaster mitigation efforts in the country.

Mitigation refers to various preventive measures to minimize the negative impacts of anticipated natural disasters in a specific area in the future (Purwadi et al., 2023). Mitigation can be understood as detecting or recognizing risks, providing information on disaster risks, planning for disaster response, and so on (Tae, P. M. S. Y., Indarwati, R., & Armini, 2024). In short, disaster mitigation involves efforts from pre-disaster to post-disaster. Law No. 24 of 2007 defines disaster mitigation as "a series of coordinated activities conducted to reduce vulnerability to, and the impact of, disasters." Those vulnerable to disasters are the primary focus of disaster mitigation efforts (Tambunan, M. A., & Abdurrahman, 2023). Spatial planning, development regulations, infrastructure development, building planning, education provision, outreach, and training are examples of how conventional and modern approaches to disaster mitigation can work together. Disasters are defined as events or series of events that threaten and disrupt the lives and livelihoods of people due to causes that can be attributed to natural and/or non-natural factors, including human factors, resulting in casualties, environmental damage, loss of property, and psychological impact (Roslaeni, R., Kusuma, A. A., & Fathya, 2022).

Disaster mitigation must begin early to prepare children for natural disasters, starting with understanding and preparing every citizen, from children to the elderly, to face natural disasters. This is key to reducing the damage caused by disasters in Indonesia (Rahiem & Widiastuti, 2020). The high number of child fatalities and the experience of stress and trauma could have been avoided if children were initially shaped with a positive self-concept in understanding disaster mitigation (Ayub, S., Kosim, K., Gunada, I. W., & Utari, 2021). Knowledge of disasters is the primary reason someone undertakes protection or preparedness activities (Rizki, A., Hidayat, W., & Sitorus, 2022). Disaster response capability refers to the capacity of individuals, families, communities, and governments to face, respond to, and recover from disasters (Ramadhan, E. H. F., Sukmana, O., & Habib, 2023). This capability involves several important factors in reducing risks, losses, and the impact of disasters (Safitri, B. V., Fajarica, S. D., Trisula, Y., Maulida, N., & Wahyudi, 2020). Important aspects of disaster response capability include awareness and education, emergency planning, early warning systems, resource availability, community involvement, and post-disaster physical recovery and reconstruction (Zuhdi, A., Yuslim, Y., & Khairani, 2024). Disaster response capability in schools is crucial because schools are environments vulnerable to various types of disasters (Suryadi, Y., Lukitawati, L., & Ulya, 2024). Disaster response capability in schools involves students, teachers, school staff, and other related parties (Lasaiba, 2023).

Central Java Province, located in Indonesia, has a Disaster Risk Index (DRI) for the 2015-2020 period in the medium category, with a score of 132.99. The Landslide Disaster Risk Index (DRI) for the same period in Central Java includes 17 regencies/cities with high landslide risk classes, such as Tegal, Purbalingga, Pekalongan, Banjarnegara, Banyumas, Batang, Purworejo, Boyolali, Wonogiri, Karanganyar, Temanggung, Pemalang, Brebes, Kota Surakarta, Cilacap, Magelang, and Wonosobo. In this context, landslides are one of the most frequently occurring and significantly impactful natural disasters in Central Java Province, particularly in Wonosobo Regency. A landslide is a geological event involving the movement of soil or rock masses down a slope along a slip surface (Latif et al., 2023). Landslides are natural events whose frequency is increasing. Landslides are geological natural disasters that, when they occur, can result in significant loss of life and extensive material damage (Hidayatush Sholikah et al., 2021). Landslides can occur due to land use patterns that do not follow environmental sustainability principles, such as deforestation and excessive exploitation of natural resources beyond their carrying capacity. Landslides are natural disasters that often result in property damage, loss of life, and destruction of public facilities, with social and economic consequences (Nurjanah, S., & Mursalin, 2022). Landslides involve soil masses' downward or outward movement along a slope (Rizal, 2023).

Looking at other regencies or cities in Central Java, the Wonosobo Regency is predominantly located in highland areas (Ndofah & Santosa, 2023). The region, with mostly mountainous and hilly terrain, is highly prone to natural disasters such as landslides (Desderius et al., 2024). According to the Wonosobo Regency Regional Disaster Management Agency's recapitulation, landslides are the most frequent type of natural disaster compared to other natural disasters. In 2023, several landslides were recorded, not only causing infrastructure damage but also resulting in fatalities and psychological trauma, especially among children.

Wonosobo Regency, mainly composed of highland areas, has mountainous and hilly terrain highly susceptible to natural disasters such as landslides (Tessa et al., 2021). Recapitulation from the Wonosobo Regency Regional Disaster Management Agency (BPBD) shows that during 2023, various types of natural disasters occurred with different frequencies each month. There were 5 landslides, 2 floods, and 1 cyclone in January. February saw an increase with 9 landslides, 1 flood, and 1 cyclone. The peak occurred in March with 35 landslides, 1 cyclone, and 16 other incidents involving various forms of damage.

The number of incidents decreased in April and May, with 15 and 23 landslides recorded, respectively. However, the number of landslides increased again in June and July. No disasters were reported in August and September. October saw a resurgence with 19 landslides, while November and December recorded 25 and 34 landslides, respectively. This data highlights the urgency of disaster mitigation in the Wonosobo area, particularly involving early childhood education in disaster response. This mitigation effort includes the development of early landslide detection tools that can be used to reduce the risks and negative impacts of landslides, as well as to improve disaster mitigation understanding among children. Disaster mitigation efforts in Wonosobo Regency, especially those involving early childhood, remain very limited. However, early childhood is among the most vulnerable groups to the impact of disasters.

Disaster risk can be reduced in various ways, including through infrastructure improvement, increased preparedness, and knowledge (Lasaiba, 2023). To minimize the possibility of children being injured or even losing their lives during a crisis, they must be prepared as early as possible by implementing disaster mitigation activities (Widanty & Pamungkas, 2023). Disaster mitigation can take the form of planning and executing spatial plans based on disaster risk analysis, regulating development, building infrastructure and layout, coordinating education and training, and conventional and modern outreach (Sadeghloo & Mikhak, 2022).

The ability of children to learn and retain information, particularly during their golden age, makes early childhood an invaluable asset for spreading awareness and knowledge about disaster preparedness throughout these critical early years (Eraku et al., 2023). Therefore, the development of media that can help children understand and prepare for disasters is crucial. Early disaster response education will enhance their preparedness and foster a generation more aware of the importance of disaster mitigation and environmental protection. When disasters strike, young children are among the most vulnerable (Munasti et al., 2023). Few people recognize the potential hazards in their immediate surroundings (Hidayat et al., 2023). Due to a lack of awareness of potential dangers, no preparatory actions are taken (Maulita et al., 2023). Disasters can occur anywhere, at any time, and affect anyone; thus, disaster management must be integrated into the field of education (Dwiningrum et al., 2020). Teaching children about natural disasters early will raise their awareness of the disasters and the importance of protecting natural resources to reduce the damage they cause (Rahma, 2020).

According to research data from the Regional Disaster Management Agency (BPBD) of Wonosobo Regency, there has been no outreach related to disaster mitigation for early childhood, and only a few locations are equipped with early warning systems for landslides in the region. The existing conventional early warning systems for landslides still require development, especially when placed around early childhood education centers (PAUD), particularly concerning the siren sound. Sadeghloo and Mikhak (2022) explained that interviews with children revealed clear signs and evidence of their suffering from tension and psychological

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disturbances due to disasters. The siren sound of conventional landslide early warning systems is considered to increase children's panic during a disaster, leading to additional negative impacts.

In recent years, Wonosobo Regency has experienced several landslides that have damaged infrastructure and resulted in casualties. In 2023, a landslide in Kalikajar District caused damage to homes and public facilities, and psychological trauma to children in the area. This incident highlights the importance of developing a more child-friendly early warning system to enhance disaster preparedness and understanding of mitigation among young children. Therefore, this has prompted researchers to develop a landslide detection tool by modifying the siren sound to optimize disaster mitigation understanding in early childhood in the Wonosobo Regency. This research focuses on developing a child-friendly early warning system for landslides, which is expected to reduce the psychological negative impacts of the current warning systems, such as the panic-inducing siren sound. This development will be tested in three PAUD institutions in Wonosobo Regency, each with different geographical characteristics but all located in disaster-prone areas.

The characteristics of these PAUD institutions include being situated on mountain slopes with a high frequency of landslides, being in highland areas with road access often blocked by landslides, and being in regions that frequently experience simultaneous landslides. By focusing the research on these three schools, the researchers can obtain more comprehensive data on the effectiveness of the landslide early warning system and disaster preparedness in various geographical conditions. This research aims to enhance children's preparedness for landslides while contributing to broader disaster mitigation efforts in Indonesia. Through this study, it is hoped that a significant contribution can be made to landslide disaster mitigation, particularly in improving the preparedness of early childhood in disaster-prone areas. Furthermore, this research is also expected to have broader implications for disaster response education in Indonesia.

Methods

This research employs the research and development (R&D) method, which is used to create specific products and involves a needs analysis to test the product's effectiveness. The R&D method is a research approach designed to produce specific products and evaluate the effectiveness of existing ones (Okpatrioka Okpatrioka, 2023). Research using the R&D method is utilized to develop and validate products used in the learning process. The development model used in this study is the ADDIE model, which comprises five stages: analysis, design, development, implementation, and evaluation. The ADDIE model consists of five interrelated and systematically structured components, meaning that each stage must be applied systematically from the first to the fifth and cannot be ordered randomly (Ishari et al., 2020). The researcher developed a landslide early warning system, focusing on the siren sound, to optimize disaster mitigation understanding for early childhood in the Wonosobo Regency. The subjects in this study are teachers and students from RA Masyitoh Mojotengah, KB Al A'la, and TK Pertiwi Mergolangu. The selection of RA Masyitoh Mojotengah, KB Al A'la, and TK Pertiwi Mergolangu is based on their strategic geographical location and their representativeness of early childhood education institutions (PAUD) in this area. Additionally, these three institutions have demonstrated readiness and commitment to implementing disaster mitigation education programs, supporting the execution of this research.

The inclusion criteria for this study include PAUD institutions located in landslide-prone areas in Wonosobo Regency, having a curriculum that includes disaster mitigation education, and being willing to actively participate in the research and implementation of the landslide early warning system. Exclusion criteria include PAUD institutions not located in landslide-prone areas, lacking the capacity or willingness to implement disaster mitigation education programs, and being unable to fully commit to this research due to time or resource constraints.

In the analysis stage, the researcher conducts a needs analysis. This needs analysis includes a thorough understanding of the currently available technology for landslide detection and mitigation, the level of disaster mitigation understanding among early childhood children, and an in-depth comprehension of the local geographical, geological, and social characteristics to ensure that the developed tool is suited to the field conditions. The researcher distributed questionnaires to teachers to assess their needs regarding the developed product and the relevance of the landslide early warning system as a disaster mitigation effort for early childhood children. Once all the questionnaires are filled out, the researcher calculates the results using percentage techniques, comparing the number of responses for each aspect chosen by the respondents with the total number of respondents. The analysis technique used involves calculating percentages to understand the level of need and readiness of PAUD institutions to use this tool.

Table 1. Scale Value Interpretation

Value	Interpretation
84%-100%	Highly accurate/very attractive/very feasible/very appropriate/very good
63%-83%	Accurate/attractive/feasible/appropriate/good
44%-62%	Moderately accurate/moderately attractive/moderately feasible/moderately good
25%-43%	Less accurate/less attractive/less feasible/less appropriate/less good

The calculation formula is as follows:

$$CapP = \frac{f}{n} \times 100\%$$

Explanation:
P = percentage
f = frequency of each questionnaire response
n = total number of responses

Second, the design phase: In this stage, the landslide detection tool for early childhood education institutions (PAUD) is designed by considering functional feasibility and presentation feasibility. The functional feasibility aspect involves selecting technical components such as speakers, modules, DFPlayer, and others, that are appropriate for detection needs in an early childhood environment. The presentation feasibility aspect focuses on designing the tool to be child-friendly in terms of appearance and usability. The initial prototype is developed based on the needs analysis and adapted to early childhood children's cognitive and psychological abilities.

Third, there are two sub-stages in the development phase: the creation of the landslide early detection tool and expert validation. The creation of the landslide early detection tool includes gathering materials such as speakers, modules, DFPlayer, memory cards, batteries, songs, and others. These gathered materials are then developed into a landslide early detection tool. The landslide early detection tool is developed by integrating all the technical components. Each component is tested individually to ensure its functionality before being assembled into a single tool.

The initial product of the landslide early detection tool for PAUD institutions that has been developed is then reviewed through validation by a media expert, a lecturer in Early Childhood Education (PG PAUD) from Semarang State University (UNNES), and the Regional Disaster Management Agency (BPBD) of Magelang Regency. The validator is a PAUD lecturer from UNNES because the lecturer has expertise in early childhood education, which is crucial to ensure that this landslide early detection tool meets young children's needs, understanding, and psychology. Validation from an academic in this field is necessary to ensure the tool is technically adequate, safe, and suitable for use in a PAUD educational environment. The expert validator from BPBD Magelang is involved because BPBD Magelang initiated the development of the

conventional landslide early detection tool and, therefore, has the relevant expertise and experience to evaluate and provide feedback for the improvement of this product.

This step aims to determine the feasibility of the developed landslide early detection tool and obtain suggestions for improvements to the initial product before it is tested on students. The researcher uses a questionnaire for product validation. This validation instrument contains questions about the prototype of the landslide early detection tool. The validity test questionnaire helps the researcher identify weaknesses in the created prototype. The measurement in this questionnaire uses a Likert scale. The Likert scale has two types of questions: positive and negative. Positive questions are scored 4, 3, 2, and 1, while negative statements are scored 1, 2, 3, and 4. The Likert scale answer options include strongly agree, agree, uncertain, disagree, and strongly disagree. The Likert scale measures the attitudes and opinions of an individual or group about a particular phenomenon (Aulia, B. N. R., & Budiningsih, 2021). This study uses the Likert scale as a measurement tool with a checklist format to determine product feasibility. The following is a blueprint for the media validation assessment scale:

Table 2. Media Expert Evaluation Interpretation

No	Interpretation	Value
1	Very Good	4
2	Good	3
3	Poor	2
4	Very Poor	1

Fourth is the implementation phase. The landslide early detection tool has improved and is deemed suitable for use. It is then implemented in real situations, specifically with young children in PAUD institutions in Wonosobo Regency. In this phase, teachers and students are directly involved in using the developed landslide early detection tool. Teachers are trained to use the tool and provide disaster mitigation education to children. The tool is tested in real-life situations, with teachers and students actively participating. Data is collected through observations, interviews, and questionnaires to evaluate the responses of children and teachers to the tool. The researcher collects data and information on the responses of teachers and students to assess the feasibility, strengths, and limitations of the media.

Fifth is the evaluation phase. Based on the responses of teachers and students during the implementation process, improvements to the landslide early detection tool for PAUD institutions are made. The essence of this evaluation is to ensure that the developed media is categorized as relatively feasible for use in real-life situations.

Result

Analysis

The researcher analyzed the need for optimizing disaster mitigation understanding of landslides among young children in Wonosobo Regency. This needs analysis was carried out through observations, direct interviews with teachers, distribution of needs questionnaires, and documentation.

The observations at three educational institutions, RA Masyitoh Mojotengah, KB Al A'la, and TK Pertiwi Mergolangu, showed that the majority of teachers felt a need for media that could enhance the understanding of landslide disaster mitigation among young children. Teachers desired media that was educational, enjoyable, and easy for children to understand. According to an interview with one of the teachers at TK Pertiwi Mergolangu, "Children need interactive and easily understandable learning media to be better prepared for disasters" (Teacher, TK Pertiwi Mergolangu, 2023). This statement reinforces the previous observation about the need for appropriate media. Questionnaires were given to teachers from the three institutions. Teachers indicated a strong need for interactive media capable of providing a deep understanding of disaster mitigation to young children. The questionnaires assessed aspects such as the need for media, ease of use, and appropriateness of content for the children's age.

Additional documentation, including field notes and photos of classroom activities, supported the observations and interviews, showing that existing media were still inadequate in providing children with an understanding of landslide disaster mitigation.

Based on the analysis of these data sources, the researcher decided to develop a landslide early detection tool. The development process of this product was fully aligned with the results obtained for the needs analysis. Data from the teachers' needs reinforced the product development questionnaires, interview results, and observations. Questionnaires were provided to teachers from the three educational institutions: RA Masyitoh Mojotengah, KB Al A'la, and TK Pertiwi Mergolangu.

Design

At this stage, the researcher designed the form and operational process of the landslide early warning system (EWS) to optimize disaster mitigation understanding among young children. The design of the landslide early warning system involved considering effective technology to minimize risk to young children. This early warning system adopts simple yet effective technology that uses a pendulum and jack mechanism to detect soil movement. Similar technology has been used in various simple disaster detection systems, such as earthquake detectors and tsunami warning systems, demonstrating its effectiveness in providing early warnings.

A metal pole is planted in the ground or attached to a building wall. A pendulum or weight is placed below the EWS and connected with a strong cord. The pendulum and EWS are connected with a durable cord. The jack is connected to a release mechanism that operates on the principle of gravity. The EWS activates during a landslide disaster. When the pendulum pulls the jack connected to the EWS, it will release and emit a siren sound. This mechanism is designed to work automatically without requiring manual input during a disaster. The siren on the EWS will be modified to minimize fear in children, aiming to reduce the risk of them becoming victims during a landslide as part of optimizing disaster mitigation understanding among young children.

Components such as the jack and release mechanism were selected for their simplicity and reliability in warning systems. Materials like nylon cord and concrete weights were chosen for their strength and durability under environmental conditions. The siren was modified to include a calming melody to reduce the psychological impact on children. Below is a simulation of the product's operation:

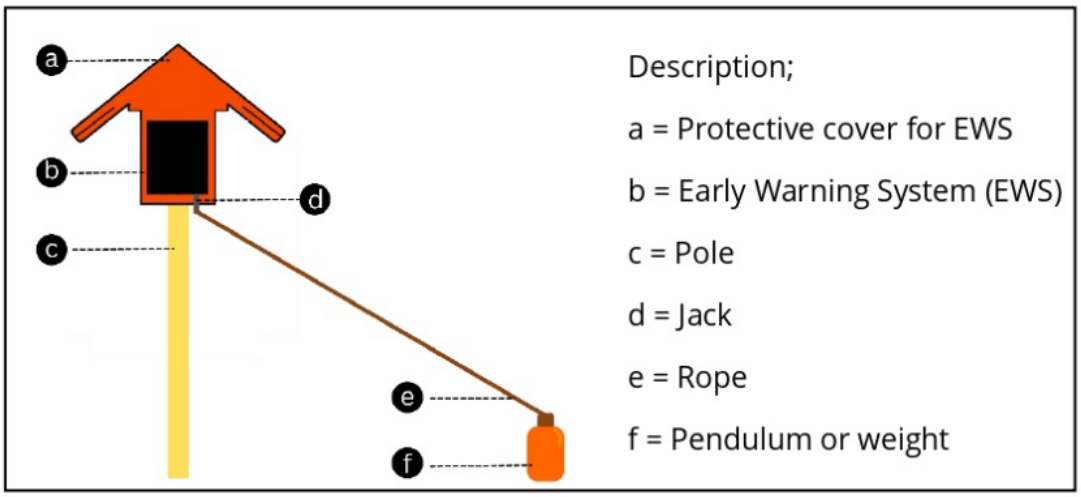

Figure 1. Work Process Simulation

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Development

In this stage, the collection of tools and materials such as speakers, modules, DFPlayer, memory cards, batteries, amplifiers, songs, and iron poles was carried out. The DFPlayer module is used to play audio files from a memory card. The DFPlayer Mini supports MP3 and WAV formats with good sound quality. A 2 GB memory card is used to store audio files containing disaster mitigation messages and relevant songs. A 9V battery is used to power the entire system, with sufficient capacity to ensure the device functions for several hours during emergencies. An amplifier is used to boost the audio signal from the DFPlayer module to the speaker, ensuring the sound is clear and loud. The iron pole serves as the physical support for the EWS components and is strategically positioned within the early childhood education institution.

The collected materials are then developed into an early warning system for landslides in early childhood institutions. The speaker is connected to the amplifier via an audio cable. The amplifier is then connected to the DFPlayer module to receive the audio signal. The DFPlayer module is connected to the memory card containing the audio files. The battery is connected to the system to provide power. During the development process, the researcher also incorporated music as an integral element of the early warning system. Music was chosen because it can attract children's attention and make them more responsive to early warnings. The songs used are tailored to the theme of disaster mitigation and are designed to convey important messages in a fun and easily understandable manner for children.

The development results of the early warning system for landslides as an effort to optimize disaster mitigation understanding among early childhood children in Wonosobo Regency are as follows. This device is equipped with sound and music features that provide children with information and disaster mitigation instructions, helping them understand and remember the steps to take during an emergency. The following is a diagram showing the relationship between the EWS components:

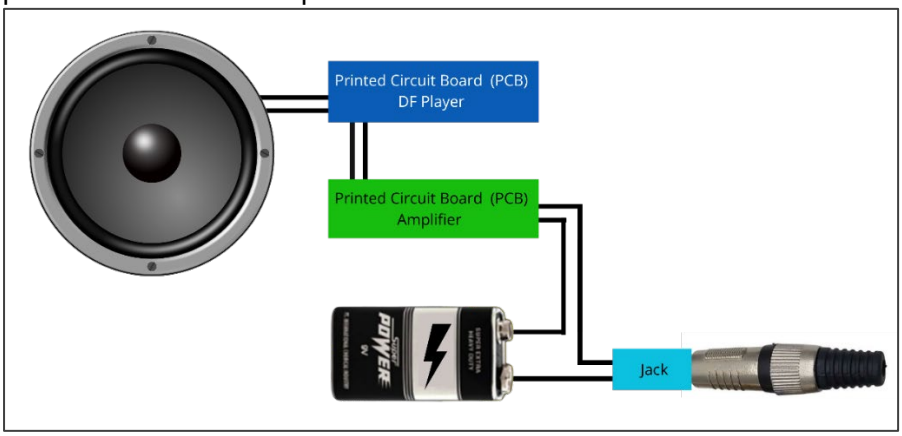

Figure 2. Components of the Early Warning System for Landslide Development

Initial testing was conducted to ensure all components functioned correctly. Testing involved checking the sound quality produced by the speaker, the stability of the DFPlayer module's signal, and the battery's durability. The test results showed that the system operated well, with clear and sufficiently loud sound. The DFPlayer module successfully played audio files without interruption, and the battery provided stable power during the test period. The components were integrated by ensuring each part was properly connected and functioned as intended. The speaker and amplifier worked together to produce the appropriate sound, while the DFPlayer and memory card managed the playback of audio files. The entire system was assembled to ensure compatibility and effectiveness in providing early warnings. Below is a picture of the assembled and ready-to-use early warning system for landslides:

Figure 3. Assembled and Ready-to-Use Early Warning System for Landslides

This device is equipped with sound and music features that provide children with information and disaster mitigation instructions, enabling them to understand and remember the steps to take in emergencies. With the effective integration of components, this tool is expected to enhance disaster mitigation understanding among early childhood children in Wonosobo Regency. The following is the musical notation for the song "Heading to Safe Places" created by Nabila Zakiyyatul.

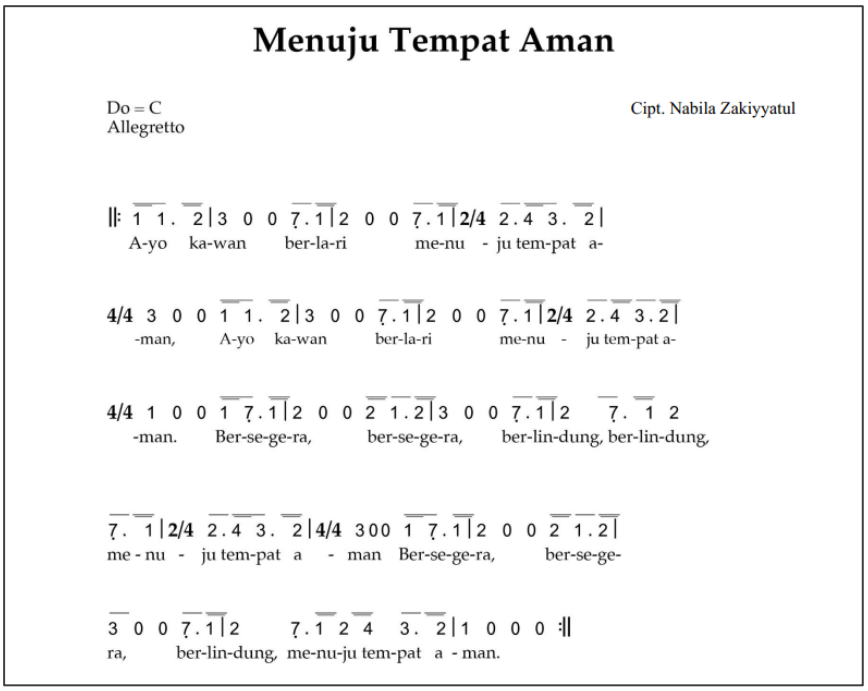

Figure 4. Siren for the Song "Menuju Tempat Aman"

This song uses numeric notation with an Allegretto tempo (relatively quick and light). The song's key is C major, meaning the base note is C. The time signature is 4/4, indicating that each measure or section of the song consists of 4 beats. Numeric notation shows pitch, where each number corresponds to the diatonic scale (1 = do, 2 = re, and so on). A dot above or below a number indicates a higher or lower octave. A horizontal line above a number denotes a longer duration, and a "/" symbol represents a half-beat or a change in timing. The song features a fairly regular rhythm with not too complex pitch variations, suitable for children or beginner groups. The theme of the song is about safety and the spirit of togetherness in facing challenges.

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Emotionally, the song conveys optimism and urgency to reach a better or safer place. It is used in educational or safety training contexts, such as disaster simulations or evacuation drills, and can also guide children in emergencies.

Validation

The early warning system for landslides, developed to optimize disaster mitigation understanding among early childhood children, was validated by experienced experts to evaluate the designed product. The media experts who supported this product include lecturers from the Early Childhood Education Department at Semarang State University and the Regional Disaster Management Agency (BPBD) of Magelang Regency. The media expert from BPBD Magelang was involved because the researcher developed the early warning system for landslides, which was initially created by BPBD Magelang, and possesses relevant expertise in this research. Validation was carried out using a questionnaire consisting of 12 evaluation indicators. This questionnaire was developed based on aspects of functional feasibility and presentation feasibility of the product. Each indicator was assessed using a 1-4 Likert scale, where one indicates poor and 4 indicates excellent.

The indicators assessed in the validation of this tool include aspects of functional feasibility and presentation feasibility. Functional feasibility indicators include whether the tool can inform about disasters, minimize children's panic during disasters, increase students' knowledge about disaster mitigation, and assist teachers in achieving learning goals related to disaster mitigation. Presentation feasibility indicators include whether the design is simple and easy to create, can be used for a long period, enhances students' motivation towards disaster mitigation learning, uses materials that are easy to obtain, has audible sound in the school environment, is related to disaster mitigation, has an appropriate size, and is weather-resistant.

According to the validator from BPBD Magelang, "This tool is very efficient in detecting soil movement in landslide-prone areas. It could be disseminated to others to make the tool's design more beneficial." The validator from Semarang State University commented, "The instructions for using the tool are quite clear and easily understood by children,"

Table 3. Validation Results

Aspect	Media Expert		Total
	BPBD Magelang Regency	ECE Lecturer Semarang State University	
Functional Feasibility	16	16	32
Presentation Feasibility	32	32	64
Total	48	48	96

Percentage Obtained

$$P = \frac{f}{n} \times 100\% P = \frac{96}{96} x 100\%$$

$$P = 100\%$$

The results show that all 12 indicators received a score of 4, with perfect criteria. The maximum score is 96, and the obtained score is 96, resulting in a feasibility percentage of 100% with a very good criterion.

Design Revision

In this phase, revisions are made to achieve a valid media design. Revisions are carried out if the design does not meet the desired level of validity. This process may involve adding or removing content from the media. After developing the initial prototype of the early warning system for landslides, an initial evaluation was conducted by a team consisting of media experts, early childhood education teachers, and several young children as test subjects. The initial evaluation focused on the functionality and effectiveness of the information delivery to the children. The criteria used in this evaluation included the clarity of the siren as a warning signal, children's engagement, and the educational impact of the tool.

Feedback from early childhood teachers indicated that children were confused by the alarm sound, and some did not recognize it as a danger signal. Based on this feedback, the researchers decided to replace the siren with a disaster mitigation-themed song with simple lyrics, which provided clearer and more enjoyable instructions to the children. In this way, the tool functions not only as an early warning device but also as an engaging educational medium.

Before the revision, the siren only consisted of a standard module that played alarm sounds. After the revision, the researchers used the DFPlayer module to integrate the disaster mitigation song into the tool. This song is designed to play automatically when the tool detects signs of a landslide. The final product evaluation stage involves the final inspection and completion of the media development. This process is also part of quality control for the created media. After the revisions and evaluations are completed, the tool is ready for use by young children.

Implementation

The implementation phase of the ADDIE model focuses on applying the results from the design and development phases of the early warning system for landslides in a real-world environment. This phase includes preparation, training, curriculum integration, classroom implementation, and monitoring and support.

Before implementing the early warning system with children, training teachers and educators to use the tool and the developed materials is important. This training includes an introduction to the function of the early warning system, interpretation of the results, and effective teaching strategies to utilize the tool in disaster mitigation. The early warning system for landslides must be integrated into the existing curriculum in a planned manner. This involves adjusting the teaching schedule, ensuring the tool supports learning objectives, and providing guidance to educators on connecting the tool with existing disaster mitigation learning activities.

Implementation is carried out directly in the early childhood learning environment. Each class will be provided access to the early warning system for landslides, and educators will teach the material using the tool. During implementation, monitoring children's interactions with the tool and gathering feedback on their engagement and understanding is crucial. Throughout the implementation phase, regular monitoring is conducted to ensure that all aspects proceed as planned. Technical and pedagogical support is provided to educators if any issues arise with using the tool. This also involves collecting data on the tool's effectiveness in enhancing disaster mitigation understanding.

Evaluation

The evaluation phase in the ADDIE model aims to assess the effectiveness of the implemented early warning system for landslides and identify areas for improvement. This phase includes formative and summative evaluation, performance and outcome analysis, recommendations and revisions, and reporting.

During implementation, formative evaluation is conducted to obtain immediate feedback from educators and children. This includes direct observation, interviews with educators, and feedback from children about their experiences with the early warning system. Formative evaluation results are used to adjust the materials or teaching methods immediately. After the implementation phase, a summative evaluation is carried out to assess the overall impact of the early warning system. This involves analyzing data collected during implementation, including test results on disaster mitigation understanding, feedback from educators and parents, and observations of changes in children's knowledge and behavior regarding disaster mitigation.

Data collected from formative and summative evaluations are analyzed to determine whether learning objectives have been achieved. This analysis also includes an assessment of the technical and pedagogical aspects of the tool, as well as the effectiveness of its implementation in a real-world context. Based on evaluation results, recommendations for improvement are developed. This includes suggestions for tool revisions, adjustments in

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teaching methods, or technical improvements. These recommendations aim to enhance the effectiveness of the early warning system in supporting disaster mitigation understanding among young children. Evaluation results are compiled into a report that includes key findings, analysis, and recommendations for further development. This report is used as a basis for decision-making regarding improvement actions and to communicate results to all involved stakeholders.

During the implementation phase, observation methods include a checklist to assess children's interactions with the early warning system for landslides. This checklist includes aspects such as the level of response to the siren, understanding of instructions given through the song, and children's engagement in disaster mitigation simulations. Additionally, field notes are used by educators to record spontaneous responses from children during learning sessions. Interviews are conducted with educators and children after the implementation sessions are completed. Example questions for teachers include, "How effective do you find the early warning system in capturing children's attention?" For children, questions are adjusted to their level of understanding, such as, "What do you do when you hear the siren?" Feedback from children is collected through small group discussions led by teachers. A simple survey assesses children's comfort level with the tool.

Formative evaluation showed that 85% of children demonstrated an increased understanding of the actions to take during a landslide after using the Early Warning System (EWS). Summative data indicated that after three practice sessions using the EWS, the average score for disaster mitigation understanding increased by 20% compared to before implementation. Example quotes from interviews with educators include, “Children seem more aware of the importance of acting quickly when the siren sounds, and they more easily remember the instructions delivered through the song.” To visualize the results, the following table shows the improvement in disaster mitigation understanding before and after using the EWS.

Table 4. Validation Results

Assessment Aspects	Before	After
Understanding Actions During Siren	60%	85%
Understanding Song Instructions	55%	80%

Based on the evaluation results, specific recommendations include improving the sound quality to ensure the siren is clearer in various environmental conditions, especially outdoors. Additionally, interactive learning modules that engage children more directly, such as simulation games, should be incorporated to reinforce their understanding of disaster mitigation.

Discussion

Early childhood can learn and retain information because they are in the golden age, making spreading awareness and knowledge about disaster preparedness during these formative years crucial. Young children are at the highest risk of being affected during crises, compounded by the fear caused by conventional siren sounds that may lead to panic during disasters. Few people know the potential dangers in their immediate environment, and anticipatory actions are not taken due to a lack of awareness about possible risks. Disaster management should be integrated into education since disasters can occur anywhere and anytime.

This research aimed to develop and evaluate the effectiveness of an early warning system for landslides explicitly designed for young children to enhance their understanding of disaster mitigation. The results show that this tool functions effectively as an early warning system and helps reduce the fear associated with conventional sirens. Children are more receptive to instructions delivered through songs, positively impacting their preparedness for landslide hazards.

The research demonstrates that developing the early warning system for landslides to optimize disaster mitigation understanding in young children has been successful. The tool

operates well in providing early warnings for potential landslide hazards. Field test data indicate that after three simulation sessions using the early warning system, 85% of the participating children could correctly respond to the siren and follow appropriate mitigation procedures. Additionally, pre-and post-implementation surveys show a 20% increase in disaster mitigation understanding, reflecting the tool's effectiveness in educating young children.

This study reinforces findings highlighting the importance of innovative approaches in disaster mitigation education for children, such as interactive educational technology, which has proven effective in enhancing disaster mitigation understanding (Zulfiya et al., 2023). Replacing conventional siren sounds with educational songs has reduced panic, aligning with prior findings that conventional sirens often induce fear in children (Sadeghloo & Mikhak, 2022). Moreover, participatory education approaches involving children in simulations have significantly improved preparedness for disaster risks (Zhong et al., 2021). Context-specific training exercises have also been found to influence children's awareness of disaster risks substantially (Parham et al., 2021). Educational approaches emphasizing interpersonal interactions enhance awareness and sustainability in disaster mitigation, as evidenced by interaction-based training results (Pormon & Lejano, 2023). Furthermore, actively involving children in disaster risk reduction education has optimized community resilience-building efforts (Delicado et al., 2017).

However, these findings also contrast with some previous studies. High-risk awareness among children, often shaped by past experiences, does not necessarily correlate directly with their level of preparedness, which tends to depend on the availability of resources and social support (Muzenda-Mudavanhu et al., 2016). In contrast, this study shows that a song-based early warning system can significantly enhance preparedness without heavy reliance on external resources. Demographic factors such as age and gender, previously found to influence risk perception, can be mitigated through targeted educational approaches, thereby improving preparedness across diverse groups (Cvetković et al., 2024). Additionally, the focus on reducing fear through educational songs offers a novel approach distinct from conventional sirens, providing children with a more positive and engaging experience in understanding disaster risk mitigation (Parham et al., 2021).

These findings have significant implications for disaster mitigation in young children. With the development of an effective early warning system for landslides, children can become more prepared and aware of landslide hazards and take appropriate preventive actions. This can reduce the risk of injury and loss of life during disasters. The successful implementation of this early warning system also encourages the development of similar technologies in other landslide-prone areas.

The limitations of this study include the limited sample size, which covers only a few groups of young children at a single test location. Moreover, the tool's effectiveness has not been tested across various geographic and socio-cultural conditions. Therefore, the generalization of results is limited to contexts similar to the test location. Further research is needed to develop this tool with additional features, such as interactive learning modules that allow children to practice simulations more thoroughly.

Conclusion

Based on the conducted research, it can be concluded that developing an early warning system for landslides effectively optimizes disaster mitigation understanding among young children in the Wonosobo Regency. The development process of this tool followed the ADDIE model, with each stage carefully executed. In the analysis stage, the needs of young children in understanding disaster mitigation were identified through interviews with educators and field surveys. The design stage involved creating a prototype tool tailored to children's needs, including selecting child-friendly educational materials and modifying the siren sound. The development stage included creating the tool and integrating the educational song 'Menuju Tempat Aman' to reduce children's fear of conventional siren sounds. During the

implementation stage, the early warning system was tested in several schools in Wonosobo Regency. Teachers and children were trained to use the tool in disaster mitigation simulations. The tool significantly reduced children's panic, as observed directly and based on questionnaires filled out by teachers. In the evaluation stage, quantitative analysis of pre-and post-implementation surveys showed a 20% increase in disaster mitigation understanding among children using the tool. Formative and summative evaluations also included feedback from educators suggesting improvements to the siren volume for noisier environments.

Field test results showed that the children involved could follow disaster mitigation instructions well after using the tool. Survey data from 6 teachers indicated that they found the tool very helpful in raising children's awareness of landslide dangers, with teachers giving positive feedback on the tool's effectiveness. Additionally, field observations revealed a significant reduction in children's panic during disaster simulations compared to conventional sirens. The validation methods used in this research involved two media experts, one from BPBD Magelang Regency and one from a lecturer at Semarang State University. They assessed the tool using 12 indicators covering functionality, presentation, and child engagement. The criteria included the suitability of educational materials for children's age, the effectiveness of the siren sound in communicating disaster threats, and ease of use by educators. Validation results showed that the tool met all criteria with maximum scores, indicating that it is highly suitable for use as an educational medium for disaster mitigation.

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