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Technology-Enhanced Disaster Education for Early Childhood: Interactive Media to Build Safety and Resilience

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Abstract

Early childhood is one of the most vulnerable groups during disasters, yet disaster education at this level is often overlooked. This lack of early preparedness can increase risks when emergencies such as earthquakes occur. To address this problem, this study developed a disaster learning model for early childhood that integrates disaster risk reduction into a contextual and enjoyable learning process. Using a Research and Development (R&D) approach with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), the research was conducted at TK Putra Kaili Permata Bangsa in Palu, involving 27 children aged 5–6 years. The model was designed through a play-based approach using child-friendly media such as videos, songs, storytelling, and a modified snakes-and-ladders game, structured in three stages: pre-play, during play, and post-play. Expert validation of instructional design, content, media, and language indicated high feasibility, with most aspects scoring above 80%. Effectiveness testing revealed significant improvements in children's disaster preparedness across six key aspects, with N-Gain scores ranging from 0.59 to 0.74. These findings highlight the importance of introducing disaster education in early childhood, as the model not only strengthens safety and resilience but also offers a participatory and enjoyable strategy for disaster mitigation learning.

Keywords: Disaster Education, Early Childhood, Learning Model, Earthquake Preparedness, ADDIE Model, Play-based Learning.

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INTRODUCTION

Indonesia is one of the most disaster-prone countries in the world. Its geographical position at the convergence of three major tectonic plates makes the region frequently experience earthquakes, tsunamis, volcanic eruptions, and floods (Djalante et al., 2017). Natural disasters can occur at any time and cause serious impacts, both in the form of physical destruction and social, economic, and psychological disruptions, especially for vulnerable groups such as children. According to ISDR (2004), a disaster is a serious disruption to the functioning of a community that causes widespread losses and exceeds the community's capacity to cope using its own resources (ISDR, 2004).

Children are among the most vulnerable groups affected by disasters. Disasters can disrupt their daily routines, cause psychological disturbances, limit opportunities for socializing and learning, and increase the risk of long-term trauma (Bryant et al., 2018; Gibbs et al., 2019; Mudavanhu et al., 2015; Peek & Fothergill, 2014). Studies show that most children lack sufficient understanding or skills to respond appropriately to emergency situations (Tuladhar et al., 2014). Limited access to disaster risk education is one of the main factors contributing to children's extreme vulnerability in disaster contexts (Thapa & Pathranarakul, 2019).

This vulnerability is exacerbated by the high rate of damage to educational facilities during disasters. Kousky (2016) highlights that many schools suffer severe damage, which hinders the teaching and learning process and increases psychological stress among children (Kousky, 2016). Therefore, educational institutions, including Early Childhood Education (ECE), must be at the forefront of providing a safe learning environment while also serving as a platform to instill disaster awareness and mitigation skills from an early age (Stough et al., 2018).

Early childhood is known as the "golden age" of child development, during which rapid cognitive, social, and emotional growth occurs. At this stage, children easily absorb information and form basic concepts through concrete experiences. Thus, introducing disaster knowledge and mitigation skills through enjoyable and developmentally appropriate learning activities is highly suitable (Midtbust et al., 2018; Nirmala et al., 2021). Play-based, singing, and storytelling learning models are effective approaches to stimulate children's understanding of disaster situations.

Several previous studies have highlighted the importance of disaster education for children (Adiyoso & Kanegae, 2012; Pfefferbaum et al., 2018; Proulx & Aboud, 2019). However, most of these studies have focused on children at the elementary school level and above (Aroyandini et al., 2023; Seddighi et al., 2022). Few studies have specifically designed and implemented disaster learning models for early childhood using a thematic-integrative approach that aligns with the characteristics of ECE (Khaerudin & Suharto, 2022). Moreover, children's involvement in disaster mitigation processes remains limited, even though active participation can enhance motivation and strengthen the development of social and cognitive skills (Javier, 2022; Krishna et al., 2022). This research gap underlines the urgent need for a disaster education model specifically tailored to early childhood, particularly in earthquake preparedness, which remains underexplored in current literature.

In addressing this gap, the present study applies the principles of Child-Centered Disaster Risk Reduction (CC-DRR), which as outlined in the literature review positions children as active participants in disaster education rather than passive recipients. Previous studies emphasize that CC-DRR fosters agency, critical thinking, and independence in children when dealing with risks (Ronan et al., 2016). The integration of CC-DRR principles into play-based learning ensures that disaster preparedness is not only informative but also participatory, enjoyable, and aligned with child development stages. In the Indonesian context, this approach resonates with Ki Hajar Dewantara's philosophy of *Merdeka Belajar* (independent learning), which emphasizes providing children with opportunities to learn according to their individual potential, interests, and developmental needs (Marwany et al., 2023).

The novelty of this study lies in the development of a disaster education model for early childhood that combines CC-DRR principles, play-based pedagogy, and instructional design through the ADDIE model. The ADDIE framework (Analysis, Design, Development, Implementation, and Evaluation) was selected because of its systematic and iterative nature, allowing the model to be tested for feasibility and effectiveness in a structured manner (Branch, 2009). Compared to existing models, the developed approach emphasizes contextual learning media such as modified snakes-and-ladders games, storytelling, and songs specifically designed to enhance earthquake preparedness in early childhood while ensuring safety, enjoyment, and cultural relevance.

Based on the above background, this study formulates the following research questions:

1) how can a disaster learning model for early childhood be developed to address earthquake preparedness?
2) what is the feasibility of the disaster learning model when evaluated by experts in instructional design, content, media, and language?
3) what is the effectiveness of the developed model in improving early childhood disaster preparedness?

Accordingly, the hypothesis of this study is that: the disaster preparedness learning model developed through play-based learning and the ADDIE framework is feasible and effective in improving children's knowledge, skills, and attitudes toward earthquake preparedness.

METHODS

The type of research used is Research and Development (R&D), an approach aimed at producing a specific product while also testing its effectiveness. This study adopts the ADDIE development model, which consists of several stages: 1) Analysis, 2) Design, 3) Development, and 4) Implementation-Evaluation (Branch, 2009; McGriff, 2000).

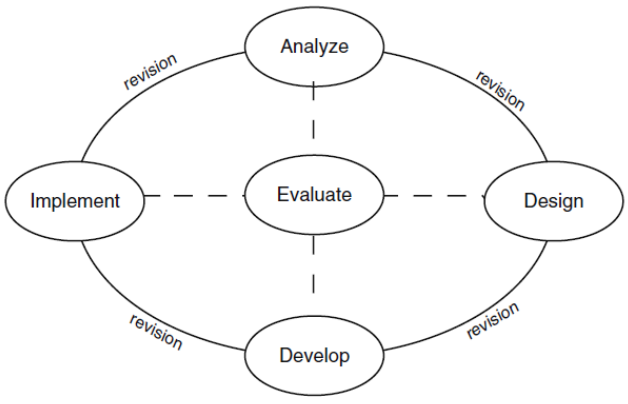

Figure 1. The ADDIE Development Model (Source: Branch, 2009)

A one-group pretest–posttest design was used in this study without a control group. The absence of a control group was due to ethical considerations in early childhood education research, as it was deemed inappropriate to exclude some

children from receiving potentially beneficial disaster preparedness education. Thus, all participants were given the opportunity to take part in the intervention.

The research was conducted at TK Putra Kaili Permata Bangsa, Palu City, an area prone to earthquake disasters. The participants consisted of 27 children aged 5–6 years, selected through purposive sampling. The sampling criteria included:

1) children enrolled in the institution during the study;
2) aged between 5–6 years;
3) able to follow learning activities with basic communication skills; and
4) having parental/guardian consent to participate.

Several instruments were employed in this study:

1) Observation sheets: used to assess children's engagement, behavior, and responses during the learning activities. Two observers were involved, and inter-rater reliability was calculated using Cohen's Kappa.
2) Interview guides: used with teachers and parents to gain qualitative insights into the practicality and impact of the model.
3) Pretest-posttest items: designed to measure children's understanding of earthquake disaster mitigation. These items underwent expert validation (instructional design experts, subject matter experts, media experts, and language experts). The Content Validity Index (CVI) was used to ensure appropriateness of items, and instrument reliability was tested using Cronbach's Alpha.
4) The validation instruments were developed by adapting criteria from (Nieveen, 1999), (Borg & Gall, 1983), (Joyce, B. & Weil, 2020), and (Mayer, 2002), as well as principles of early childhood education (Bredekamp & Copple, 1997). These references guided the formulation of aspects assessed by instructional design experts, subject matter experts, media experts, and language experts

Data analysis in this study employed both quantitative and qualitative methods. Quantitative data were derived from expert validations and the results of pretests and posttests. The feasibility assessment of the learning model was carried out using a four-point Likert scale (Very Good = 4; Good = 3; Fair = 2; Poor = 1) (Risdianto et al., 2022).

The total scores obtained from the evaluation forms were then converted into percentages by dividing the actual score by the maximum possible score and multiplying the result by 100. This percentage conversion method is widely used in instructional design and model development research to determine feasibility levels (Sugiyono, 2015). Based on the percentage values, the criteria for the feasibility level of the disaster learning model for early childhood education were established, as shown in Table 1.

Table 1. Eligibility Criteria

Percentage (X)	Criteria
$X > 80\%$	Very Feasible
$61\% < X \leq 80\%$	Feasible
$41\% < X \leq 60\%$	Fairly Feasible
$21\% < X \leq 40\%$	Less Feasible
$0\% < X \leq 20\%$	Not Feasible

After all components of the learning model were declared feasible, a field trial was conducted to test the effectiveness of the model. According to Nieveen (1999), the effectiveness of a product can be measured by how much students appreciate the program they are learning and the extent to which they are motivated to continue using the program (Nieveen, 1999).

Effectiveness analysis was carried out by calculating the percentage of children's performance before and after observation. The results of the analysis were then interpreted. The increase in children's knowledge was calculated using the normalized gain formula developed by (Meltzer, 2002). The formula used is as follows:

$$\text{N-Gain (g)} = \frac{\text{Skor posttest} - \text{skor pretest}}{\text{Skor ideal} - \text{skor pretest}}$$

Table 2. N-Gain Score

***N-Gain* (g)**	**Category**
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

Source: (Hake, 1998)

This research followed ethical research principles in early childhood education. Ethical clearance was obtained from the Research Ethics Committee. Informed consent was obtained from parents/guardians, and children's participation was voluntary. All data were kept confidential and used solely for research purposes.

RESULTS & DISCUSSION

Data and information were obtained through preliminary studies, development, and field trials. The presentation of research results is as follows:

Result

The disaster education learning model for early childhood was developed based on user needs. This model was designed and developed through a model validation stage, which includes Analysis, Design, Development, Implementation, and Evaluation. These phases are illustrated as a cyclical and continuous process to enhance instructional development related to disaster education for young children.

Analysis Phase

Needs analysis was conducted through field studies, observations, and interviews with teachers and heads of early childhood education (ECE). The findings show that most ECE institutions do not yet have a systematic disaster learning model that aligns with the developmental characteristics of early childhood (CO.2, b.6). Specifically, teachers reported that disaster education was usually limited to simple verbal instructions or emergency drills without structured learning activities. Children generally did not yet understand the basic steps of disaster mitigation, such as how to protect themselves during an earthquake, where to take

cover, or how to stay calm during an evacuation (CO.1, b.17; CW.1).

In addition, the analysis of early childhood characteristics was carried out to ensure that the learning model developed aligns with their developmental stages. Data obtained from curriculum documentation, classroom observations, and interviews with educators revealed that children responded better when disaster-related content was integrated into play activities, stories, songs, and real-life simulations. For example, during observations, children showed higher engagement and retention when disaster concepts were introduced through role-play and games rather than lecture-based explanations. The findings also highlighted the need to establish structured phases during implementation to guide teachers in delivering content progressively (CO.4, b.14; CD.08).

Based on these findings, this study designed a model consisting of three key learning phases: the pre-play phase, the during-play phase, and the post-play phase.

Design Phase

The second phase, the design phase, involved outputs from the analysis phase such as videos, educational play tools, songs, simulations, educational games, and storybooks. Adobe Illustrator, Corel Draw X7, and Adobe Photoshop were used in the design process. Specifically for the snakes and ladders game board, the researcher designed the media through the following steps:

1) The first step was to design the initial concept of the snakes and ladders game using Corel Draw X7.
2) The second step involved planning the content of the snakes and ladders game in accordance with the early childhood education curriculum.
3) The third step was sourcing supportive and age-appropriate images related to the disaster mitigation theme. These images were downloaded from the internet and redesigned to suit early childhood characteristics.
4) The fourth step involved designing the content of the snakes and ladders game guidebook.
5) Designing the cover of the instructional book and the game rules using CorelDraw X6.

The instructional flow design for early childhood disaster education is illustrated in Figure 2 below:

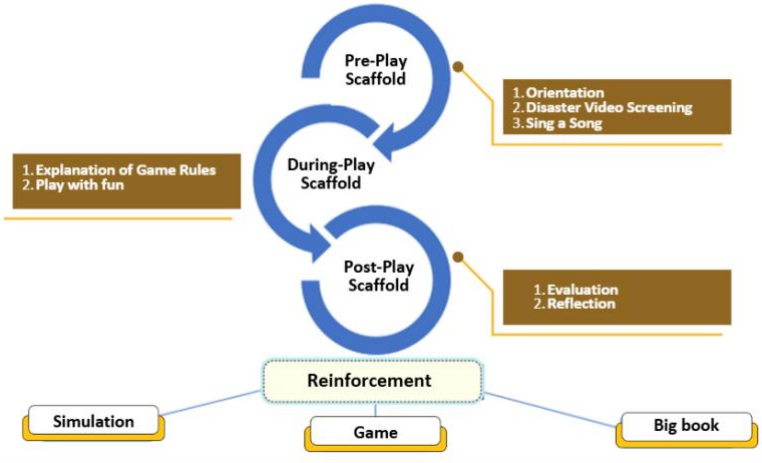

Figure 2. Syntax of the Disaster Learning Model for Early Childhood

Based on Figure 2 above, the disaster learning model for early childhood consists of three main phases: pre-play, during-play, and post-play. The pre-play phase includes three activities: orientation, viewing a disaster video, and singing a motivational song to spark learning interest. The during-play phase consists of two activities: explanation of the rules of the game and play with fun. Finally, the post-play phase includes two activities: evaluation and reflection.To reinforce learning, teachers can add additional activities related to disaster education such as simulations, online games, or reading storybooks.

Development Phase

The development phase continued after the disaster education learning model for early childhood was designed. This model was developed based on the learning through play principle and adjusted to the characteristics and needs of young children. The model will be validated by evaluating how it supports children's learning abilities and behaviors after participating in disaster education sessions. Through the validation phase, the model will be revised based on suggestions and input from experts including instructional design experts, subject matter experts, media experts, and language experts.

Table 3. Feasibility of Disaster Learning Models

No.	Assessed Aspect	Percentage (%)	Criteria
Instructional Design Expert			
1	Model alignment with early childhood learning principles	90	Highly Feasible
2	Clarity of learning objectives	88	Highly Feasible
3	Clarity of model syntax	85	Highly Feasible
4	Ease of model implementation for early childhood	79	Feasible
5	Media alignment with learning objectives	82	Highly Feasible
Subject Matter Expert			
1	Relevance of disaster material to early childhood characteristics	88	Highly Feasible
2	Material relevance to early childhood needs	85	Highly Feasible
3	Accuracy of content	83	Highly Feasible
4	Content completeness	80	Feasible
Media Expert			
1	Visual design of media	90	Highly Feasible
2	Quality of media materials	87	Highly Feasible
3	Practicality of media usage	85	Highly Feasible
4	Media durability	82	Highly Feasible
5	Child safety of the media	80	Feasible
6	Media alignment with learning objectives	78	Feasible
Language Expert			
1	Accuracy of language use	90	Highly Feasible
2	Ease of language comprehension	88	Highly Feasible
3	Consistency in terminology usage	85	Highly Feasible

4	Grammar and spelling	82	Highly Feasible

The validation results showed that the model received a highly feasible rating from experts in instructional design, content, media, and language, with the majority of aspects receiving percentages above 80%. However, some aspects such as ease of implementation and media suitability still indicated room for improvement. These findings serve as a critical foundation for revising and refining the model before broader implementation.

Implementation and Evaluation Phase

The implementation phase involved 27 children aged 5–6 years to evaluate their knowledge and skills in responding to an earthquake disaster. Six aspects were evaluated in this study: 1) understanding of different types of disasters; 2) awareness of disaster hazards; 3) knowledge of safety procedures; 4) ability to follow evacuation simulations; 5) attitudes and behaviors when facing disasters; and 6) communication skills related to disaster situations.

Evaluation of these six aspects was conducted through a series of methods, including direct observation during evacuation simulations, interviews with children, and assessments of both verbal and non-verbal responses during the learning activities. Teachers and researchers collaborated to collect data that reflect children's levels of understanding and readiness in facing earthquake emergencies. These evaluation results form the basis for assessing the effectiveness of the developed disaster learning model and for providing recommendations for improvements in the next development phase. The implementation of disaster education for early childhood is presented in Table 4 below.

Table 4. Implementation of Disaster Education Learning

No.	Learning Scaffold	Implementation Phase	Documentation
1.	Pre-Play Scaffold	**Orientation** In the orientation phase, the teacher conducts initial activities such as building on prior knowledge, checking in on children's well-being, and asking triggering questions related to the topic. The teacher also introduces the *Snakes and Ladders Disaster Response* game that will be played during the core activity. **Disaster Video Screening** Next, the teacher shows several disaster mitigation videos using an LED screen or projector with a sound system to capture children's attention. The video duration is approximately 5 minutes to match children's short attention span and to avoid boredom. After watching, the teacher asks questions related to the story and encourages children to summarize and retell using their own words. **Sing a Song** This phase involves singing a song related to the learning theme using audiovisual aids. While singing, children are encouraged to move according to the	 **Figure 3.** Vidio Screening

		song's content, for example: "if there's an earthquake, protect your head" (children hold their heads), "if there's an earthquake, hide under the table" (children take cover under a table), and so on.	 **Figure 4.** Sing a Song
2.	**During-Play Scaffold**	**Explanation of Game Rules** The teacher explains the rules of the Disaster Response Snakes and Ladders game: a) Define teams b) Rock-paper-scissors to decide who starts c) Jump according to the dice d) Answer questions or follow instructions on the game board e) If landing on a ladder, climb up f) If landing on a snake's tail, go down to the head g) The first team to reach the finish wins and receives praise. **Play with Fun** Game phases include: a) Each round involves two alternating teams b) Each team consists of 3–4 children with roles: one throws the dice, one jumps, 1–2 answer questions; all perform the action (e.g., drop and cover, avoid glass, hide under the table) c) Landing on a ladder means climbing to the top d) Landing on a snake means sliding down e) The game ends when one team reaches the finish.	 **Figure 5.** Explaining Rules  **Figure 6.** Play with Fun
3.	**Post-Play Scaffold**	**Evaluation** After the game, the teacher evaluates the children's knowledge. Observers or teachers prepare questions in child-friendly, simple language. Answers use two-choice formats like yes/no, like/dislike, bored/not bored. **Reflection** The teacher and observer reflect on the entire learning session-from pre-play, during play, to post-play. They discuss areas needing improvement for future revisions.	 **Figure 7.** Evaluation

4.	**Reinforcement**	**Simulation** As reinforcement, an earthquake simulation can be conducted. The teacher creates a scenario, prepares simulation tools such as sirens, gathering points, evacuation routes, etc. Simulations should be scheduled and conducted regularly during the semester. **Disaster Mitigation Games** Reinforcement can also be done through online disaster mitigation games, which are more appealing to young children in the 4.0 era. **Big Book** A disaster-themed Big Book can help children understand how to protect themselves. The teacher can use storytelling at the beginning of the lesson. Parents are encouraged to participate in storytelling at home during breaks.

Figure 8. Simulation

Figure 9. Big Book

To determine the effectiveness level of the developed disaster education learning model, an analysis was conducted on the improvement of early childhood children's abilities in six aspects of earthquake preparedness. Measurements were carried out through pretests and posttests involving 27 children aged 5–6 years, and the data were analyzed using the normalized gain (N-Gain) formula to assess the extent of score improvement after the learning intervention. The N-Gain results provide an overview of how much the learning intervention impacted children's understanding and skills in recognizing and responding to disaster situations. The following table presents the N-Gain calculation results for each observed aspect.

Table 5. N-Gain Calculation Results

No.	Observed Aspect	Average Pretest Score	Average Posttest Score	Ideal Score	N-Gain (g)	N-Gain Category
1	Understanding of disaster types	45	80	100	0.64	Medium
2	Awareness of disaster hazards	40	78	100	0.63	Medium
3	Knowledge of safety procedures	42	85	100	0.74	High
4	Ability to follow evacuation simulations	38	82	100	0.71	High
5	Attitudes and behaviors during disaster events	46	79	100	0.61	Medium
6	Ability to communicate about disasters	44	77	100	0.59	Medium

Based on the N-Gain calculation results (Table 5), it can be seen that there was an improvement in children's abilities across all observed aspects after participating in the disaster preparedness learning model. Two aspects showed a high level of improvement: knowledge of safety procedures (g = 0.74) and the ability to follow evacuation simulations (g = 0.71). This indicates that early childhood learners are capable of understanding and applying safety procedures as

well as actively participating in disaster simulations after receiving the learning intervention. Meanwhile, the other four aspects showed a medium level of improvement, namely understanding of disaster types, awareness of disaster hazards, attitudes and behaviors during disasters, and the ability to communicate about disasters, with N-Gain values ranging from 0.59 to 0.64.

These results indicate that the developed disaster preparedness learning model has made a significant contribution to improving the knowledge, awareness, skills, and attitudes of early childhood learners in facing disasters. Although most aspects fall into the medium category, the N-Gain values that are close to the high category demonstrate the effectiveness of this model in equipping children with better preparedness.

The variation in N-Gain values may be influenced by several factors. Cognitive aspects, such as knowledge of safety procedures, may be easier for children to grasp and demonstrate, resulting in higher gains. In contrast, affective and behavioral aspects, such as attitudes, awareness, and communication, generally require longer-term reinforcement and repeated practice, which explains their moderate improvement levels. Environmental support, teacher facilitation, and children's prior experiences with disaster-related events may also contribute to the observed differences.

Discussion

This disaster preparedness learning model was designed using the principle of learning through play, which aligns with the developmental characteristics of early childhood. As stated by Morrison & George (2004), early childhood learning must involve interactive and enjoyable play activities that support the holistic development of children's cognitive, social, and emotional aspects (Morrison & George, 2004). One of the media used in this model is a modified snakes and ladders game, where children are encouraged to investigate and discuss disaster risks with their peers in a participatory manner. This medium not only enhances knowledge but also fosters a proactive attitude toward disaster mitigation and communication skills essential in emergency situations (Ronan et al., 2016; Winarni & Purwandari, 2018; Widowati dkk., 2020).

These findings align with research emphasizing the importance of creative and expressive approaches, such as art, music, play, and visual media to help children understand and process experiences through play (Agusniatih & Nirmala, 2020; Cox et al., 2017; Fletcher et al., 2016; Freeman et al., 2015). This is consistent with the results of this study, which show that the use of simulations and games is highly effective in enhancing children's disaster preparedness. The evacuation simulations incorporated into this model have proven to provide direct experiences that enhance children's readiness for earthquakes. This supports Steward & Wan's (2007) theory that simulation is an effective method to assess and improve disaster preparedness (Steward & Wan, 2007).

According to Olson et al. (2010), disaster education that integrates simulations and games results in a higher level of preparedness compared to conventional, passive methods (Olson et al., 2010). This finding is highly relevant to the current study, which demonstrates that children are able to follow evacuation

simulations effectively and display appropriate behaviors when facing disasters, reinforcing the importance of using active and contextual learning methods.

However, not all aspects of preparedness reached a high level of improvement. Four dimensions understanding disaster types, awareness of hazards, attitudes and behaviors during disasters, and communication skills achieved only medium improvement (N-Gain = 0.59-0.64). This variation suggests that while procedural knowledge and practice can be strengthened relatively quickly through simulation, more abstract or affective dimensions (such as awareness and attitudes) may require longer exposure, repeated reinforcement, and the involvement of parents and communities beyond the classroom. This finding points to an important limitation: short-term interventions may be insufficient to shape deeper behavioral and attitudinal change in young children.

The disaster preparedness learning included in this model is also aligned with global findings related to disaster risk mitigation education. Torani et al. (2019) found that in various countries, including Japan, the systematic integration of disaster education into the curriculum improves risk perception and mitigation actions among children (Torani et al., 2019). In this context, tailoring content and learning methods to the developmental stage and needs of children becomes a key success factor for the program.

This adaptive approach has also been adopted in other countries such as Iran and the Philippines, where disaster education is packaged using a variety of media and methods appropriate to the child's age and cultural context, such as posters, videos, role-playing, and songs (Ani et al., 2015; Izadkhah & Hosseini, 2005). Thus, this disaster preparedness learning model utilizes visual media and interactive games not only in accordance with modern learning theories but also in line with best practices.

Additionally, this model applies the principles of Child-Centered Disaster Risk Reduction (CC-DRR), which as outlined in the literature review positions children as active participants in disaster education rather than passive recipients. Previous studies emphasize that CC-DRR fosters agency, critical thinking, and independence in children when dealing with risks (Ronan et al., 2016). The findings of this study strengthen that perspective, as the model encourages children to actively engage in discussions, decision-making, and problem-solving through games and simulations. By doing so, children not only acquire knowledge but also develop essential life skills such as communication, cooperation, and resilience.

Importantly, this approach also resonates with Ki Hajar Dewantara's philosophy of independent learning, which underlines the importance of providing children with opportunities to learn according to their individual potential, interests, and developmental needs (Marwany et al., 2023). Thus, the application of CC-DRR principles within this disaster preparedness model not only reflects global best practices but also aligns with Indonesia's educational philosophy, making it contextually relevant and culturally grounded.

In a psychosocial context, providing disaster education through a participatory approach also contributes to reducing children's stress and anxiety about disasters (Krishna et al., 2022). Through enjoyable and interactive activities, children not only learn technical aspects of disasters but also receive emotional

support that helps them overcome fear and build confidence in emergency situations.

This study also provides empirical evidence that well-designed learning media, including child-safe materials, can enhance children's motivation and engagement in the learning process (Sukardjo et al., 2023). The aspects of ease of use and media safety were given special attention, considering the physical condition and vulnerable motor development of early childhood (Shofyatun & Nirmala, 2018).

Overall, this disaster preparedness learning model not only meets the validity criteria assessed by instructional design, content, media, and language experts but also proves effective in improving early childhood disaster preparedness based on field trial results. This indicates that a learning approach integrating participatory techniques, simulations, and interactive media that align with the needs and characteristics of young children is highly recommended for wider adoption.

As a recommendation, further development can be pursued by integrating digital technologies such as Augmented Reality (AR) to provide a more immersive and engaging learning experience for early childhood learners (Nirmala et al., 2024a, 2024b). This is supported by recent research highlighting the potential of AR technology in disaster education (Novitasari & Qurrotaini, 2024). In addition, involving parents and communities in disaster preparedness learning programs is also crucial to strengthen children's learning environments and holistic readiness.

CONCLUSION

The disaster preparedness learning model developed in this study has proven effective in improving early childhood learners' knowledge, attitudes, and skills in facing earthquake disasters, as shown by the increase in N-Gain scores across six observed aspects, ranging from medium to high categories. By integrating play-based learning, participatory games, group discussions, and evacuation simulations, the model not only provides meaningful and developmentally appropriate learning experiences but also contributes to building children's life skills, resilience, and cooperation as part of a broader culture of disaster preparedness. However, the study has several limitations, including the use of a one-group pretest-posttest design without a control group, purposive sampling with limited participants, and a short intervention period that may not fully capture long-term behavioral change. Future research should involve larger and more diverse samples, longitudinal designs, and the integration of parental and community involvement to strengthen outcomes and sustainability. While this study was conducted in the context of early childhood earthquake preparedness in Indonesia, the findings have the potential to be adapted and generalized to other hazard types and cultural settings, with necessary contextual adjustments.

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REFERENCES

Adiyoso, W., & Kanegae, H. (2012). The effect of different disaster education programs on tsunami preparedness among schoolchildren in Aceh, Indonesia. *Disaster Mitigation of Cultural Heritage and Historic Cities*, *6*(1), 165–172.

Agusniatih, A., & Nirmala, B. (2020). Development of Motion Creativity and Songs for Stimulating Children's Social Emotional at Kindergarten in Palu Sulawesi. *International Conference of Early Childhood Education (ICECE 2019)*, 173–177. https://doi.org/https://doi.org/10.2991/assehr.k.200715.036

Ani, P. A. B., Daquio, C. R., & Aquino, A. P. (2015). *Republic Act 10121: An Approach in Strengthening Disaster Risk Reduction and Management in the Philippines*.

Aroyandini, E. N., Rusilowati, A., Supriyadi, S., Hartono, H., Subali, B., Hamid, N., & Juhadi, J. (2023). Analysis of Disaster Education Models: Studies from Early Childhood to Higher Education Levels. *Proceedings of International Conference on Science, Education, and Technology*, *9*, 208–220.

Borg, W. R., & Gall, M. D. (1983). *Education Research: An Introduction New York: Logman*.

Branch, R. M. (2009). Approach, Instructional Design: The ADDIE. In *Department of Educational Psychology and Instructional Technology University of Georgia* (Vol. 53, Issue 9).

Bredekamp, S., & Copple, C. (1997). *Developmentally Appropriate Practice in Early Childhood Programs.(Revised Edition)*. ERIC.

Bryant, R. A., Gibbs, L., Gallagher, H. C., Pattison, P., Lusher, D., MacDougall, C., Harms, L., Block, K., Sinnott, V., & Ireton, G. (2018). Longitudinal study of changing psychological outcomes following the Victorian Black Saturday bushfires. *Australian & New Zealand Journal of Psychiatry*, *52*(6), 542–551. https://doi.org/https://doi.org/10.1177/0004867417714337

Cox, R. S., Scannell, L., Heykoop, C., Tobin-Gurley, J., & Peek, L. (2017). Understanding youth disaster recovery: The vital role of people, places, and activities. *International Journal of Disaster Risk Reduction*, *22*, 249–256.

Djalante, R., Garschagen, M., Thomalla, F., & Shaw, R. (2017). Introduction: Disaster risk reduction in Indonesia: Progress, challenges, and issues. In *Disaster risk reduction in Indonesia* (pp. 1–17). Springer. https://doi.org/https://doi.org/10.1007/978-3-319-54466-3_1

Fletcher, S., Cox, R. S., Scannell, L., Heykoop, C., Tobin-Gurley, J., & Peek, L. (2016). Youth creating disaster recovery and resilience: A multi-site arts-based youth engagement research project. *Children, Youth and Environments*, *26*(1), 148–163.

Freeman, C., Nairn, K., & Gollop, M. (2015). Disaster impact and recovery: what children and young people can tell us. *Kōtuitui: New Zealand Journal of Social Sciences Online*, *10*(2), 103–115.

Gibbs, L., Nursey, J., Cook, J., Ireton, G., Alkemade, N., Roberts, M., Gallagher, H. C., Bryant, R., Block, K., & Molyneaux, R. (2019). Delayed disaster impacts on academic performance of primary school children. *Child Development*, *90*(4), 1402–1412.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American*

Journal of Physics, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Izadkhah, Y. O., & Hosseini, M. (2005). Towards resilient communities in developing countries through education of children for disaster preparedness. *International Journal of Emergency Management*, *2*(3), 138–148. https://doi.org/https://doi.org/10.1504/IJEM.2005.007355

Javier, S. P. (2022). *Risk Reduction Through Disaster Literacy Among School-Age Children in Barangay Parian, Calamba City*.

Joyce, B. & Weil, M. (2020). *Models of teaching* (9h ed.). Pustaka Pelajar.

Khaerudin, K., & Suharto, N. T. (2022). Disaster education model for pre-school age children. *Jurnal Iqra': Kajian Ilmu Pendidikan*, *7*(2), 194–208. https://doi.org/10.25217/ji.v7i2.1967

Kousky, C. (2016). Impacts of natural disasters on children. *The Future of Children*, 73–92. https://doi.org/https://doi.org/10.1353/foc.2016.0004

Krishna, R. N., Spencer, C., Ronan, K., & Alisic, E. (2022). Child participation in disaster resilience education: potential impact on child mental well-being. *Disaster Prevention and Management: An International Journal*, *31*(2), 134–143. https://doi.org/10.1108/DPM-03-2021-0110

Marwany, M., Nirmala, B., & Muslim, S. (2023). The Concept of Independent Learning to Stimulate Creativity of Early Children: A Study of Ki Hajar Dewantara's Philosophy. *Al-Ishlah: Jurnal Pendidikan*, *15*(2), 62–70. https://doi.org/10.35445/alishlah.v15i2.1496

Mayer, R. E. (2002). Multimedia learning. In *Psychology of learning and motivation* (Vol. 41, pp. 85–139). Elsevier. https://doi.org/10.1016/S0079-7421(02)80005-6

McGriff, S. (2000). *Instructional System Design (ISD): Using the ADDIE Model. Instructional Systems, College of Education, Penn State University*.

Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gains in physics: A possible "hidden variable" in diagnostic pretest scores. *American Journal of Physics*, *70*(12), 1259–1268. https://doi.org/10.1119/1.1514215

Midtbust, L. G. H., Dyregrov, A., & Djup, H. W. (2018). Communicating with children and adolescents about the risk of natural disasters. *European Journal of Psychotraumatology*, *9*(sup2), 1429771. https://doi.org/https://doi.org/10.1080/20008198.2018.1429771

Morrison, G. S., & George, S. (2004). *Early Childhood Education Today* (9th ed.). Pearson Merrill Prentice Hall Upper Saddle River, NJ.

Mudavanhu, C., Manyena, S. B., Collins, A. E., Bongo, P., Mavhura, E., & Manatsa, D. (2015). Taking children's voices in disaster risk reduction a step forward. *International Journal of Disaster Risk Science*, *6*(3), 267–281.

Nieveen, N. (1999). Prototyping to Reach Product Quality. In Design Approaches and Tools in Education and Training. *Springer*. https://doi.org/10.1007/978-94-011-4255-7_10

Nirmala, B., Agusniatih, A., & Annuar, H. (2021). Development of snakes and ladders game (disaster response) as earthquake mitigation for children. *Journal of Early Childhood Care and Education*, *3*(2), 97. https://doi.org/10.26555/jecce.v3i2.3111

Nirmala, B., Solihatin, E., & Sukardjo, M. (2024a). Augmented Reality in Early Childhood Education: Trends, Practices, and Insights from a Literature Review. *International Journal of Interactive Mobile Technologies*, *18*(22). https://doi.org/10.3991/ijim.v18i22.50337

Nirmala, B., Solihatin, E., & Sukardjo, M. (2024b). Augmented Reality in Education : A Bibliometric Analysis. *Proceedings of International Conference on Education*, *2*(1), 325–340. https://doi.org/10.32672/pice.v2i1.1378

Novitasari, T., & Qurrotaini, L. (2024). Pengembangan Media Pembelajaran Buku Cerita Mitigasi Bencana Berbasis Augmented Reality. *Prosiding Seminar Nasional Penelitian LPPM UMJ*.

Olson, D. K., Scheller, A., Larson, S., Lindeke, L., & Edwardson, S. (2010). Using gaming simulation to evaluate bioterrorism and emergency readiness education. *Public Health Reports*, *125*(3), 468–477.

Peek, L., & Fothergill, A. (2014). Post-disaster decline: Understanding children's vulnerability before, during, and after Katrina. *The Dialogue*, *10*(3), 2–4.

Pfefferbaum, B., Pfefferbaum, R. L., & Van Horn, R. L. (2018). Involving children in disaster risk reduction: the importance of participation. *European Journal of Psychotraumatology*, *9*(sup2), 1425577. https://doi.org/https://doi.org/10.1080/20008198.2018.1425577

Proulx, K., & Aboud, F. (2019). Disaster risk reduction in early childhood education: Effects on preschool quality and child outcomes. *International Journal of Educational Development*, *66*, 1–7. https://doi.org/https://doi.org/10.1016/j.ijedudev.2019.01.

Reduction, I. S. for D. (2004). *Living with risk: A global review of disaster reduction initiatives*.

Risdianto, E., Wachidi, W., Riyanto, R., Fathurrochman, I., Yanto, M., & Asmara, A. (2022). Feasibility Test of Learning Media with Blended Learning Model and Augmented Reality-Assisted MOOCs. *Jurnal Ilmiah Peuradeun (JIP)*, *10*(1), 149–164. https://doi.org/10.26811/peuradeun.v10i1.626

Ronan, K. R., Haynes, K., Towers, B., Alisic, E., Ireland, N., Amri, A., Davie, S., & Petal, M. (2016). Child-centred disaster risk reduction: Can disaster resilience programs reduce risk and increase the resilience of children and households? *Australian Journal of Emergency Management, The*, *31*(3), 49.

Seddighi, H., Sajjadi, H., Yousefzadeh, S., López, M. L., Vameghi, M., Rafiey, H., & Khankeh, H. (2022). School-based education programs for preparing children for natural hazards: A systematic review. *Disaster Medicine and Public Health Preparedness*, *16*(3), 1229–1241. https://doi.org/10.1017/dmp.2020.479

Shofyatun, A. R., & Nirmala, B. (2018). Permainan Tradisional Sebagai Upaya Menstimulasi Tingkat Pencapaian Perkembangan Anak Usia Dini. *Early Childhood Education Journal of Indonesia*, *1*(2), 31–38.

Steward, D., & Wan, T. T. H. (2007). The role of simulation and modeling in disaster management. *Journal of Medical Systems*, *31*(2), 125–130.

Stough, L. M., Kang, D., & Lee, S. (2018). Seven school-related disasters: Lessons for policymakers and school personnel. *Education Policy Analysis Archives*, *26*, 100. https://doi.org/https://doi.org/10.14507/epaa.26.3698

Sugiyono. (2015). Metode penelitian & pengembangan research and development. *Bandung: Alfabeta*.

Sukardjo, M., Nirmala, B., Ruiyat, S. A., Annuar, H., & Khasanah, U. (2023). Loose Parts: Stimulation of 21st Century Learning Skills (4C Elements). *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *7*(1), 1073–1086. https://doi.org/10.31004/obsesi.v7i1.4088

Thapa, V., & Pathranarakul, P. (2019). Gender inclusiveness in disaster risk governance for sustainable recovery of 2015 Gorkha Earthquake, Nepal. *International Journal of Disaster Risk Reduction*, *34*, 209–219. https://doi.org/https://doi.org/10.1016/j.ijdrr.2018.11.019

Torani, S., Majd, P. M., Maroufi, S. S., Dowlati, M., & Sheikhi, R. A. (2019). The importance of education on disasters and emergencies: A review article. *Journal of Education and Health Promotion*, *8*.

https://doi.org/https://doi.org/10.4103/jehp.jehp_262_18

Tuladhar, G., Yatabe, R., Dahal, R. K., & Bhandary, N. P. (2014). Knowledge of disaster risk reduction among school students in Nepal. *Geomatics, Natural Hazards and Risk*, *5*(3), 190–207. https://doi.org/https://doi.org/10.1080/19475705.2013.809556

Widowati, E., Sugiharto, S., Wahyuningsih, A. S., Husodo, A. H., & Istiono, W. (2020). Transformation Prospect of a Non Disaster-Prepared-School in Implementing Management of Child Safety Education. *Unnes Journal of Public Health*, *9*(1), 34–42. https://doi.org/https://doi.org/10.15294/ujph.v9i1.34378

Winarni, E. W., & Purwandari, E. P. (2018). Disaster Risk Reduction for Earthquake Using Mobile Learning Application to Improve the Students Understanding in Elementary School. *Mediterranean Journal of Social Sciences*, *9*(2), 205.