

Fostering Tsunami Preparedness in Early Childhood: A Gamified Learning Approach for Banda Aceh

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Abstract

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This study aimed to develop and assess the feasibility of a gamified digital learning media for tsunami disaster mitigation designed for early childhood education in Banda Aceh, a disaster-prone region. Using the Research and Development (R&D) method with the ADDIE model, the study involved 25 children from class A1 at TK IT Baitussalihin selected through total sampling. Data were collected through expert validation sheets and observation during field trials. The media, developed on the Educaplay platform as an interactive picture quiz titled "Fun Picture Quiz: Froggy Jumps," obtained a final validation score of 100% from media and material experts, with an average expert score of 85% (Very Feasible). Field testing showed an overall feasibility score of 88% (Very Feasible), with 13 children achieving perfect scores and 12 scoring 75%. The findings indicate that the gamified media is engaging, visually appropriate, and pedagogically suitable for supporting early childhood cognitive development while addressing the need for interactive digital resources in tsunami preparedness. Further studies are recommended to examine its long-term effectiveness in enhancing children's disaster preparedness knowledge.

Keywords: Gamified Digital Learning, Tsunami Disaster Preparedness, Early Childhood Education

Abstrak

Penelitian ini bertujuan mengembangkan dan menilai kelayakan media pembelajaran digital berbasis gamifikasi untuk mitigasi bencana tsunami pada pendidikan anak usia dini di Banda Aceh. Metode yang digunakan adalah Research and Development (R&D) dengan model ADDIE, melibatkan 25 anak kelas A1 TK IT Baitussalihin melalui teknik total sampling. Data diperoleh melalui lembar validasi ahli dan observasi saat uji coba lapangan. Media dikembangkan pada platform Educaplay dalam bentuk kuis gambar interaktif berjudul "Fun Picture Quiz: Froggy Jumps." Hasil validasi akhir menunjukkan skor 100% dari ahli media dan materi, dengan rata-rata skor ahli 85% (Sangat Layak). Uji coba lapangan menghasilkan skor kelayakan 88% (Sangat Layak), dengan 13 anak memperoleh skor sempurna dan 12 anak mencapai 75%. Media ini terbukti menarik, sesuai secara visual dan pedagogis, serta mampu menjawab kebutuhan sumber daya digital interaktif untuk kesiapsiagaan tsunami pada anak usia dini. Penelitian lanjutan disarankan untuk menguji efektivitas jangka panjang terhadap peningkatan pengetahuan kesiapsiagaan bencana anak..

Kata Kunci: Pembelajaran Berbasis Gamified, Mitigasi Tsunami, Pendidikan Anak Usia Dini

INTRODUCTION

Indonesia is a country prone to natural disasters due to both geological and meteorological factors. (Mujiburrahman et al., 2020). Geological disasters are natural disasters that occur on the Earth's surface, such as earthquakes, landslides, volcanic eruptions, and tsunamis. Meteorological disasters are natural disasters that occur due to extreme climate change, including floods during the rainy season and droughts during the dry season (Persada et al., 2020). Major natural disasters not only cause physical damage and significant economic losses but also claim lives and cause lasting trauma. This reality serves as a stark reminder that we live in disaster-prone areas, as exemplified by the 2004 tsunami in Aceh (Indonesia, 2024). The occurrence of major natural disasters has increasingly made people aware of the importance of disaster education in Indonesia, especially in Banda Aceh (Mujiburrahman et al., 2020).

The Aceh region, particularly the city of Banda Aceh, has been a frequently earthquake-affected area since the 2004 tsunami. The 2004 Aceh tsunami was one of the most devastating natural disasters in history. Occurring on Sunday, December 26, 2004, this disaster left deep sorrow for Indonesia and the world. The event began with an undersea earthquake measuring 9.1–9.3 on the Richter scale in the Indian Ocean, which triggered a giant tsunami wave that struck the coast of Aceh and several other countries surrounding the Indian Ocean (Hendrawan & Sukresno, n.d.). Furthermore, the 2004 tsunami in Aceh claimed a significant number of lives. According to United Nations data from January 2005, it is estimated that more than 230,000 people died as a result of the tsunami, with over 167,000 fatalities recorded in Aceh alone, in addition to thousands of others who were injured or reported missing (Febriansah, 2024).

The psychological impact of the Aceh Tsunami was not limited to the immediate post-disaster period, as many survivors experienced significant long-term mental health problems that affected their social, economic, personal, and daily lives. The trauma extended beyond the loss of loved ones and property to include directly witnessing death, injury, and widespread destruction. Studies published in peer-reviewed journals and reports from official disaster agencies confirm that these psychological effects persisted for many years after the disaster (Amna et al., 2025). In response to the need for effective disaster education, gamification, defined as the use of game elements such as points, challenges, and rewards in learning activities to increase motivation and engagement has emerged as a suitable approach, particularly for early childhood education, as children learn most effectively through play (Sumartiningsih, 2025). Therefore, this study focuses on developing and testing the feasibility of a gamified tsunami mitigation learning media, aiming to evaluate its appropriateness for use in early childhood education rather than to measure its learning effectiveness.

When a disaster strikes, children are the most vulnerable group, as they are unsure what to do. This is clarified by the statement by Balaban, Amir, and colleagues that when a disaster occurs, children are the most vulnerable group to become victims. Children are among those categorized as vulnerable to disasters. Children are at higher risk of suffering trauma and stress than adults (Hesti et al., 2019). Therefore, children

need to be empowered to mitigate the impact of disasters. Mitigation, as stated by Nirmalawati, is a stage aimed at reducing the possibility of negative impacts when a disaster occurs (Arumsari & Putri, 2020; Pratama, 2022). For this reason, disaster mitigation knowledge must be introduced from an early age to better educate the public about what they should and should not do in the event of a disaster. Disasters are extremely worrying and frightening events, and disaster mitigation education is expected to help people understand the potential threats they pose (Munasti et al., 2023). Consequently, the implementation of disaster mitigation education policies should be integrated into early childhood education through the consistent incorporation of disaster preparedness into curriculum activities, along with adequate training and support provided to educators (Munawarah & Maemunah, 2022).

A simple way to introduce the concept of natural disasters is to use interactive learning media. This is done to reduce the risk of disasters for children, who are a vulnerable group (Pratama, 2022). The development of interactive disaster mitigation media is essential to attract children's interest in creatively learning about disaster mitigation. Disaster mitigation education policies should be introduced into early childhood education through consistent integration of disaster preparedness into curriculum activities. Gamified learning media is considered effective because it balances play and learning, enabling children to understand the concept of tsunami warning signs and self-rescue actions in a concrete, visual, and contextual way, in accordance with their cognitive developmental stages (Nurdin et al., 2025).

Numerous studies have shown that the use of learning media influences the growth and development of early childhood. The media used in early childhood learning today includes both digital and non-digital forms, with previous study showed that digital media showed a positive influence toward children's understanding toward disaster (Aini et al., 2024). Digital media that has been used includes digital pop-up books (Najilla et al., 2025), learning video digital media (Nurani et al., 2022), and web-based digital media on natural disaster mitigation material (Nurdin et al., 2025). The non-digital media used includes Lift The Flap Books (Ulfah et al., 2021), board game-based non-digital media (R. Megumi, 2019), Snakes and Ladders media (Rahmawati et al., 2024). Augmented Reality-based disaster mitigation storybook learning media (Novitasari & Qurrotaini, n.d.), storybooks entitled "Siaga" (Kartika et al., 2023), and "Lift The Flap Book" based disaster mitigation storybooks (Ulfah et al., 2021).

Regarding tsunami disaster mitigation media specifically implemented for early childhood, flood mitigation has been introduced through digital learning videos characterized by animated images accompanied by sound and storylines played by characters (Nurani et al., 2022). However, among all the gamified learning media for tsunami disaster mitigation currently available, none exist in the form of an Educaplay-based game specifically designed for tsunami disaster mitigation. Therefore, this study aims to develop and assess the feasibility of a gamified digital learning medium for tsunami disaster mitigation tailored to early childhood education in Banda Aceh,

addressing the gap in the availability of interactive gamified digital media specifically designed for early childhood education in disaster-prone areas.

METHODS

Research Design and Participants

This study employed the Research and Development (R&D) method (Judjianto, 2024), utilizing the ADDIE development model. This model comprises five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model, originally formulated by Dick and Carey for designing learning systems, provides a robust framework for this developmental research (Andi Rustandi & Rismayanti, 2021).

The procedural flowchart for the ADDIE model is illustrated in Figure 1.

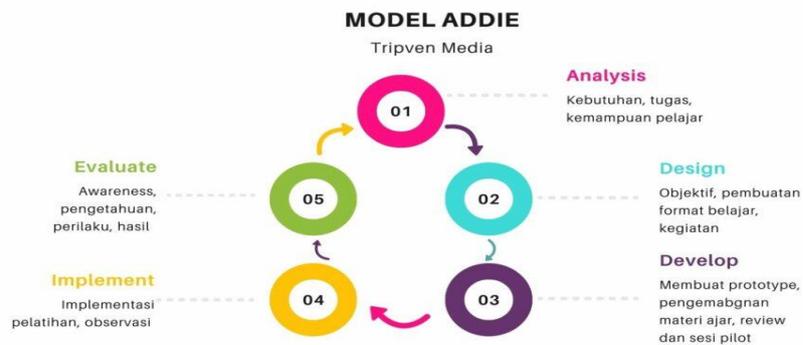


Figure 1. ADDIE Model Research Chart

The research was conducted during the odd semester of the 2024-2025 academic year at TK IT Baitussalihin, Banda Aceh. The study employed total sampling, involving all 25 children from class A1 as participants.

Data Collection and Analysis

Data were collected using validation sheets for media and material experts, and observation instruments for field trials. Two validators, both lecturers in Early Childhood Education (PAUD), served as subject matter and media experts. The feasibility analysis and assessment percentage for the gamified media were calculated using the following formula:

$$P = \frac{f}{N} \times 100\%$$

Where:

P = Percentage of score achieved

F = Total score obtained

N = Maximum possible score (Agustia & Fitriani, 2025).

A Likert scale was used to gauge respondents' perceptions and determine media feasibility. The criteria for interpreting the feasibility percentages are presented in Table 1 (Wahyu Ningtiyas et al., 2019). The specific indicators used by media and material experts for validation are detailed in Tables 2 and 3, respectively. For the child trials, the criteria were simplified: a score above 75% indicated "feasible," while a score below 75% indicated "not feasible," as shown in Table 4.

Table 1. Feasibility Interpretation Criteria

Percentage	Qualification
0-20 %	Not Feasible
21-40 %	Less Feasible
41-60 %	Enough
61-80 %	Feasible
81-100 %	Very Feasible

Table 2. Media Expert Validation Indicators (Najilla et al., 2025)

No	Indicator	Aspects
1	Language	clarity of language
2	color	Color quality
3	Performance	Children's involvement in gaming activities
4	Graphic design	Variations in the game Ease of use of the game
5	Ease of use aspect	Use of mitigation games Opening/initial instructions Alignment of game objectives with learning materials
6	Learning Activities	Reinforcement of material through activities Question presentation stage
7	Color	Color quality
8	Performance	Children's involvement in gaming activities
9	Graphic design	Variations in the game Ease of use of the game
10	Ease of use aspect	Use of mitigation games

Table 3. Material Experts Validation Indicators

No	Aspect	Indicator
1	Content Eligibility	Suitability of material to learning objectives
2	Performance	Suitability of the material with the research title
3	Language	Correspondence of letters in reading Ease of reading
4	Relevance and knowledge of the material	Game material refers to learning outcomes Game materials support the achievement of learning objectives. Fill in relevant material

The content of the material is relevant to the competencies that are to be achieved.
Materials according to cognitive development stages
Game activities strengthen children's understanding of disaster warning signs.
Game activities strengthen children's understanding of evacuation routes.
The material encourages early preparedness skills.

Tabel 4. Child Trial Score Interpretation (Najilla et al., 2025)

Score	Indicator
Above 75%	Feasible
Below 75%	Not Feasible

RESULTS AND DISCUSSIN

The following section delineates the results of the research, describing the systematic development process of the gamified tsunami disaster mitigation media.

Analysis Stage

The initial stage involved a comprehensive analysis to gather foundational data for the media design process. This encompassed market, user, curriculum, media, and facility analyses. A review of relevant academic literature and documented educational platforms revealed a significant gap: interactive, gamified digital media specifically focused on tsunami disaster mitigation for early childhood remains limited. This conclusion is drawn from scholarly sources rather than commercial platform searches. An analysis of the target users, children at TK IT Baitusshalihin, indicated a need for concrete, visually engaging, and non-threatening media to facilitate understanding of disaster preparedness concepts. An examination of the PAUD curriculum confirmed that topics such as recognizing tsunami warning signs and understanding evacuation procedures are appropriate and can be effectively integrated into early childhood learning outcomes. While various media like videos and pop-up books are readily available, gamified game media was found to be scarce. Consequently, the Educaplay platform was selected for its capacity to balance play and educational elements effectively. A concurrent facility analysis was conducted to ensure that the necessary technological infrastructure (e.g., projectors, laptops) was available at the school to support the web-based media. This step was crucial to guarantee the media could be implemented smoothly and optimally in the classroom. Figures 2 and 3 illustrate examples of existing media, such as a picture storybook and a pop-up book.



Figure 2. An existing picture story book entitled "SIAGA"

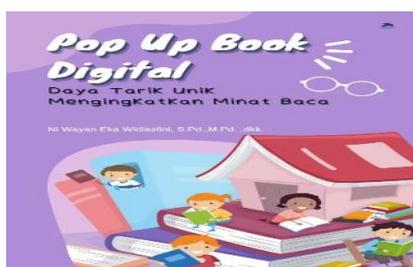


Figure 3. Existing Pop-Up Book Media

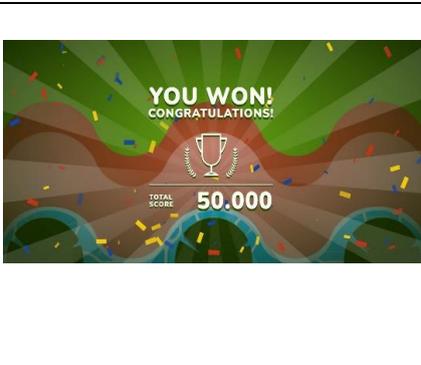
Design Stage

In the second stage, based on the analysis findings, the researchers designed a digital gamified learning media for tsunami disaster mitigation using the Educaplay platform. The design process was systematic, beginning with defining learning objectives, structuring the mitigation material, designing visual elements, and developing interactive game mechanics. The media was conceptualized as an interactive picture quiz titled "Fun Picture Quiz: Froggy Jumps." This format was chosen to align with the developmental characteristics of early childhood, who learn best through concrete visuals and interactive activities. The design incorporated bright colors, simple navigation, clear instructions, and child-friendly characters to foster a safe and engaging learning environment (Nurani et al., 2022).

Crucially, the game mechanics were directly aligned with the intended learning outcomes. Each quiz question was designed to introduce fundamental tsunami mitigation concepts, such as identifying early warning signs (e.g., a strong earthquake, receding water), recognizing evacuation routes (e.g., moving to higher ground), and understanding simple self-rescue steps (e.g., staying calm, following an adult). The "jump" mechanic, where the frog progresses by selecting correct answers, provides immediate feedback, reinforcing understanding and supporting cognitive development. This ensures the game is not only visually appealing but also pedagogically meaningful. Supporting features, including a preparatory countdown screen, a timer to maintain focus, and a final reward screen, were incorporated to enhance motivation and engagement (Rini et al., 2023). Following the initial design, validation instruments were developed to assess the media's feasibility before proceeding to the development stage. Table 5 presents the initial media design.

Table 5. Initial Media Design

No	Picture	Description
1.		<p>This image depicts the start screen of the interactive learning media, "Fun Picture Quiz: Froggy Jumps." The cover features engaging visuals for young children and includes a prominent "Start" button to initiate the game.</p>

2.		<p>This image shows a countdown animation intended to prepare children visually and mentally for the upcoming activity, serving as a transitional element.</p>
3.		<p>This screen presents interactive quiz questions on a vibrant blue background. A timer and score display are visible to help children maintain focus. The content is designed to introduce tsunami early warning signs while developing visual observation skills.</p>
4.		<p>On the next screen, the words "You Won!" and "Congratulations," indicating successful completion of the quiz. A central trophy icon, green and brown striped background, and colorful confetti effects create a celebratory and encouraging atmosphere.</p>

Development Stage

The development stage involved actualizing the design into a functional prototype and subjecting it to expert validation. The digital gamified tsunami mitigation media was assessed for feasibility by two expert lecturers in Early Childhood Education (PAUD) using the pre-designed feasibility assessment sheets. Table 6 outlines the steps taken during development based on the initial design.

Table 6. Steps for developing Educaplay media from the initial design

No	Picture	Description
1.		<p>Following media expert validation, the game's cover was deemed appropriate and required no further revision.</p>
2.		<p>The countdown display was considered clear and appropriate, thus requiring no revision.</p>

3.		<p>This screen displays the media after revisions based on expert input. In addition to the timer and scoring features, the revision emphasized providing more communicative visual feedback when children successfully answer questions related to evacuation steps.</p>
4.		<p>The number of questions was increased, and the final score display was modified based on feedback.</p>

At this stage, a validation process was conducted with the validators to assess the feasibility of the developed media. The process covered both media and material aspects, evaluating the suitability of the design, visual appearance, and content for early childhood characteristics. Suggestions and feedback from the validators were used as the basis for iterative improvements. The results of the feasibility assessments are presented in the following tables.

Table 7. Media Expert Validation Results (Stage 2)

Category	Amount
Total Score	16
Maximum Score	16
Percentage	100%
Results	Very Feasible

As shown in Table 7, the media expert validation yielded a perfect score of 16 out of 16 (100%), categorizing the media as "Very Feasible." This indicates that the visual appearance, language, graphic design, and usability of the gamified tsunami mitigation media were deemed highly appropriate for early childhood characteristics and required no further revision.

Table 8. Results of Validation by Material Expert 1 (Stage 1)

Category	Amount
Total Score	9
Maximum Score	12
Percentage	75%
Results	Feasible

Table 9. Results of Validation by Material Expert 2 (Stage 2)

Category	Amount
Total Score	12
Maximum Score	12
Percentage	100%

Results

Very Feasible

The initial validation by material expert 1 (Table 8) resulted in a score of 9 out of 12 (75%), categorizing the media as "Feasible." This indicated that while the material was generally appropriate for the learning objectives and child developmental stage, some refinements were needed. Following revisions based on this feedback, the second material expert validation (Table 9) achieved a perfect score of 12 out of 12 (100%), placing it in the "Very Feasible" category. The tsunami disaster mitigation material was ultimately deemed highly relevant, well-aligned with learning outcomes, and suitable for use without further revision. This two-stage process, resulting in a final combined expert feasibility score of 85% (average of 100% and 100% for media and material respectively in the final stage), demonstrates the effectiveness of the iterative refinement process.

Implementation Stage

Following successful validation and refinement, the product was implemented in a field trial at TK IT Baitusshalihin, Banda Aceh. This large-scale trial involved 25 children from class A1. The primary objective was to evaluate the media's practical suitability in a classroom setting, focusing on children's engagement, ease of use, and understanding of the material. During the activity, observers documented children's interactions with the game, which consisted of multiple stages designed to introduce tsunami signs, evacuation routes, and self-rescue steps. The detailed results of the trial are presented in Table 10.

Table 10. Respondent Trial Results for Gamified Tsunami Mitigation Media (%)

Respondent	P1-P4				Total score	Max Score	Percentage	
	Statement	P1	P2	P3				P4
AS		1	1	1	1	4	4	100%
CFN		1	1	1	1	4	4	100%
CQA		1	1	0	1	4	3	75%
CZG		1	0	1	1	4	3	75%
FAF		1	1	1	0	4	3	75%
HAZ		1	1	1	1	4	4	100%
HU		1	1	1	1	4	4	100%
KH		1	1	1	1	4	4	100%
HA		1	1	1	1	4	4	100%
KD		1	1	1	1	4	4	100%
MAQA		1	0	1	1	4	3	75%
MDI		1	1	0	1	4	3	75%
MFAZ		1	1	1	1	4	4	100%
MQH		1	1	1	1	4	4	100%
MRAG		1	1	1	1	4	4	100%
MZP		1	0	1	1	4	3	75%
MZP		1	1	1	0	4	3	75%

NS	1	1	1	1	4	4	100%
NA	1	1	1	0	4	3	75%
NH	0	1	1	1	4	3	75%
PJNK	1	0	1	1	4	3	75%
SMM	1	1	1	0	4	3	75%
SL	1	0	1	1	4	3	75%
SSK	1	1	1	1	4	4	100%
ZAN	1	1	1	1	4	4	100%

The number of respondents in this study was 25 children, with a maximum score per child of 4. Therefore, the maximum total score (N) was calculated as $25 \times 4 = 100$. Based on the results, 13 children obtained a score of 100% (score 4), while 12 children obtained a score of 75% (score 3). The total score was calculated as $13 \times 4 = 52$ and $12 \times 3 = 36$, resulting in a total score obtained (f) of $52 + 36 = 88$. Thus, the percentage score was calculated using the formula $P = f/N \times 100\%$, namely $P = 88/100 \times 100\% = 88\%$.

The trial results, detailed in Table 10, show that out of 25 children, 13 achieved a perfect score of 100%, while 12 scored 75%. The overall feasibility score calculated was 88%. This high percentage, categorized as "Very Feasible," indicates that the vast majority of children found the game engaging, easy to understand, and enjoyable. Observations confirmed that most children could follow the game's flow, although some required assistance in maintaining focus. The 75% scores for some children can be attributed to individual differences in concentration levels, prior understanding of the concepts, and the ability to independently process game instructions. Photographs from the implementation (Figures 4-5) illustrate the children's active and enthusiastic participation, from watching an introductory video to playing the game with joy and focus.



Figure 4. Children Watching an Educational Tsunami Video and Engaging in Interactive Games with Joy and Enthusiasm

Evaluation Stage

The evaluation phase involved a comprehensive review of the implementation process, focusing on children's responses and any challenges encountered. According to Branch (Surahman, 2024), this phase is crucial for ensuring all preceding stages were executed according to established procedures. The children demonstrated strong enthusiasm and active engagement with the gamified media. Their interaction with the

visuals, animations, and game mechanics facilitated the recognition of basic mitigation concepts, such as tsunami warning signs and simple self-rescue steps (Rini et al., 2023).

The success of this media can be theoretically underpinned by Jean Piaget's theory of cognitive development. According to Piaget, early childhood falls within the preoperational stage, characterized by concrete thinking and a reliance on visual and symbolic experiences. The gamified media aligns perfectly with this stage by presenting abstract mitigation concepts through concrete images, bright colors, and interactive quizzes. The process of play allows children to engage in assimilation, linking new information such as "a loud siren means danger" to existing schemas, and accommodation, adapting their understanding to new information such as learning that receding water is a tsunami warning sign. Through direct interaction in the game, children are not passive recipients of information but active constructors of their own understanding, making the learning process both meaningful and effective (Ayu et al., 2024)

CONCLUSION

This study successfully developed and evaluated a gamified digital learning media for tsunami disaster mitigation designed for early childhood education in the disaster-prone region of Banda Aceh. Through the systematic application of the ADDIE model, the media underwent iterative refinement and demonstrated a very high level of feasibility based on expert validation and field testing with children. The findings indicate that the media is engaging, visually appropriate, easy to use, and pedagogically aligned with early childhood developmental characteristics. By integrating play-based elements with structured disaster mitigation content, it promotes meaningful and contextually relevant learning experiences. This study contributes to addressing the limited availability of interactive gamified digital resources for tsunami preparedness in early childhood settings. Future research is recommended to expand its implementation and examine its long-term effectiveness in strengthening children's disaster preparedness knowledge across diverse educational contexts.

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