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Gamification Framework for Early Childhood Flood Disaster Preparedness in Indonesia: A Systematic Literature Review

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Abstract

Indonesia's repeated exposure to hydrometeorological hazards, particularly floods, makes disaster preparedness a pressing educational concern from the early years of life. Yet research on disaster learning for young children remains limited, and gamification has rarely been examined in this area with sufficient conceptual precision. This study addresses that gap through a systematic literature review guided by PRISMA 2020, focusing on how gamified approaches have been used in flood-related disaster education for early childhood contexts. Searches of Scopus, Web of Science, ScienceDirect, Wiley Online Library, and DOAJ covered publications from 2015 to 2025. Of 340 records identified, 28 studies met the inclusion criteria and were synthesised through thematic analysis and narrative synthesis. Three recurrent patterns emerged. Gamification was most educationally meaningful when it functioned as pedagogical scaffolding rather than as a reward system, enabling children to approach abstract risk through staged, participatory learning. Play-based simulation, feedback, and repetition also appeared to create psychologically safer ways of engaging difficult topics. Its value, however, was strongly shaped by context, especially in settings marked by uneven infrastructure, limited pedagogical resources, and high disaster exposure. The review therefore does not support broad claims that digital enhancement is inherently effective in disaster education. Instead, it suggests that gamification matters when it is developmentally grounded and carefully aligned with early childhood pedagogy. The study contributes to international discussion by recasting gamification less as a motivational device than as a form of pedagogical mediation in early childhood disaster education, particularly in settings where vulnerability is high and educational conditions are uneven. It also points to the need for further work across a wider range of hazards, settings, and pedagogical designs.

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Introduction

Indonesia is widely recognized as one of the most disaster-prone countries in the world because its geological position, tectonic setting, and climatic conditions expose it to both geophysical and hydrometeorological hazards (Nugroho et al., 2020; Tjandra, 2018; Bencana, 2020b; Prabowo & Salahudin, 2017). National disaster profiles show that floods, tornadoes, and landslides account for the large majority of recurrent events, with flood-related losses remaining especially severe in material and social terms (Badan Nasional Penanggulangan Bencana, 2019; Kodoatie, 2021; Pertiwi & Kurniawan, 2017; Apriadi et al., 2022). This pattern is not unique to Indonesia. Comparable flood vulnerabilities have been documented in China, India, Thailand, Nigeria, Kenya, Europe, and Australia, which suggests that flood preparedness is not only a national concern but also part of a wider international educational challenge (Lempérière, 2017; Singh & Kumar, 2013; Pathak & Ahmad, 2016; Nkwunonwo et al., 2020; Njogu, 2021; Priest et al., 2016; Kammerbauer & Minnery, 2019). Media and public reporting have likewise documented repeated flood and landslide events across Indonesian regions, including West Java, East Java,

and Cilacap, reinforcing the regularity of these hazards in everyday social life (Tim Detik Jabar, 2022; Tim Detik Jatim, 2022; Rizaty, 2022).

For early childhood, such exposure is not simply a matter of physical safety. Floods interrupt routines, schooling, emotional security, and the social environments through which young children learn. Yet disaster governance has long tended to privilege infrastructure, emergency response, and general awareness over pedagogically grounded preparation for young learners. In Indonesia, the policy basis for disaster risk reduction is already substantial, as reflected in Law No. 20 of 2003, the National Disaster Management Plan 2020–2024, and the school preparedness agenda formalized through Permendikbud No. 33 of 2019 (Bencana, 2020a). At the same time, a considerable number of educational institutions are located in disaster-prone zones, including areas vulnerable to floods and landslides (Ministry of Education and Culture, 2019; Kementerian Pendidikan dan Kebudayaan, 2019). Disaster education scholarship has also argued that schools should be understood not merely as places of instruction, but as critical sites for cultivating a culture of risk reduction, particularly when children are introduced early to the causes of hazards, the disaster management cycle, and the responsibilities shared across institutions and communities (Shiwaku & Fernandez, 2011, as cited in Shaw et al., 2015; Proulx & Aboud, 2019; Tatebe & Mutch, 2015a; Muetya et al., 2022).

Even so, policy presence does not automatically translate into pedagogical readiness. Children are among the groups most vulnerable to disaster impacts, yet educational responses for this age group must be developmentally calibrated: the material has to be concrete enough to be understood, emotionally safe enough to avoid fear, and meaningful enough to support durable habits of preparedness (Shiwaku & Fernandez, 2011; Tatebe & Mutch, 2015b; Proulx & Aboud, 2019). For that reason, disaster mitigation in early childhood cannot be reduced to procedural drills or adult-centered information delivery. It needs to be taught through forms of learning that help children observe their environments, connect natural signs to risk, and rehearse protective responses in age-appropriate ways (Setyowati, 2019; Walther, 2021; Rahma, 2020; Rivera, 2021; Boss & Krauss, 2022; DeBoer, 2019). Evidence from Indonesia and other contexts has shown that disaster content can be integrated into educational practice and school preparedness programs, including through curriculum-based approaches in Indonesia, Lebanon, China, and Afghanistan (Rahma, 2018; Apriyanti, 2019; Prakoso et al., 2021; Baytiyeh, 2018; Zhu & Zhang, 2017; Naseri & Kang, 2017). What remains unresolved is how such content can be translated into pedagogies that are both educationally serious and developmentally appropriate for young children.

Recent disaster education literature suggests that this translation is increasingly being attempted through diverse communicative and technological pathways, including science communication, social media, social entrepreneurship, digital disaster management systems, mobile applications, machine learning, and drone-based interventions (Chirisa & Matamanda, 2022; Kartashova et al., 2022; Rayamajhee et al., 2022; Munawar et al., 2022; Navarro de Corcuera et al., 2022; Rolnick et al., 2022; Daud et al., 2022). These developments are important, but most of them are oriented toward general populations, institutional management, or technically mature users. They offer only limited guidance for early childhood settings, where preparedness must be mediated through play, repetition, narrative, and emotionally secure participation rather than through information transfer alone.

Within this landscape, gamification has emerged as a potentially relevant pedagogical approach. Broadly understood, gamification refers to the use of game elements, game thinking, and structured interaction to reshape learning experiences so that participation, feedback, and progression become more meaningful to learners (Koivisto & Hamari, 2019; Durahman & Nugraha, 2022; Ariani, 2020; Kapp, 2013a; Gachkova & Somova, 2016). In educational settings, its most visible components include points, badges, leaderboards, progression systems, levels, statistics, and acknowledgment, with acknowledgment often reported as one of the most frequently deployed design elements (Alexander et al., 2021; Mitsuhashi et al., 2017; Toda et al., 2019; Klock et al., 2018). Kapp (2013b) further distinguishes between structural gamification and

content gamification, a distinction that is especially relevant in educational design because it clarifies whether game elements are used to frame participation or to reshape the learning material itself. Prior scholarship also suggests that the educational value of gamification does not lie only in reward mechanics, but in replayability, freedom to fail, immediate feedback, visible progress, narrative structure, and sustained engagement, all of which can support iterative learning and reduce fear of failure when learning involves challenge or uncertainty (Mekler et al., 2017; Roosta et al., 2016; Groening & Binnewies, 2019; Shaliha & Fakhzikril, 2022; Dicheva et al., 2015b; Pratomo, 2018; Binastya Benedictus Arya, 2018). This orientation is pedagogically relevant for young children, for whom repetition, story, and guided experimentation are central to meaning-making.

Even so, the intersection between gamification and disaster mitigation education remains conceptually thin in early childhood research. Existing studies have shown that games and gamified systems can contribute to disaster risk reduction and emergency planning, including through video games and community resilience initiatives (Gampell & Gaillard, 2016; Kankanamge et al., 2020; Kankanamge et al., 2022). However, most of this literature has not been built around early childhood pedagogy, nor has it adequately examined how gamified learning might help young children engage with flood risk without reducing disaster education to entertainment or technological novelty. This gap matters especially in Indonesia, where recurrent flood exposure, uneven infrastructure, and the need for developmentally appropriate learning converge in particularly sharp ways. Accordingly, this study examines the pedagogical role of gamification in disaster mitigation learning and its relevance for introducing flood preparedness to early childhood learners. Rather than treating gamification as a stand-alone digital solution, this review approaches it as a pedagogical question: under what conditions can game-based structures help young children make sense of disaster risk in ways that are cognitively accessible, emotionally safe, and educationally meaningful?

Methods

Research Design

This study employed a Systematic Literature Review (SLR) guided by the PRISMA 2020 statement to ensure procedural transparency and a traceable study-selection process. The review was designed to synthesize a heterogeneous body of literature addressing gamification, disaster mitigation, and early childhood learning. Because the included studies varied in design, scope, and evidentiary orientation, the review did not pursue meta-analysis. Instead, it adopted a narrative synthesis informed by thematic analysis in order to identify recurrent pedagogical patterns, conceptual convergences, and contextual gaps across the corpus.

Search Strategy and Information Sources

The literature search was conducted across five major academic databases: Scopus, Web of Science, ScienceDirect, Wiley Online Library, and the Directory of Open Access Journals (DOAJ). The search was limited to peer-reviewed journal articles and conference proceedings published between 2015 and 2025. To increase retrieval precision while retaining conceptual breadth, the search strategy combined four clusters of terms related to gamification, disaster mitigation, flood risk, and early childhood education. Database-specific syntax was adjusted where necessary, but the core Boolean logic followed the structure below:

("gamification" OR "game-based learning") AND ("disaster education" OR "disaster mitigation" OR "disaster risk reduction") AND ("flood" OR "flood preparedness" OR "flood mitigation") AND ("early childhood education" OR "early childhood" OR "young children")

The search categories are summarized in Table 1.

Table 1. Keywords for Search Strategy

Category	Keywords
Gamification	gamification OR game-based learning
Disaster Mitigation	disaster education OR disaster mitigation OR disaster risk reduction

Category	Keywords
Flood Focus	flood OR flood preparedness OR flood mitigation
Early Childhood	early childhood education OR early childhood OR young children

Eligibility Criteria

Eligibility criteria were established before screening to maintain consistency in study selection and to ensure alignment with the review focus. Studies were included when they addressed gamification or game-based learning in relation to disaster education, disaster mitigation, or disaster risk reduction, with relevance to early childhood settings, learners, educators, or parents. Given the substantive focus of this review, particular attention was paid to studies that could inform flood preparedness and developmentally appropriate disaster learning. Only full-text publications in English or Indonesian, published between 2015 and 2025, were considered. Editorials, opinion pieces, book reviews, and studies unrelated to either gamified learning or disaster-preparedness education were excluded. The inclusion and exclusion criteria are presented in Table 2.

Table 2. Inclusion and Exclusion Criteria

Criteria	Inclusion Criteria	Exclusion Criteria
Document Type	Peer-reviewed journal articles and conference proceedings	Editorials, book reviews, news articles, and opinion pieces
Language	English and Indonesian	Languages other than English and Indonesian
Timeframe	Published between 2015 and 2025	Published before 2015
Target Population	Early childhood (ages 0–8), teachers, or parents in ECE settings	Secondary school students, university students, or adult general populations without ECE relevance
Core Topics	Gamification or game-based learning in disaster preparedness, disaster mitigation, or disaster risk reduction, with relevance to flood-related learning in early childhood contexts	General education, technology use, or disaster studies without a gamification focus or without relevance to early childhood learning
Access	Full-text available	Abstract only or inaccessible full-text

Selection Procedures

The study-selection process followed the PRISMA 2020 sequence of identification, screening, eligibility assessment, and inclusion. A total of 340 records were identified from the five databases: Scopus (n = 60), Web of Science (n = 45), ScienceDirect (n = 110), Wiley Online Library (n = 55), and DOAJ (n = 70). No additional records were identified through registers. Prior to screening, 152 duplicate records were removed and 10 records were excluded through automated filtering, resulting in 178 records for title and abstract screening.

At the screening stage, 178 records were reviewed for topical relevance, and 115 were excluded because they did not match the scope of the review. This left 63 reports for full-text retrieval and eligibility assessment. All 63 full-text reports were successfully retrieved and assessed. Of these, 35 were excluded after full-text review for three principal reasons: insufficient focus on early childhood pedagogy (n = 15), limited discussion of gamification mechanisms (n = 12), and insufficient relevance to disaster-preparedness learning, including the flood-related focus of the review (n = 8). The final synthesis therefore included 28 studies.

This selection pathway is illustrated in Figure 1. The PRISMA sequence reports the following counts: records identified (n = 340), records removed before screening (n = 162), records screened (n = 178), records excluded (n = 115), reports sought for retrieval (n = 63), reports not retrieved (n = 0), reports assessed for eligibility (n = 63), reports excluded (n = 35), and studies included in review (n = 28).

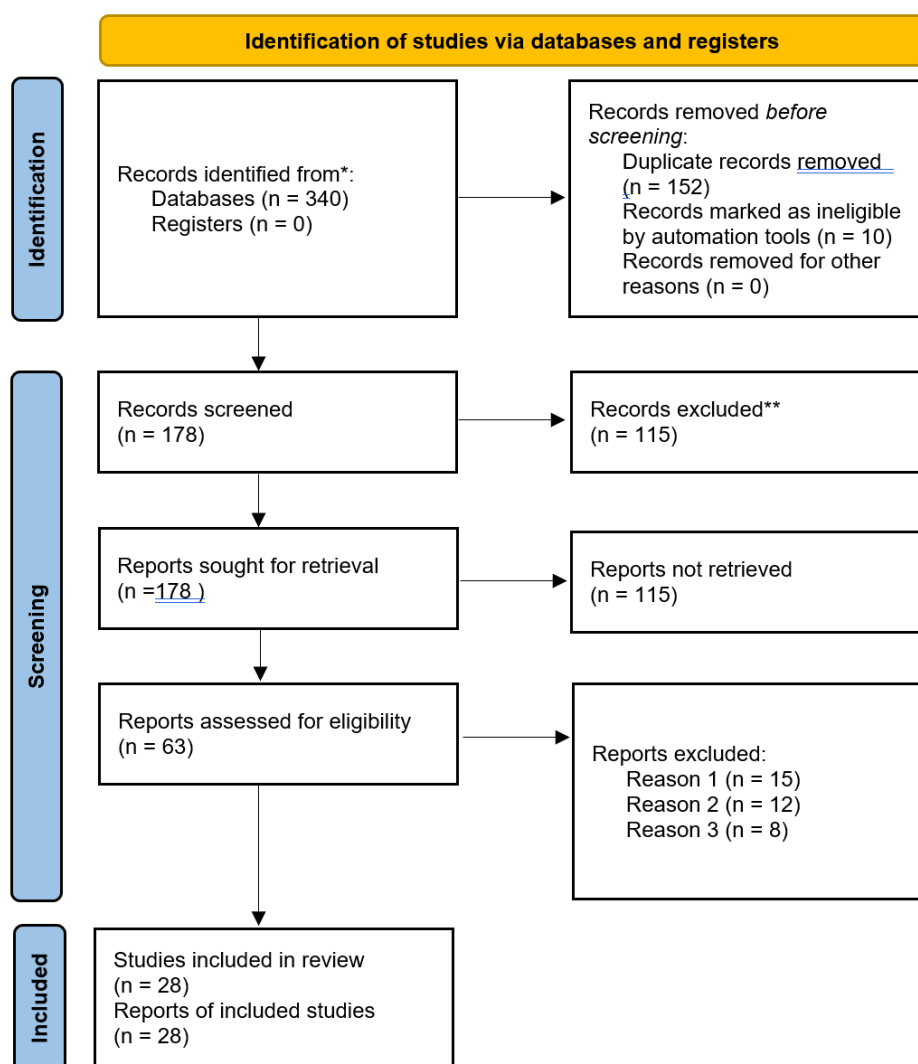


Figure 1. PRISMA 2020 flow diagram of study selection

Quality Appraisal

Methodological quality was appraised to strengthen the interpretive reliability of the synthesis. Because the reviewed corpus included qualitative, quantitative, mixed-methods, and review-oriented studies, appraisal was conducted in a design-sensitive manner. The Critical Appraisal Skills Programme (CASP) checklist informed the assessment of qualitative studies, whereas the Mixed Methods Appraisal Tool (MMAT) guided the appraisal of empirical quantitative and mixed-methods studies. For review-oriented studies, appraisal focused on procedural transparency, clarity of scope, and analytic coherence. Across these categories, assessment considered methodological appropriateness, design quality, clarity of findings, and relevance to the review question. Only studies judged to meet at least a medium level of methodological adequacy were retained in the final synthesis framework.

Data Analysis

The selected studies were analysed through thematic analysis combined with narrative synthesis. First, the full set of included studies was read closely to extract information on study purpose, educational setting, participant focus, type of gamification, disaster-learning orientation, and key findings. Second, initial codes were generated to identify recurring pedagogical mechanisms, such as explicit rules, feedback loops, simulation, role-play, progression, and emotionally secure participation. Third, related codes were clustered into broader themes that captured shared patterns across the literature, including pedagogical

scaffolding, psychological safety, and contextual implementation trends. Finally, these themes were interpreted in relation to early childhood education in Indonesia in order to identify conceptual implications, policy relevance, and areas requiring further empirical development.

Because the evidence base was conceptually and methodologically diverse, the synthesis did not seek statistical aggregation. Instead, it aimed to produce an analytically coherent account of how gamification has been positioned and operationalised in disaster-related learning for young children, and where important gaps remain in the literature.

Result

Quality Profile of the Included Studies

The included studies provided a reasonably strong evidence base, although the corpus remained heterogeneous in design, scope, and analytical depth. Most studies were appraised as high or medium-high in methodological adequacy, while a smaller number were retained at a medium threshold because they remained relevant to the review question despite more limited design strength or narrower empirical reach. Across the corpus, stronger studies tended to provide clearer links between pedagogical design, gamified mechanisms, and learning outcomes, whereas weaker studies were more descriptive or broader in technological scope.

The appraisal matrix is positioned here as Table 3 and should be inserted at this point in the manuscript. It covers the 28 included studies, namely Baytiyeh (2018), Chen et al. (2020), Daud et al. (2022), Dehghanzadeh et al. (2024), Dicheva et al. (2015a), Gampell and Gaillard (2016), Groening and Binnewies (2019), Kammerbauer and Minnery (2019), Kankanamge et al. (2022), Kankanamge et al. (2020), Koivisto and Hamari (2019), Krath et al. (2021), Lamrani and Abdelwahed (2020), Mazhar (2019), Mekler et al. (2017), Mitsuhara et al. (2017), Munawar et al. (2022), Naseri and Kang (2017), Navarro de Corcuera et al. (2022), Njogu (2021), Nkwunonwo et al. (2020), Priest et al. (2016), Sivakumar (2024), Toda et al. (2019), Xu and Hamari (2023), Yildiz and Yildiz (2021), Zeybek and Saygı (2024a), and Zhu and Zhang (2017).

Table 3. Quality Appraisal using the CASP checklist and the MMAT

No	Study ID	Methodology Appropriateness	Research Design Quality	Findings Clarity	Quality Rating
1	(Baytiyeh, 2018)	High. Explores the link between education and urban resilience in developing societies.	Strong. Robust conceptual analysis of recurring disaster impacts.	Excellent. Clearly articulates the role of education in impact reduction.	High
2	(Chen et al., 2020)	High. Appropriate use of role-play gamification within a classroom setting.	Strong. Longitudinal approach (1-16 pages of data) focusing on motivation.	Very Clear. Directly links gamification to student engagement levels.	High
3	(Daud et al., 2022)	High. Scoping review methodology is well-suited for emerging drone technology.	Moderate. Comprehensive but primarily descriptive of existing tech.	Clear. Provides a good overview of tech applications in disasters.	Medium-High
4	(Dehghanzadeh et al., 2024)	Excellent. Systematic review following rigorous SLR protocols (PRISMA-like).	Very Strong. High-quality analysis of 36+ pages on K-12 gamification.	Excellent. Synthesizes complex data into actionable learning insights.	High
5	(Dicheva et al., 2015a)	Excellent. Employs a rigorous Systematic Mapping Study (SMS) approach, which is ideal for categorizing a broad, emerging field.	Very Strong. Highly systematic in its classification of gamification design patterns and educational levels.	Excellent. Provides a clear taxonomy of game elements and identifies the "lack of empirical evidence" in early research phases.	High
6	(Gampell & Gaillard, 2016)	High. Focuses on "Stop Disasters 2.0" as a specific tool for DRR.	Strong. Specific case analysis of video games as functional	Excellent. Clear correlation between game mechanics and	High

No	Study ID	Methodology Appropriateness	Research Design Quality	Findings Clarity	Quality Rating
				DRR knowledge.	
7	(Groening & Binnewies, 2019)	Excellent. Uses a rigorous experimental design to isolate the specific impact of "achievements" as a game element.	Very Strong. High-quality empirical data focusing on the psychological nuances of performance and motivation.	Excellent. Clearly distinguishes between how digital rewards affect different types of learners and tasks.	High
8	(Kammerbauer & Minnery, 2019)	High. Employs an in-depth case study and qualitative analysis of post-disaster risk communication.	Strong. Provides a critical evaluation of the gap between official warnings and public risk perception during a major flood event.	Very Clear. Offers valuable lessons on why traditional communication fails, justifying the need for more engaging methods.	High
9	(Kankanamge et al., 2022)	Excellent. Specifically uses effectiveness testing (pre- and post-test) for a gamified community education model.	Very Strong. Directly bridges the gap between gamification theory and disaster resilience outcomes in a real-world setting.	Excellent. Quantifies the improvement in disaster preparedness through gamification, providing a direct empirical link.	High
10	(Kankanamge et al., 2020)	High. Systematic review targeting emergency planning integration.	Strong. Methodical approach to identifying gamification patterns in planning.	Excellent. Clearly defines how games fit into emergency frameworks.	High
11	(Koivisto & Hamari, 2019)	Excellent. A high-level systematic review covering a vast range of empirical studies across multiple domains.	Very Strong. Rigorous categorization of gamification research evolution, focusing on the transition toward "motivational information systems."	Excellent. Clearly identifies the long-term benefits and psychological outcomes of gamification, providing a gold standard for the field.	High
12	(Krath et al., 2021)	Excellent. Deep theoretical analysis of gamification basis.	Very Strong. Analyzes 100+ theories, providing high scientific value.	Very Clear. Bridges the gap between theory and practical game elements.	High
13	(Lamrani & Abdelwahed, 2020)	High. Specifically addresses early years education through gamification.	Strong. Focuses on skill improvement in early development stages.	Clear. Provides evidence of skill gains through game-based learning.	High
14	(Mazhar, 2019)	High. Employs Action Research, which is highly effective for observing direct pedagogical shifts in a classroom setting.	Strong. Provides a detailed, step-by-step account of the implementation process and its impact on student engagement.	Clear. Successfully demonstrates how digital games facilitate skill acquisition (writing) through iterative practice.	High-Medium
15	(Mekler et al., 2017)	Excellent. A seminal experimental study that isolates the effects of points, leaderboards, and levels on intrinsic motivation.	Very Strong. High internal validity; uses a large sample size and rigorous psychological scales to measure user experience.	Excellent. Provides a critical finding that game elements can boost performance without necessarily undermining intrinsic motivation.	High
16	(Mitsuhara et al., 2017)	High. Investigates advanced training scenarios using a combination of digital games, AR, and Head-Mounted Displays.	Strong. Technically rigorous; focuses on "immediate-action" training which is highly relevant to disaster response.	Very Clear. Shows how immersive tech can enhance situational awareness and decision-making for	High

No	Study ID	Methodology Appropriateness	Research Design Quality	Findings Clarity	Quality Rating
				commanders/trainees.	
17	(Munawar et al., 2022)	High. Review of disruptive technologies for disaster management.	Moderate. Broad scope; covers many technologies beyond gamification.	Clear. Identifies solutions for modern risk management.	Medium-High
18	(Naseri & Kang, 2017)	Moderate. Appropriately uses a primary assessment method to evaluate local mitigation capacity in a conflict-affected area.	Average. While the sample size is limited, it provides rare and valuable data on society-based mitigation in Kabul.	Clear. Explicitly identifies the lack of public awareness and the need for community-based education.	Medium
19	(Navarro de Corcuera et al., 2022)	High. Employs a rigorous multi-criteria assessment to evaluate the adequacy of mobile apps for DRR.	Strong. Comprehensive evaluation framework that considers usability, functionality, and disaster phases.	Excellent. Provides a clear ranking and diagnostic of current technological gaps in disaster reduction apps.	High
20	(Njogu, 2021)	High. Uses a focused approach to analyze the socio-economic impacts of floods on infrastructure users in Kenya.	Strong. Good use of empirical data to link environmental hazards with user vulnerability in a Global South context.	Very Clear. Directly illustrates the disruption of livelihoods caused by flood events, supporting the need for early mitigation.	High-Medium
21	(Nkwunonwo et al., 2020)	High. Provides a highly relevant review of flood modeling status specifically within the context of developing nations.	Strong. Systematic and critical analysis of data gaps and technical limitations in urban flood management.	Excellent. Very clear in highlighting why Western models require adaptation for Global South contexts.	High
22	(Priest et al., 2016)	High. Uses a robust comparative analysis across six European countries to evaluate societal resilience.	Very Strong. Mature policy analysis framework based on the EU Floods Directive with strong socio-legal grounding.	Excellent. Provides sophisticated insights into how institutional policies translate into community resilience.	High
23	(Sivakumar, 2024)	Moderate-High. Focuses on the pedagogical aspects of gamification for creative learners in disruptive tech environments.	Average-Strong. Offers a solid conceptual foundation, though it is more theoretical/textbook-oriented than purely empirical.	Clear. Provides practical guidance on how game elements stimulate high-order cognition in students.	High-Medium
24	(Toda et al., 2019)	High. Uses a specific taxonomy to analyze educational environments.	Strong. Technical and structured analysis of gamification elements.	Excellent. Highly structured results using a clear taxonomy.	High
25	(Xu & Hamari, 2023)	Excellent. Uses a sophisticated experimental design to isolate the variables of gamification, monetary rewards, and punishment.	Very Strong. High internal validity with controlled conditions to measure creative performance accurately.	Excellent. Provides a nuanced explanation of how gamification elements specifically influence intrinsic vs. extrinsic motivation.	High
26	(C. Yildiz & Yildiz, 2021)	High. Employs a quasi-experimental pre-test/post-test design, which is ideal for	Strong. Specifically targets pre-service teachers, providing valuable insights for	Very Clear. Demonstrates a statistically significant positive effect of	High

No	Study ID	Methodology Appropriateness	Research Design Quality	Findings Clarity	Quality Rating
		measuring shifts in motivation.	the "pedagogical design" aspect of your research.	gamification on teacher motivation and creative thinking skills.	
27	(Zeybek & Saygi, 2024a)	High. Systematic review of the "Why, Where, When, and How" of gamification.	Strong. Recent data (2024) providing up-to-date SLR findings.	Excellent. Very sharp synthesis of pedagogical mechanisms.	High
28	(Zhu & Zhang, 2017)	High. The empirical investigation is highly appropriate for assessing the status of disaster education in a large-scale context (China).	Strong. Utilizes a comprehensive survey-based approach to gather evidence from both elementary and secondary schools.	Excellent. Clearly identifies the gaps between policy and implementation, particularly regarding regional disparities.	High

Patterns in the Use of Gamification

Across the reviewed literature, gamification appeared less as a single technique than as a cluster of pedagogical design choices used to structure participation, sustain attention, and support incremental learning. Although gamification has been applied across health, sports, business, marketing, tourism, environmental protection, emergency planning, and education, the included studies consistently identified education as one of its most established domains (Koivisto & Hamari, 2019; Mitsuahara et al., 2017). Within educational settings, frequently reported elements included points, progression, levels, statistics, and acknowledgment, with acknowledgment often noted as one of the most common design features in learning environments (Toda et al., 2019; Klock et al., 2018).

The synthesis further showed that the educational value of gamification was not reducible to reward systems alone. Studies repeatedly emphasized immediate feedback, visible progress, repetition, and low-risk opportunities to try again as mechanisms that support engagement and persistence, particularly when learners are expected to work through uncertainty or challenge (Mekler et al., 2017; Roosta et al., 2016; Groening & Binnewies, 2019; Dicheva et al., 2015b; Pratomo, 2018). This pattern also aligns with broader accounts of gamification as the integration of game elements, interactional structure, and game thinking into learning environments in order to shape behaviour, strengthen participation, and make learning experiences more responsive to learner action (Durahman & Nugraha, 2022; Ariani, 2020; Kapp, 2013a; Gachkova & Somova, 2016).

A second pattern concerned the form through which gamification entered educational content. The reviewed literature distinguished between structural gamification, in which game elements frame participation around existing content, and content gamification, in which the learning material itself is reshaped through challenge, story, or game-like progression (Kapp, 2013b). This distinction matters because the more relevant studies in this review did not merely attach rewards to tasks. Rather, they used narrative sequencing, guided repetition, and staged progression to help learners move through content in manageable ways. Related studies also emphasized that points, badges, and leaderboards are best understood as surface elements unless they are tied to pedagogical purpose and learner readiness (Alexander et al., 2021; Binastya Benedictus Arya, 2018). The stronger literature therefore framed gamification not as decorative motivation, but as a structured learning environment whose effectiveness depends on fit between learner characteristics, educational goals, and the logic of the activity itself (Lamrani & Abdelwahed, 2020; Krath et al., 2021; Sivakumar, 2024; Zeybek & Saygi, 2024a; Xu & Hamari, 2023; Yildiz & Yildiz, 2021).

Disaster Learning in Early Childhood Contexts

Across the reviewed studies, a consistent point emerged: disaster mitigation in early childhood requires more than information delivery. Children were consistently positioned as a vulnerable group whose preparedness depends on developmentally appropriate educational mediation rather than on adult-oriented instruction alone (Shiwaku & Fernandez, 2011; Tatebe & Mutch, 2015b; Proulx & Aboud, 2019). In this corpus, disaster learning in early childhood was most often connected to observation, environmental awareness, simple explanation, guided practice, and emotionally manageable forms of participation. Several studies suggested that when disaster content is introduced through science-related inquiry and structured observation of environmental signs, children are better able to connect abstract risk with their immediate surroundings (Rahma, 2020; Rivera, 2021; Boss & Krauss, 2022; DeBoer, 2019).

Another recurring issue was curriculum integration and institutional readiness. The literature showed that disaster mitigation education has increasingly been framed as part of school-based preparedness, whether through curricular integration, extracurricular provision, or broader disaster-safe school initiatives (Bencana, 2020a; Rahma, 2018; Apriyanti, 2019; Prakoso et al., 2021). Similar tendencies were documented beyond Indonesia, including Lebanon, China, and Afghanistan, where schools were positioned as sites for strengthening awareness, resilience, and basic mitigation knowledge (Baytiyeh, 2018; Zhu & Zhang, 2017; Naseri & Kang, 2017). At the same time, the reviewed literature made clear that institutional recognition of disaster risk does not automatically produce age-appropriate pedagogy. Young learners require forms of engagement that are concrete, repetitive, safe, and socially supported, especially when the topic carries the potential to evoke fear.

The literature also pointed to the growing overlap between disaster education and wider technological and communicative infrastructures. Studies documented the use of science communication, social media, social entrepreneurship, digital applications, machine learning, and drone-supported systems in disaster-related education and management (Chirisa & Matamanda, 2022; Kartashova et al., 2022; Rayamajhee et al., 2022; Munawar et al., 2022; Navarro de Corcuera et al., 2022; Rolnick et al., 2022; Daud et al., 2022). However, these studies were not equally useful for early childhood contexts. Many were informative at the level of innovation and system design, yet offered limited guidance for the pedagogical problem at the centre of this review: how risk concepts can be translated into forms of learning that remain accessible to young children.

Integrative Synthesis: Gamification and Early Childhood Disaster Preparedness

Reading the gamification literature alongside work on disaster education and early childhood learning brought three recurrent patterns into view. First, gamified structures were most pedagogically relevant when they functioned as scaffolds for understanding rather than as external reward systems alone. Studies on role-play, simulation, challenge sequencing, and guided participation suggested that game-based structures can help learners move from isolated actions to more coherent understanding of disaster-related procedures and risk awareness (Gampell & Gaillard, 2016; Kankanamge et al., 2020; Kankanamge et al., 2022; Chen et al., 2020; Dehghanzadeh et al., 2024).

Second, the reviewed literature indicated that gamified learning environments can create psychologically safer entry points into difficult topics. Repetition, trial without penalty, immediate feedback, and role enactment reduce the pressure of error and allow learners to explore potentially distressing material through controlled participation. This pattern appeared especially important for early childhood, where emotional regulation and cognitive access develop in close relation to play, imitation, and social interaction (Mekler et al., 2017; Mazhar, 2019; Lamrani & Abdelwahed, 2020; Groening & Binnewies, 2019).

Third, the evidence suggested that context matters sharply. Studies on floods, risk communication, and disaster education in developing or disaster-prone settings showed

that pedagogical transfer cannot be assumed across contexts without attention to infrastructure, local relevance, and forms of community vulnerability (Kammerbauer & Minnery, 2019; Nkwunonwo et al., 2020; Njogu, 2021; Priest et al., 2016). For this reason, the most relevant contribution of gamification in this review was not its digital novelty, but its capacity to organize learning through story, staged action, repetition, and shared participation in ways that can be adapted to local educational realities.

Figure 2 brings these recurring patterns together. Rather than functioning as a stand-alone theoretical claim, the figure represents the review findings in an integrated form by linking gamified pedagogical structures with four clusters of learning outcomes in early childhood disaster preparedness: cognitive understanding of disaster risk, socio-emotional preparedness, adaptive and safety behaviours, and social interaction skills.

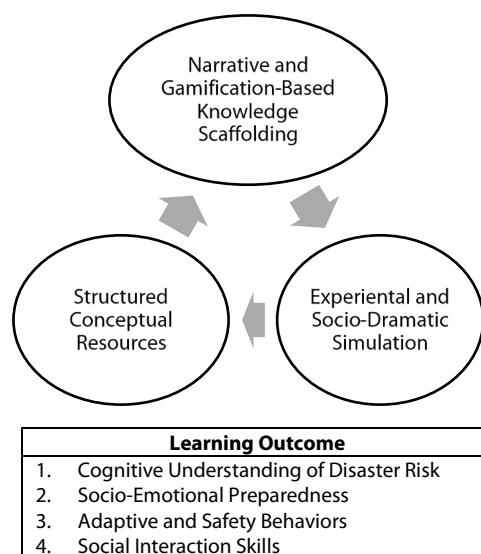


Figure 2. Conceptual Model of Gamification-Based Disaster Mitigation Education for Early Childhood

The results suggest that the strongest evidence does not support a simplistic equation between gamification and motivation. Instead, the literature more consistently points to gamification as a pedagogical arrangement that becomes meaningful when it translates disaster-related content into staged, participatory, and developmentally responsive learning experiences. Within this synthesis, its relevance to flood preparedness lies in its capacity to connect abstract risk, practical rehearsal, and emotionally manageable learning in ways that remain appropriate for early childhood settings.

Discussion

The discussion emerging from this review suggests that current international writing on gamification in education still carries two recurrent tendencies. One is to treat gamification primarily as a device for boosting motivation and engagement. The other is to assume that digital enhancement, by itself, represents pedagogical improvement. The evidence synthesised here points to a narrower and more cautious conclusion. In early childhood disaster learning, the educational significance of gamification lies less in its digital appearance than in the pedagogical mediation it makes possible. The stronger studies in the corpus did not present gamification as a self-sufficient technological fix. More often, they showed that game-based structures become educationally relevant when they translate abstract risk into staged, graspable, and emotionally manageable activity. In this respect, the present review does not reject wider discussions of technology-rich learning in early childhood, including those associated with digital and AI-supported environments, but it does place a limit on more expansive claims by suggesting that such environments become meaningful only when they remain anchored in developmentally grounded pedagogy (Fatmawati, 2024; Krichen et al.,

2024).

This framing also clarifies the position of the review within the broader literature on gamification. A substantial part of that literature has been organised around reward systems, behavioural incentives, or generalized claims about engagement. The studies reviewed here complicate that orientation by indicating that effectiveness is conditional rather than inherent. Gamification appears pedagogically productive when its design aligns with the developmental logic of early childhood learning, particularly the importance of play, repetition, social interaction, and guided exploration. This reading is consistent with scholarship that has moved beyond narrow reward-based models toward more layered accounts of participation and meaning-making in gamified environments (Krath et al., 2021; Xu & Hamari, 2023; Sivakumar, 2024; Zeybek & Saygi, 2024a). The contribution of this review therefore lies not in claiming that gamification offers a superior route to disaster education, but in specifying the conditions under which it becomes educationally persuasive for young children.

A second point concerns how early childhood learners are positioned within disaster education itself. International discussions of preparedness have often been shaped by institutional logics, risk communication strategies, and community resilience frameworks that do not fully address the pedagogical problem of how young children come to understand risk. The reviewed evidence suggests that gamified disaster learning matters not because it keeps children occupied or entertained, but because it can reposition them as participants in meaning-making. In early childhood settings, learning is inseparable from doing, rehearsing, imitating, and negotiating with others. Across the corpus, gamified environments were associated not only with task engagement but also with collaboration, turn-taking, communicative exchange, and shared problem-solving among young learners (Mekler et al., 2017; Mazhar, 2019; Lamrani & Abdelwahed, 2020; Yildiz & Yildiz, 2021; Chen et al., 2022; Dehghanzadeh et al., 2024). Read against broader disaster education literature, this shifts the emphasis away from the passive receipt of safety information and toward guided participation in situational understanding.

The review also sharpens the discussion of mechanism. Across the included studies, explicit rules, feedback loops, role-play, repeated trials, and simulated scenarios were not merely recurring design features. They worked as mediating devices between abstract hazard knowledge and concrete learning action. This is where the present synthesis speaks most directly to international debates on game-based learning. Rather than asking whether gamification motivates learners in general, the reviewed evidence makes it more useful to ask how game-based structures organise access to difficult knowledge for specific learner groups. In early childhood disaster education, that distinction matters because risk cannot be introduced in the same way it might be presented to older learners. The studies reviewed here suggest that when flood-related or disaster-related scenarios are organised through staged participation, children are better able to connect concrete action with emerging conceptual understanding (Gampell & Gaillard, 2016; Kankanamge et al., 2020; Kankanamge et al., 2022; Chen et al., 2020; Dehghanzadeh et al., 2024). The issue, then, is not novelty in itself, but the conversion of uncertainty into structured experience.

A third point concerns context. Global discussions of disaster education and educational technology often move toward transferable models, but the evidence reviewed here suggests that transfer cannot be assumed without attention to infrastructure, institutional capacity, social vulnerability, and communicative habits. Studies on floods, disaster communication, and preparedness in risk-prone settings repeatedly show that what counts as workable pedagogy is shaped by the conditions in which learning takes place (Kammerbauer & Minnery, 2019; Nkwunonwo et al., 2020; Njogu, 2021; Priest et al., 2016). This is especially important for Indonesia, where flood exposure is recurrent, infrastructural unevenness remains marked, and pedagogical resources vary sharply across settings. The relevance of the Indonesian case should therefore not be read as an isolated national exception. It is better understood as part of a wider Global South problem in which disaster education must be made pedagogically workable under

uneven material and institutional conditions. From that perspective, the review does not support a high-tech imaginary in which digital sophistication alone guarantees educational gain. It suggests instead that the more durable contribution of gamification lies in its adaptability to local pedagogical conditions, including low-risk simulation, narrative framing, and shared participation.

What this discussion adds, then, is a more discriminating account of where the literature currently stands. The evidence does not justify sweeping claims that gamification transforms disaster education in general, nor does it support the opposite view that game-based learning is merely a motivational veneer. A more defensible conclusion is that gamification becomes most useful when it mediates between abstract risk, practical rehearsal, and emotionally secure participation in ways that fit early childhood pedagogy. That conclusion is deliberately limited. It does not claim that gamification resolves the wider challenges of disaster education. It does, however, suggest that future work on curriculum design, teacher preparation, and intervention development would benefit from shifting attention away from technological novelty alone and toward the pedagogical conditions under which young children are helped to interpret, rehearse, and socially inhabit preparedness.

Conclusion

This review suggests that the contribution of gamification to early childhood disaster education is more specific than some broader accounts of educational technology tend to imply. The reviewed literature does not support the view that gamification is inherently effective or that digital design alone improves preparedness learning. What emerges more consistently is a narrower but more useful conclusion. Gamification becomes educationally relevant when it helps translate abstract risk into forms of participation that young children can enter through play, repetition, guided action, and socially mediated interaction. Read in this way, its value lies less in technological novelty than in its capacity to function as pedagogical mediation between hazard knowledge, practical rehearsal, and emotionally manageable learning. This conclusion has wider relevance beyond Indonesia because it speaks to a broader international question about how disaster education can be made developmentally workable in early childhood, especially in contexts where vulnerability is high and educational conditions are uneven.

At the same time, these conclusions should be read within the limits of the review. The synthesis focused primarily on flood-related disaster learning, which restricts direct transfer to other forms of hazard such as earthquakes or volcanic events. The reviewed studies were also heterogeneous in design and scope, and the analysis did not systematically compare gamification with alternative pedagogical approaches across equivalent settings. For that reason, the review does not claim that gamification offers a general solution to disaster education in early childhood. A more cautious implication is that future research should examine how different pedagogical designs shape children's preparedness over time, across a wider range of hazards, and under varying institutional conditions. Further work would also benefit from testing when immersive or digitally enhanced environments, including AR-based formats, genuinely support understanding and rehearsal, and when they add complexity without sufficient pedagogical value. The practical implication is therefore not to expand technology for its own sake, but to strengthen curriculum design, teacher preparation, and context-sensitive implementation so that preparedness learning remains educationally meaningful for young children.

Declarations

Author Contribution Statement

Mallevi Agustin Ningrum: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – Original Draft, Visualization, Project administration. Mohammad Fauziddin: Conceptualization, Validation, Supervision, Writing – Review & Editing. Mohd. Syahidan Zainal Abidin: Validation, Supervision, Writing – Review & Editing.

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Data Availability Statement

No primary dataset was generated or analysed in this systematic review beyond the published studies cited in the reference list and described in the Methods section.

Declaration of Interests Statement

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Additional Information

No additional information is available for this paper.

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