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DEVELOPING DISASTER MITIGATION SIMULATION MODEL IN EARLY CHILDHOOD EDUCATION THROUGH A SERVICE-LEARNING APPROACH

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ABSTRACT

This study developed a disaster mitigation simulation model for early childhood education using a service-learning approach in Yogyakarta. Many institutions previously lacked age-appropriate evacuation procedures and structured preparedness programs, increasing risks for children and schools. A research and development design was implemented through needs assessment, model design, expert validation, limited field trials, and product revision. Data were collected through classroom observations, semi-structured interviews, focus group discussions, document analysis, and questionnaires involving 112 children aged 4–6 years, 14 teachers, 8 principals, and 24 PIAUD students. Semi-structured interviews with teachers and principals explored institutional readiness, implementation feasibility, and contextual constraints, while focus group discussions refined simulation procedures and facilitation strategies. Questionnaires were administered to teachers before and after the simulation to measure changes in disaster preparedness knowledge, confidence, and facilitation competence. Expert validation showed high feasibility of the model (M = 3.58 out of 4), indicating strong relevance, safety, and applicability for young children. Limited field trials in eight institutions demonstrated improvements in children's protective responses, teacher facilitation capacity, and overall school readiness despite environmental constraints. The study concluded that the model was practical, replicable, and developmentally appropriate while strengthening pre-service teachers' professional skills through service-learning.

Keywords: *Disaster Education; Disaster Mitigation; Early Childhood Education; Evacuation SOP; Service-Learning; Simulation Model*

A. INTRODUCTION

Yogyakarta is widely recognized as one of the most disaster-prone areas in Indonesia, with frequent earthquakes, volcanic eruptions, floods, and landslides (BNPB, 2023). Despite this high level of vulnerability, early childhood disaster education remains limited and fragmented. Most early childhood education (PAUD) institutions lack a structured disaster mitigation system, including evacuation standard operating procedures (SOPs) tailored to the developmental characteristics of young children (Willyaldo, 2024). In Indonesia, early childhood education is generally referred to as PAUD (Pendidikan Anak Usia Dini, Early Childhood Education). Teachers generally have limited formal training in disaster preparedness and child-friendly risk reduction practices, which limits their ability to implement systematic mitigation programs (Ramadhani & Nurfadilah, 2018; Handayani et al., 2021).

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Early childhood education is among the most vulnerable groups in emergency situations. Recent studies emphasize that children aged 4-6 are capable of understanding basic evacuation concepts when presented through developmentally appropriate, play-based approaches, such as role-playing, storytelling, simulations, and songs (Handayani et al., 2021; UNDRR, 2022). However, preliminary observations at eight early childhood education institutions in Yogyakarta revealed that most schools had never conducted evacuation simulations, lacked child-oriented standard operating procedures (SOPs), and lacked relevant educational media. This situation highlights the urgent need for a structured, age-appropriate, and institutionally sound disaster mitigation model for early childhood education environments.

Research on disaster education in early childhood education remains limited and largely evaluative. Previous studies have documented gaps in safety practices, teacher preparedness, and institutional readiness, but generally focused on identifying problems rather than developing practical intervention models (Fahrunnisa, 2025; Willyaldo, 2024). Existing initiatives in early childhood disaster education tend to be one-off outreach activities and rarely incorporate structured simulations or ongoing program integration (Ramadhani & Nurfadilah, 2018; UNESCO, 2021). Newer global frameworks, such as the Sendai Framework and the UNDRR report (2022), call for stronger risk reduction education from an early age, yet there is a lack of empirically and operationally validated simulation models designed specifically for the ECE context.

This study addresses this gap by integrating three domains rarely combined in previous research: disaster mitigation simulations, early childhood pedagogy, and service-based learning. Service-based learning is used as a pedagogical strategy that enables pre-service ECE students to facilitate real-world disaster preparedness activities while strengthening their professional competencies (Bringle & Hatcher, 1995; Furco, 2019). Recent literature suggests that service-based learning can enhance community resilience and foster sustainable institutional practices when aligned with local needs (Salam et al., 2019; Furco, 2019).

This study is among the first to integrate disaster mitigation simulations, developmentally appropriate early childhood education pedagogy, and service-based learning into a validated and operational model for early childhood education institutions. Through this integration, this study moves beyond raising awareness to creating a systematic, replicable, and sustainable disaster preparedness framework for early childhood

education. Therefore, this study aims to develop and validate a disaster mitigation simulation model for early childhood education that results in child-friendly evacuation standard operating procedures (SOPs), educational materials, and enhanced preparedness for children, teachers, and institutions.

B. MATERIALS AND METHODS

This study employed a Research and Development (R&D) design adapted from Borg and Gall (1983) to develop a disaster mitigation simulation model for early childhood education (ECE). The R&D process consisted of five stages: (1) needs assessment, (2) model development, (3) expert validation, (4) limited field trials, and (5) revision based on expert and field feedback. The needs assessment involved fourteen ECE institutions, while the limited field trials were conducted in eight purposively selected institutions from this group. Participants included 112 children aged 4–6 years, 14 ECE teachers, 8 principals, and 24 PIAUD students serving as service-learning facilitators. Experts in disaster education and early childhood development contributed to model validation.

Data were collected through observations, semi-structured interviews, focus group discussions (FGDs), document analysis, and questionnaires. Observations captured children's protective actions and evacuation responses, as well as teacher facilitation practices during simulations. Interviews and FGDs explored implementation feasibility, contextual constraints, and institutional readiness. Questionnaires were administered to teachers before and after the simulation to measure changes in disaster preparedness knowledge, confidence, and facilitation competence.

Qualitative data were analyzed thematically to identify patterns related to implementation challenges and good practices. Quantitative data were analyzed descriptively using percentages, mean scores, and normalized gain scores (N-gain) to assess improvements in teacher preparedness from pre-test to post-test. Model feasibility was ensured through expert validation and methodological triangulation.

Ethical approval was obtained, and informed consent was secured from participating institutions, teachers, and parents. All activities followed child safety and developmentally appropriate research principles.

C. RESULTS AND DISCUSSION

1. Needs Assessment Results

A needs assessment conducted across fourteen early childhood education (ECE) institutions revealed consistent gaps in disaster preparedness. The needs assessment was

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conducted in fourteen ECE institutions, while the subsequent limited field trials of the developed model were implemented in eight purposively selected institutions from this group. None of the institutions had child-friendly evacuation Standard Operating Procedures (SOPs), hazard maps, or formal disaster response teams. Key institutional weaknesses—including limited evacuation routes, low teacher preparedness, infrastructure vulnerabilities, and limited child preparedness—are summarized in **Table 1.**

Table 1 . Identified Disaster Preparedness Issues in 14 Early Childhood Institutions

Institution	Identified Issues
Institution A	No evacuation SOPs; incomplete evacuation routes; no hazard maps; teachers lack disaster training; no disaster education media; relies on external building management for safety procedures.
Institution B	No evacuation SOPs; evacuation routes partially available but no dedicated assembly point; limited informal teacher training; infrastructure not fully adapted for emergencies.
Institution C	No evacuation SOPs; evacuation routes available but not child-oriented; lacks hazard maps and disaster education media; health facilities limited.
Institution D	No evacuation SOPs; children do not understand evacuation direction; classroom infrastructure not earthquake-resistant; absence of early warning systems and preparedness media.
Institution E	No SOPs, maps, or evacuation routes; school located in a high-risk volcanic area; inadequate infrastructure for safe evacuation; teachers untrained in disaster preparedness.
Institution F	Multi-storey building with no evacuation procedures; absence of hazard maps and warning systems; low child readiness; insufficient teacher preparedness.
Institution G	Narrow evacuation paths; limited staff-to-child ratio; no SOPs or hazard maps; slippery floors pose additional risks; no structured preparedness drills.
Institution H	Only one exit route creating high evacuation risk; no SOPs or maps; teachers lack training; absence of disaster media and early warning devices.
Institution I	No evacuation SOPs or designated routes; infrastructure still minimal; no hazard mapping; children's preparedness is low; no first-aid room.
Institution J	Partial evacuation route but no SOPs; teachers have limited understanding of formal procedures; only fire extinguisher available; infrastructure relatively safe but not supported by early warning systems.
Institution K	Multi-level building without child-friendly evacuation procedures; no hazard maps; no warning system; children unfamiliar with evacuation actions.
Institution L	High student population increases evacuation risk; no SOPs or hazard maps; limited teacher training; infrastructure needs improvement; no disaster response team.
Institution M	Clear evacuation route available but lacking SOPs; located in dense residential area with fire hazards; limited teacher training; no preparedness media; no early warning system.
Institution N	Evacuation route still under development; wooden and aging structures increase vulnerability to wind and earthquakes; environmental hazards (tree roots, uneven ground); no SOPs or hazard maps.

Teacher preparedness was generally low, with minimal formal training in disaster education, limiting the capacity to conduct structured evacuation simulations, even for basic procedures such as *drop–cover–hold*. Infrastructure assessments identified recurring risks,

including single exit routes, unsafe building conditions, and the absence of early warning systems. Children demonstrated limited understanding of evacuation procedures, reinforcing the need for developmentally appropriate, visual, and play-based preparedness strategies.

Overall, the distribution of unmet disaster preparedness indicators across institutions is illustrated in **Figure 1**, highlighting systemic deficiencies in SOP availability, disaster education media, teacher training, and safety infrastructure. These findings underscore the urgency of developing a structured, age-appropriate disaster mitigation model tailored to early childhood education (ECE) settings.

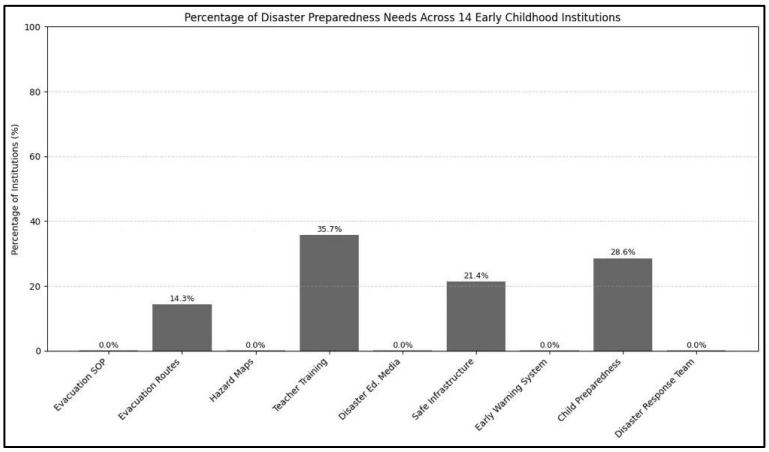


Figure 1. Percentage of Disaster Preparedness Needs Across 14 Early Childhood Institutions *(Percentages were calculated based on the total number of 14 institutions included in the needs assessment.)*

Figure 1 shows the distribution of unmet disaster preparedness indicators among fourteen early childhood institutions. The data reveal substantial systemic deficiencies, including the complete absence of evacuation SOPs, hazard maps, disaster education media, early warning systems, and disaster response teams (0%). The limited availability of evacuation routes (14.3%), safe infrastructure (21.4%), teacher training (35.7%), and moderate levels of child preparedness (28.6%) **reflects** the overall insufficiency of institutional readiness. These findings underscore the urgent need for structured, developmentally appropriate disaster preparedness interventions in early childhood education settings.

2. Model Development

Based on the needs assessment findings, a disaster mitigation simulation model for early childhood education was developed using child-centered and experiential learning principles (UNDRR, 2022; UNESCO, 2021). The model integrates three core components: (1) child-friendly evacuation Standard Operating Procedures (SOPs) using simplified

language, visual cues, and age-appropriate instructions (BNPB, 2019; UNDRR, 2022); (2) play-based simulation activities grounded in constructivist and social learning theories, including role play, storytelling, guided drills, and adult modeling to support children's behavioral preparedness (Bandura, 1977; Vygotsky, 1978; Handayani et al., 2021); and (3) a service-learning facilitation component in which pre-service early childhood educators supported experiential learning cycles (Kolb, 1984; Furco, 2019).

The conceptual framework of the model and its theoretical foundations are presented in **Figure 2**, while the Research and Development workflow guiding model formulation is illustrated in **Figure 3**. The model was developed iteratively to ensure alignment with children's developmental characteristics, institutional readiness, and early childhood safety requirements. Key outputs—including child-friendly SOPs, visual media, teacher facilitation guides, and simulation flowcharts—were designed to be practical, replicable, and adaptable across diverse ECE institutions.

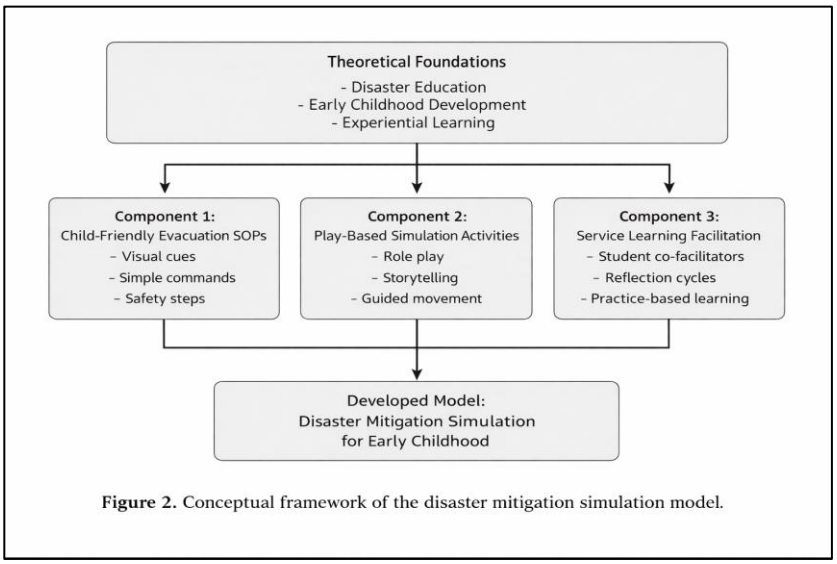


Figure 2. Conceptual framework of the disaster mitigation simulation model.

Figure 2 presents the conceptual framework guiding the model's development, adapted from the Borg and Gall Research and Development (R&D) cycle (Borg & Gall, 1983). Theoretical foundations in disaster education, early childhood development, and experiential learning inform the formulation of the preliminary product, which comprises three key components: child-friendly evacuation SOPs, play-based simulation activities, and a service-learning facilitation system. These components represent the structured preliminary model subjected to expert validation, field testing, and iterative revision in accordance with Borg & Gall's procedural stages to ensure feasibility, developmental appropriateness, and practical applicability in early childhood education settings.

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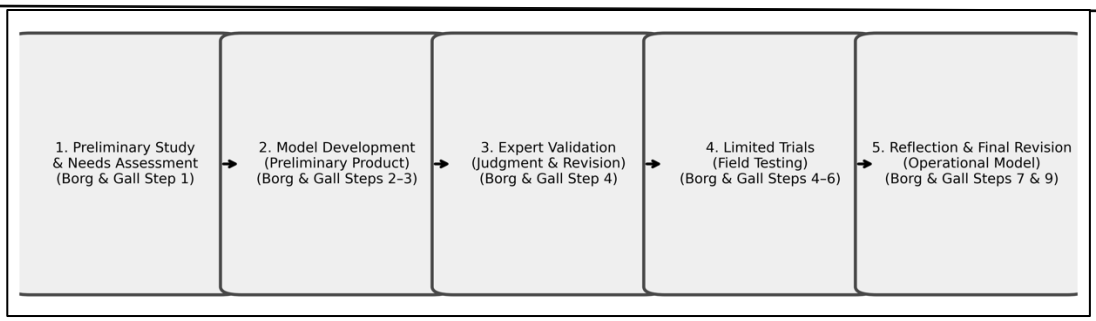


Figure 3. Horizontal Flowchart of the R&D Procedures Integrating Theoretical Foundations with Practical Model Development.

Figure 3 illustrates the streamlined R&D workflow used in this study, adapted from the Borg and Gall model. The sequence demonstrates how theoretical foundations in disaster education, early childhood development, and experiential learning were systematically translated into practical outputs through five stages: preliminary needs assessment, model development, expert validation, limited trials, and final revision. Each stage is aligned with the corresponding steps of the original ten-stage Borg and Gall framework, highlighting the iterative process through which theoretical constructs were operationalized into a functional disaster mitigation simulation model for early childhood education settings.

3. Expert Validation

The preliminary disaster mitigation simulation model underwent expert validation by a certified occupational safety (K3) and disaster preparedness specialist with experience in early childhood education settings. The model was assessed using a structured instrument covering six domains: content relevance, developmental appropriateness, procedural clarity, safety and risk management, implementation practicality, and media design.

Using a four-point rating scale (1 = not appropriate to 4 = very appropriate), the model achieved a mean feasibility score of **3.58**, indicating a **very high level of validity**. Expert feedback recommended improving evacuation route illustrations, simplifying instructional language, and enhancing visual contrast in SOP materials. These revisions were incorporated into the final model to strengthen developmental suitability, usability, and implementation readiness.

4. Limited Trial Implementation Results

The disaster mitigation simulation model was implemented in eight early childhood education institutions to assess feasibility and effectiveness. Trial outcomes across institutions—including children's responsiveness, teacher facilitation capacity, environmental constraints, and implementation challenges—are summarized in **Table 2**.

Table 2 synthesizes qualitative observations across eight participating institutions during limited field trials.

Table 2. Summary of Limited Trial Findings Across Eight Early Childhood Institutions (Institutions A–H)

Institution	Children's Performance	Teacher Facilitation Capacity	Environmental Constraints	Key Implementation Issues	Observed Strengths
A	Demonstrated rapid uptake of protective actions following modeling	Initially dependent on facilitators; improved across cycles	Inadequate evacuation signage	Minor confusion during route transitions	Strong engagement; improved accuracy on repetition
B	Required guidance initially; performance improved notably in second cycle	Increasing mastery in delivering clear, calm instructions	Narrow circulation pathways causing bottlenecks	Clustering behavior among younger children	Marked improvement in movement organization
C	Highly engaged in role-play; actively repeated safety phrases	Consistent cueing and reinforcement of safety steps	Lack of predefined assembly point	High frequency of spontaneous questions	High verbal retention of disaster concepts
D	Varied confidence levels; younger children required closer prompting	Progressive improvement in pacing and procedural clarity	Limited movement space within classrooms	Initial hesitation during evacuation sequences	Teachers' procedural mastery increased substantially
E	Adapted well to fire simulation after modeling	Effective use of SOP visuals and demonstrations	Absence of fire safety equipment; unclear exits	Difficulty sustaining low-crawling posture	Children verbalized key safety messages post-simulation
F	Responsive; followed commands after guided modeling	High reliance on facilitators due to limited staff capacity	Restricted outdoor assembly area	Congestion during gathering formation	Model remained adaptable under spatial limitations
G	Calm, attentive, and consistent in protective movements	Improved confidence and clarity across repetitions	Multiple exit points reduced route clarity	Required repeated instruction clarification	Enhanced evacuation order in subsequent trials
H	Highly enthusiastic; anticipated procedural steps after practice	Efficient coordination of group movement	Classroom layout required route modification	Slow transition between command sequences	Achieved smooth, full-sequence implementation

Overall, children demonstrated improved compliance with protective actions and evacuation procedures (e.g., drop–cover–hold and guided evacuation) following repeated simulation sessions, indicating increased procedural readiness. Teachers showed progressive improvement in instructional clarity and facilitation confidence, transitioning from reliance on facilitators to more independent leadership, supporting social learning and experiential learning principles in early childhood disaster education.

Although environmental constraints—such as limited evacuation space, unclear signage, and insufficient safety equipment—persisted, institutions were able to adapt procedures without compromising core safety objectives. **As shown in Figure 4, positive indicators are more prominent in child and teacher domains than in environmental factors**, suggesting that pedagogical readiness improved more substantially than infrastructural conditions.

Overall, these findings indicate that the simulation model is developmentally appropriate, adaptable, and effective in strengthening disaster preparedness in early childhood education contexts.

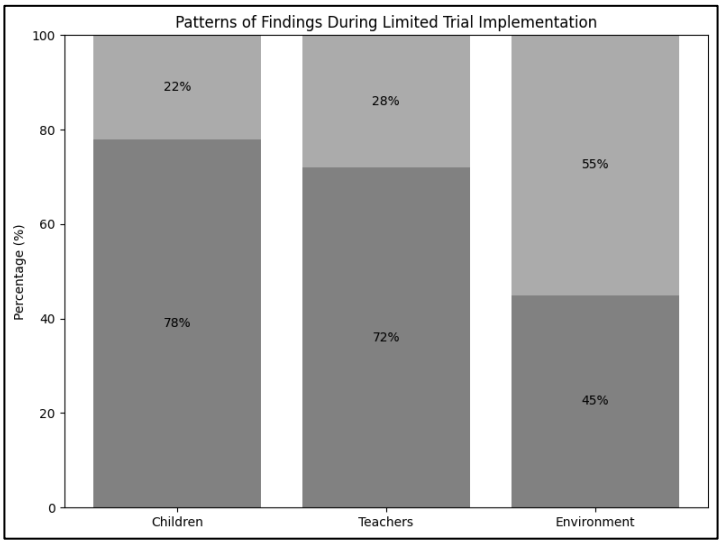


Figure 4. Distribution of Positive and Negative Indicators Across Child, Teacher, and Environmental Domains

5. Discussion

The findings demonstrate that a structured, play-based disaster mitigation simulation model can enhance preparedness among young children and strengthen teacher facilitation capacity. Unlike prior disaster education initiatives that relied predominantly on one-time awareness activities or socialization programs (Ramadhani & Nurfadilah, 2018), this model offers a systematic, repeatable, and institutionally embedded framework that promotes

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sustained preparedness rather than episodic learning. In contrast to earlier evaluative studies that mainly identified gaps in readiness without providing operational solutions (Fahrunnisa, 2025; Willyaldo, 2024), the present study advances the field by developing, validating, and trialing a concrete simulation model that can be directly implemented in PAUD settings.

The integration of service-learning supported smoother implementation and contributed to teacher capacity-building, reinforcing experiential learning principles. This differs from previous approaches that positioned teachers as passive recipients of training; instead, this model positioned teachers and pre-service students as co-facilitators within authentic learning environments (Furco, 2019). Children's improved procedural accuracy aligns with social learning and scaffolding theories (Bandura, 1977; Vygotsky, 1978), while teachers' facilitation growth reflects experiential learning processes (Kolb, 1984). Despite ongoing environmental constraints, the model's adaptability confirms its feasibility across diverse early childhood education contexts.

Practically, the model provides ECE institutions with ready-to-use tools, including child-friendly SOPs, visual media, and structured simulation protocols that can be integrated into routine school activities such as weekly safety drills or thematic learning. The service-learning component also offers a sustainable mechanism for continuous support, as PIAUD students can be regularly deployed to assist schools in conducting simulations, updating materials, and mentoring teachers. For policymakers, the model operationalizes SPAB (Safe School) principles into classroom-level practices that are feasible for resource-constrained PAUD institutions.

Theoretically, this study contributes by integrating three previously separate domains—disaster risk reduction, early childhood pedagogy, and service-learning—into a coherent operational framework. While prior research has addressed these domains individually, few studies have synthesized them into a validated simulation model tailored to young children's developmental characteristics. The model extends experiential learning theory by demonstrating how reflection–practice cycles can be applied not only to university students but also to teachers and children in community settings.

This study advances disaster education in early childhood by providing a validated and practice-oriented intervention that translates abstract safety policies into child-friendly SOPs and routine simulation practices, thereby strengthening both pedagogical and institutional readiness. Several limitations should be noted. The limited number of participating institutions

restricts generalizability, and the study relied primarily on descriptive and observational data without longitudinal follow-up.

Future research should examine long-term behavioral retention, expand disaster scenarios (e.g., floods, volcanic eruptions, and fires), and explore large-scale implementation across diverse regional contexts. Overall, these findings indicate that the proposed model offers a scalable, theoretically grounded, and policy-aligned contribution to strengthening disaster preparedness in early childhood education.

D. CONCLUSION

This study developed a disaster mitigation simulation model for early childhood education through a systematic Research and Development approach. The model offers a practical response to the lack of developmentally appropriate disaster preparedness systems in ECE settings by integrating simplified evacuation SOPs, play-based simulation activities, and a service-learning approach involving pre-service teachers.

The findings indicate that the model is feasible for implementation across diverse early childhood contexts and supports improvements in children's procedural readiness and teacher facilitation capacity, while remaining adaptable to environmental constraints. By embedding service-learning within the model, this study strengthens the link between academic preparation and community-based disaster education, contributing to the sustainability of preparedness practices in schools.

Limitations. This study was conducted in a limited number of ECE institutions in one region, which restricts the generalizability of the findings. In addition, the evaluation relied primarily on descriptive and observational data and did not include longitudinal measurement of children's preparedness retention over time.

Future research. Subsequent studies should examine the long-term effects of the model on children's disaster preparedness, apply the model to different disaster scenarios (e.g., floods, volcanic eruptions, and fires), and test its implementation in a larger and more diverse sample of ECE institutions across multiple regions.

Overall, this research contributes a theory-informed and implementable framework that advances disaster education in early childhood settings. From a policy perspective, the model provides a concrete reference for operationalizing SPAB principles within ECE programs and teacher professional development initiatives.

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G. APPENDIX

Appendix A. Expert Validation Instrument (Expert Judgment Form)

Appendix B. Needs Assessment Checklist (Institutional Disaster Preparedness Indicators)

Appendix C. Observation Sheet for Simulation Implementation (Limited Trial)

Appendix D. Teacher Questionnaire (Pre–Post; Descriptive Use)

Appendix E. Limited Trial Implementation Protocol (Five-Step Simulation Session)