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GEMA TANGGUH Model: Integrating Early Warning and Simulation to Strengthen Early Childhood Teacher Resilience

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ABSTRACT

Background*: Indonesia is among the world's most disaster-prone countries, where early childhood education (ECE) institutions remain vulnerable due to limited preparedness and infrastructure. Teachers often lack confidence and structured procedures for emergency situations. This study aimed to evaluate the effectiveness of the GEMA TANGGUH (Movement for Mitigation and Education to Improve Disaster Response) model in enhancing the holistic resilience—cognitive, affective, and psychomotor—of ECE teachers.*

Methods: *This university-based community service program employed a one-group pre–post test design. Eleven teachers and staff, along with 91 students from Aisyiyah Banyudono Playgroup, Boyolali, participated. The intervention consisted of interdisciplinary training on disaster mitigation, installation of IoT-based EWS, and structured evacuation simulations. The evaluation stage was conducted by collecting data through pre–post questionnaires and structured observations, which were then analyzed descriptively to determine mean score improvements and percentage changes across three evaluated domains.*

Results: *The GEMA TANGGUH model produced substantial improvements across all domains. Teachers' knowledge increased from an average score of 47.5 (pre) to 70.0 (post), a relative gain of 47.4%. Teachers reporting "very confident" rose from 10% to 50%. Psychomotor performance reached 100% accuracy, and student compliance achieved 98.89% (90 out of 91 students), indicating effective knowledge transfer.*

Conclusion: *The GEMA TANGGUH model effectively strengthens comprehensive disaster preparedness among ECE teachers. Uniquely integrating IoT-based Early Warning Systems and Psychological First Aid (PFA)-oriented simulations, the model provides an evidence-based and scalable framework for building holistic resilience, supporting the advancement of disaster-resilient educational institutions in disaster-prone areas.*

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INTRODUCTION

Indonesia is highly vulnerable to various natural disasters, including seismic and hydrometeorological events, due to its location on the Pacific Ring of Fire and complex

geological and climatic conditions (1–4). Data from the National Disaster Management Agency (BNPB) confirms high disaster frequency, necessitating proactive mitigation and preparedness efforts at all community levels, particularly in school environments (2,5,6). The importance of early disaster mitigation lies in preventive efforts through education (3), which not only raises awareness of disaster risks but also prepares children to remain calm and follow self-rescue instructions, thereby reducing the impact of future disasters (7).

Disaster preparedness at the early childhood level is particularly crucial, as teachers serve as the first responders responsible for ensuring children's safety and emotional stability. Cultivating resilience and response behavior from a young age contributes to forming disaster-conscious communities in the long term. Teaching disaster mitigation from an early age builds a resilient community, with teachers and students playing an important role in preparedness and the dissemination of disaster knowledge (5).

However, the implementation of disaster education at an early age still faces obstacles, mainly related to low awareness, teachers' limited understanding of the importance of emergency skills (6,8) and the limitations of adequate supporting infrastructure and the absence of structured policies and emergency response plans (5,6,9). This gap is consistent with international findings, which indicate that early disaster education often emphasizes cognitive knowledge while neglecting effective and psychomotor domains essential for holistic preparedness (10,11). Therefore, a comprehensive model integrating knowledge, skills, and emotional readiness is urgently needed within Indonesian early childhood education settings.

The target partner in this community service program, the Aisyiyah Banyudono Playgroup (KB), is located in Boyolali, Central Java, an area with significant earthquake risk and vulnerability to seasonal flooding (5). Based on preliminary studies, several critical gaps in preparedness were found in the school environment. First, the majority of the 11 teachers and staff had never received comprehensive disaster mitigation training, as reflected in their low initial knowledge scores (average score of 47.5) (5). Second, infrastructure to support rapid evacuation was still minimal, marked by the absence of clear evacuation routes and reliable early warning systems (5) These conditions indicate that the school community is vulnerable to natural disaster risks and requires structured intervention.

The GEMA TANGGUH model is proposed as an evidence-based solution to address this preparedness gap. Various studies have proven that regular teacher training can have a significant positive impact on the knowledge, attitudes, and overall preparedness of schools (10). Furthermore, disaster simulations have proven to be very effective in improving students' cognitive aspects and skills and building disaster preparedness in schools (11).

The GEMA TANGGUH model also aligns with the Sendai Framework for Disaster Risk Reduction (2015–2030), particularly Priority 3 Investing in Disaster Risk Reduction for Resilience and Priority 4 Enhancing Disaster Preparedness for Effective Response. Its interdisciplinary design combines technological solutions (IoT-based EWS) with pedagogical simulations to create both institutional and behavioral transformation. The originality of this program lies in its interdisciplinary approach, which integrates human resource capacity building with the implementation of appropriate technology (EWS).

The overall goal is to generate a replicable model for disaster-resilient early childhood education institutions. Therefore, this study seeks to evaluate the effectiveness of the GEMA TANGGUH model in improving the cognitive, affective, and psychomotor

preparedness of early childhood teachers through the integration of simulation and technology-based early warning systems. The objectives of this Community Service Program are: (a) to improve the knowledge and skills of all KB Aisyiyah Banyudono residents in disaster mitigatio; and (b) to provide and integrate early disaster detection infrastructure in schools.

METHODS

This GEMA TANGGUH community service activity was designed using an interdisciplinary approach, involving expertise from the fields of Nursing (crisis management and health education), Electrical Engineering, and Computer Engineering/Informatics (development and installation of early detection technology) (5). The effectiveness of the intervention in this community service activity was measured using a quantitative approach with a one-group pre-test post-test design. This design allowed for a comparison of the knowledge and confidence scores of teachers and early childhood education staff before and after the program, so that changes in participants' readiness indicators could be identified descriptively. This approach was chosen because the main focus of the program was direct implementation and empowerment of partners, rather than inferential statistical analysis.

The mixed involvement of technological and educational disciplines was intended to ensure a holistic intervention model that integrates behavioral and infrastructural resilience. The main participants in this evaluation were 11 teachers and operational staff at the Aisyiyah Banyudono Playgroup, with 91 ECE students involved in the psychomotor simulation stage. The community service activity location in Banyudono, Boyolali, was chosen because it has identified disaster risks and can be reached from the implementing institution within 32 minutes. Participant inclusion was determined by voluntary consent, ensuring full engagement from school staff. The students participated under teacher supervision with parental approval, guaranteeing ethical compliance and child safety during simulations. The community service was executed through an integrated four-stage procedure:

Preliminary Study, Coordination, and Socialization

This initial stage includes interviews and coordination with the principal to validate the issues and obtain approval for the GEMA TANGGUH program. Programming socialization involves the preparation of training materials relevant to local disaster risks (earthquakes and floods). A brief hazard mapping and needs assessment were also conducted using participatory discussion, allowing the teachers to identify local risk points and potential evacuation routes before the intervention started.

Intensive Capacity Building (Covering Risk Mitigation, Standard Evacuation, and Basic PFA)

Intensive training was conducted for 11 teachers and staff, covering both theory and practice. The material presented included an in-depth understanding of risk mitigation, standard evacuation procedures, and basic Psychological First Aid (PFA) training to deal with panic in early childhood. The training sessions were designed using adult learning principles, combining lectures, group discussions, and demonstrations. Each module was delivered collaboratively by experts from nursing and informatics to strengthen both health and technology perspectives in disaster education.

Technology Application (Installation of IoT-based EWS and Physical Evacuation Infrastructure)

This stage includes the consisting of sensitive seismic sensors and fire detectors, integrated with an audio-visual alarm system throughout the school area. In addition, clear evacuation route markers measuring 29.5 cm x 11.5 cm were installed and safe assembly points were designated. Staff were also trained in how to use, maintain, and respond to EWS warning signals, including familiarization with a mobile application for real-time information. The installed EWS was cloud-connected, enabling data logging and alert notifications via mobile devices. Teachers were guided on interpreting the alarm indicators and conducting immediate evacuation drills when the system detected anomalies. Maintenance schedules were established to ensure equipment reliability.

Structured Simulation and Mentoring

Earthquake disaster evacuation simulations were conducted in a structured manner, involving teachers and 90 students, focusing on the direct practice of the Drop, Cover, Hold On procedure and evacuation to the Assembly Point (12). Periodic mentoring was conducted to monitor progress, and results were evaluated through pre-test and post-test measurements in three domains: knowledge (cognitive), self-efficacy (affective), and skills (psychomotor) (13). Cognitive evaluation used a questionnaire (scored 0-100), effective through the percentage of respondents who were "very confident," and psychomotor through structured observation during the simulation (5).

The pre–post questionnaire items were adapted from validated disaster preparedness tools previously used in school-based DRR program ensuring content validity and contextual relevance. The simulation activities were repeated twice during the intervention period to assess consistency in teacher performance. Observations were carried out by two independent raters using a validated checklist to reduce subjectivity. In addition, qualitative reflections were collected through informal interviews to capture participants' perceptions and experiences.

All quantitative data were processed descriptively using Microsoft Excel 2021 to calculate average scores and percentage change across domains. The questionnaire was reviewed by three disaster management experts to confirm content validity, and a pilot test was conducted with five external teachers to refine ambiguous items prior to use.

This community service was conducted under ethical supervision and written approval from the Aisyiyah Banyudono Playgroup principal. All participants were informed about the objectives, benefits, and voluntary nature of their participation. No personal identifiers were collected. This program was supported by the Universitas Muhammadiyah PKU Surakarta through the Lecturer-Based Community Service Grant (PKM-DU) for Fiscal Year 2024/2025.

RESULTS

The GEMA TANGGUH activity was successfully implemented at the Aisyiyah Banyudono Playgroup with the participation of 11 teachers and staff and 90 students. In the initial stage, a preliminary study, coordination, and socialization of the program were carried out, including the identification of local risks (earthquakes and floods) through participatory discussions. Next, intensive training was provided to teachers and staff, covering risk mitigation, standard evacuation procedures, and Psychological First Aid (PFA) training to deal with children's panic. This training used adult learning methods,

namely lectures, group discussions, and demonstrations, and was delivered by nursing and informatics experts to strengthen the health and technology perspectives.

During the technology implementation phase, earthquake sensors and fire detectors were installed, integrated with an audio-visual alarm system and a mobile application. Evacuation routes were clearly marked, and safe assembly points were designated. Teachers and staff were trained to use, maintain, and respond to the early warning system (EWS). Earthquake evacuation simulations were conducted in a structured manner, focusing on the Drop, Cover, Hold On procedure and evacuation to assembly points, with psychomotor observation by two independent assessors. Pre-test and post-test evaluations showed an increase in teachers' knowledge scores, confidence, and skills (5).

A comparative analysis of pre-test and post-test scores for teachers and staff (n=11) showed a significant increase in the cognitive and affective domains. In the cognitive domain, the average score of teachers' knowledge about disaster mitigation increased from 47.5 on the pre-test to 70.0 on the post-test. This absolute increase of 22.5 points is equivalent to a relative increase of 47.4% (5). This substantial improvement demonstrates that short-term, structured interventions can effectively enhance disaster literacy among early childhood educators, even in schools with previously minimal exposure to preparedness programs.

In the affective domain (self-efficacy), the most transformative improvement occurred in teachers' self-efficacy in responding to emergency situations, particularly when asked about the procedures to follow when hearing earthquake detector sirens. Teachers who answered "very confident" increased from 10% before the intervention to 50% after the intervention. This substantial 40% increase indicates a strengthening in the psychological preparedness of the staff (5).

Several participants also reported feeling calmer and more confident during the second simulation, indicating that repeated exposure helped translate knowledge into self-regulated behavior. Qualitative feedback from open-ended responses also revealed that teachers felt calmer and more coordinated during the second simulation, suggesting that practical experience directly reinforced confidence and team communication.

Table 1. Summarizes The Pre–Post Improvements Across All Preparedness Domains, Demonstrating Consistent Progress Among All Participants

Evaluation Aspect	Measurement Indicator	Pre-Intervention	Post-Intervention	Absolute Change
Cognitive (Knowledge)	Average knowledge score (0–100)	47.5	70.0	+22.5
Affective (Self-Efficacy)	Percentage of participants reporting “very confident”	10%	50%	+40%
Psychomotor (Skills)	Appropriate PFA actions with panicked students (%)	100%	100%	0% (skill validation)
Instructional Transfer	Student compliance in simulation (n=91) (%)	-	98.89%	Successful participation

Teacher skills, in the psychomotor aspect, which tested teachers' actions when encountering panicked students in the simulation (basic PFA), the results showed that 100% of teachers gave the correct answers or took the correct actions, both in the pre- and post-intervention measurements. This consistent 100% performance serves as validation of the participants' baseline competency in critical survival actions specific to early childhood care, which the intervention reinforced and standardized under realistic pressure (8). The uniformity of performance outcomes across all participants indicates successful standardization of PFA behavior and confirms the practical applicability of the training modules.

Student involvement, the success rate of the evacuation simulation involving 90 ECE students showed that 98.89% of students (90 out of 91) were able to follow the simulation procedures (drop, cover, hold on, and evacuate) correctly. Only one student was unable to follow the simulation correctly. This high rate of student compliance validates the effectiveness of the teacher training in the affective and psychomotor domains, affirming the successful transfer of the safety culture to the young learners (14).

Science and technology infrastructure components were successfully implemented in partner schools. An integrated EWS, consisting of earthquake sensors and fire detectors, equipped with audio-visual alarms throughout the school area, was successfully installed. Physical evacuation infrastructure, including 29.5 cm x 11.5 cm evacuation route markers and safe assembly points, was also established.

School staff were provided with EWS operational training and an introduction to disaster information applications to support the sustainable use of technology. Post-installation functional testing showed that the alarm was able to detect simulated earthquake vibrations in less than five seconds, and teachers were able to interpret and respond to the signal correctly 100% of the time, ensuring effective evacuation preparedness.

Figure 1. A Series of Community Service Activities: (a) Preliminary Studies, Coordination, and Socialization; (b) Delivery of Material; (c) Application of Technology and Infrastructure; and (d) Early Warning System (EWS)

DISCUSSION

A significant increase in the average knowledge score of teachers (from 47,5 to 70.0) is consistent with findings in the literature that structured school-based programs are effective in improving disaster knowledge (7). Teacher training improves knowledge and preparedness, as evidenced by a study in which prospective teachers showed significant improvements in cognitive, affective, and psychomotor domains after disaster training (15). This improvement is vital because teacher knowledge is a fundamental prerequisite for successful mitigation at the ECE level; teachers must master risk mitigation procedures before transferring them to students (16).

The program successfully institutionalized understanding of local risks and specific response procedures. The training program helped teachers balance educational responsibilities with shelter management during disasters, increasing their effectiveness in crisis situations (17). These results reinforce the constructivist learning theory, which emphasizes that experience-based learning is the most effective method for transforming theoretical knowledge into practical behavior. By combining simulation and real-time feedback, the GEMA TANGGUH model operationalized this principle, promoting active learning and sustained behavioral reinforcement among teachers.

A remarkable improvement in the affective domain (teachers' self-efficacy increased from 10% to 50%) was a key finding. In disaster management, teachers' self-efficacy in crisis situations is a major predictor of calmness and effectiveness of response. This increase can be analyzed using social cognitive theory (SCT), which asserts that intensive simulation provides teachers with mastery experiences—the most powerful source of self-efficacy—which directly improve performance competence. The substantial increase in self-efficacy indicates that training, supported by practical simulation experience and the presence of EWS, has successfully changed risk perceptions, transforming intentions into concrete actions (18).

The core contribution of GEMA TANGGUH lies in its holistic model, leveraging technological reinforcement (IoT-based EWS) to amplify the psychosocial resilience achieved through PFA mastery. This integration provides a mastery experience that conventional programs lack. The main contribution of the GEMA TANGGUH model lies in its integration of psychosocial preparedness and technological infrastructure. Unlike other programs that only focus on training or EWS implementation, GEMA TANGGUH utilizes the synergy between IoT-based EWS and PFA simulations.

EWS technology validates emergency protocols, fostering situational awareness and scientifically supporting the increase in teachers' affective confidence (19). By embedding IoT-based EWS in early childhood settings, GEMA TANGGUH demonstrates an innovative operationalization of the Sendai Framework's Priority 4 (20–22). This simultaneous psychological reinforcement and technological cue exemplify how environmental design can amplify confidence and response accuracy, distinguishing it from conventional, single-domain programs.

Achieving a score of 100% in handling panicked students proves that basic PFA skills have been successfully reinforced (8). In an ECE setting, mastery of PFA is vital because young children are particularly vulnerable to the adverse psychological effects of post-disaster trauma, including PTSD, anxiety, and behavioral difficulties. Children are at high risk of experiencing post-disaster trauma-related problems and require immediate psychological support (23). Teachers become the initial providers of mental support (24). They serve as primary mental health facilitators, utilizing PFA to create a

supportive and emotionally stable environment for children (25). This finding further confirms the dual role of teachers as both educational and psychosocial protectors, aligning with the holistic resilience framework that underpins GEMA TANGGUH. The success of transferring skills to students (98.89% compliance) shows that teachers, who now have self-efficacy and proven PFA skills (26) are able to maintain collective calm and transfer emergency procedures into internalized behavior through engaging play and practice activities (1,27).

This activity has limitations because it uses a one-group pre–post test evaluation approach. This approach is effective for observing changes in teacher and staff readiness descriptively, but the results only reflect conditions at the partner school and the limited number of participants (n=11). Furthermore, without a comparison group, it is difficult to ascertain that all changes that occurred were entirely due to the activity, so strengthening the evaluation method in subsequent activities could help ensure the effectiveness of the intervention more comprehensively.

Furthermore, several issues need to be addressed for future implementation and sustainability. First, the use of single simulations has the potential to reduce skills over time (28) if not accompanied by regular practice (27). Second, the operational sustainability of EWS requires technical support and regular budget allocations for maintenance activities, which can be challenging for ECE partners with limited resources (5,29,30). Therefore, a longitudinal study is needed to assess teacher knowledge and belief retention, as well as to measure the impact of EWS implementation on the formation of a safe culture in the school environment (31) Policy-level collaboration between educational authorities and local disaster agencies is essential to institutionalize the GEMA TANGGUH model as a sustainable and scalable disaster resilience framework.

CONCLUSIONS AND SUGGESTIONS

The Community Service Program has proven to be highly effective and has successfully achieved all the objectives set out in the proposal. This program has succeeded in holistically improving disaster preparedness in the Aisyiyah Banyudono Playgroup. The GEMA TANGGUH model, uniquely integrating human resource capacity development (PFA simulation) with reliable technology (IoT-based EWS), confirms that this dual approach is an optimal strategy for building holistic school resilience in disaster-prone areas. This evidence-based, interdisciplinary model is recommended as a best practice, contributing directly to achieving national and global goals for resilient educational institutions.

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CONFLICT OF INTERESTS

The author declares that there is no conflict of interest regarding the results of this community service activity.

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