



Developing a Disaster-Ready Physical Literacy Program for Schools in Multi-Hazard-Prone Areas

Widya Hary Cahyati¹, Adi S.^{2*}, Harlyn Mae S. Ompoc³, Johnlenon N. Aliser³, Jet Longakit³, Mahenderan Appukutty⁴, Khoiril Anam⁵, Hilmy Alirid⁶, Laily Mita Andriana⁷, Indra Ramadhan⁸

¹ Public Health Department, Universitas Negeri Semarang, Semarang 50229, Indonesia

² Physical Education Department, Universitas Negeri Semarang, Semarang 50229, Indonesia

³ Physical Education Department, Mindanao State University-Iligan Institute of Technology, Iligan City 9200, Philippines

⁴ Programme of Sports Science, Faculty of Sports Science and Recreation, Universiti Teknologi MARA, Shah Alam 40450, Malaysia

⁵ Sport Science Department, Universitas Negeri Semarang, Semarang 50229, Indonesia

⁶ Physical Education Department, Universitas Nahdlatul Ulama Sunan Giri, Bojonegoro, Jawa Timur 62115, Indonesia

⁷ Sports Coaching Education Department, Universitas Negeri Surabaya, Surabaya 60213, Indonesia

⁸ Sport Coaching Education Department, Universitas Negeri Semarang, Semarang 50229, Indonesia

Corresponding Author Email: adis@mail.unnes.ac.id

Copyright: ©2026 The authors. This article is published by IETA and is licensed under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

<https://doi.org/10.18280/ijse.160819>

ABSTRACT

Received: 11 June 2026

Revised: 13 August 2026

Accepted: 21 August 2026

Available online: 31 August 2026

Keywords:

embodied learning, Research and Development design, Southeast Asia, school curriculum, movement-based learning, ecological dynamics

The increasing frequency and severity of natural disasters in Southeast Asia have highlighted the limitations of conventional school-based disaster education, which is often knowledge-oriented and insufficient in developing students' practical response skills. Although Disaster Risk Reduction (DRR) programs have been introduced in schools, evidence regarding the integration of physical literacy into disaster preparedness through physical education remains limited. This study aimed to develop and evaluate a Disaster-Ready Physical Literacy Program (DR-PLP) using a Research and Development (R&D) approach that combined the Borg and Gall model with the ADDIE framework. The study involved 1,520 students, 98 physical education teachers, and 10 expert validators from six disaster-prone schools. Results showed very high content validity ($M = 4.62/5.00$; Aiken's $V = 0.905$) and significant within-group improvements in physical literacy, disaster preparedness, and Student Health Index (all $p < 0.001$). Given the one-group pretest-posttest design without a comparison group, these findings should be interpreted as preliminary evidence of program-related improvement rather than definitive causal effectiveness. The DR-PLP provides a scalable, evidence-informed framework promoting movement-based disaster preparedness learning for disaster-prone regions worldwide.

1. INTRODUCTION

Southeast Asian countries such as Indonesia and the Philippines are highly exposed to natural hazards, including earthquakes, tsunamis, volcanic eruptions, and tropical cyclones, which significantly disrupt education systems and threaten children's well-being. These disasters not only damage school infrastructure but also cause prolonged learning interruptions, psychological distress, and long-term developmental impacts among students [1]. Disaster Risk Reduction (DRR) through education has therefore emerged as a critical strategy to enhance preparedness and resilience. Although DRR initiatives have been integrated into formal and non-formal education systems, their implementation remains inconsistent and highly dependent on local leadership and resource availability [2-4]. Therefore, this study addresses the lack of embodied, movement-based disaster preparedness models in Physical Education by developing and evaluating a Disaster-Ready Physical Literacy Program (DR-PLP) that

integrates physical competence, psychosocial readiness, and action-oriented disaster response skills. Accordingly, this study adopts a multi-hazard perspective, recognizing that disaster preparedness competencies developed through physical literacy should be transferable across different hazard contexts rather than being limited to a single disaster type.

Children represent a particularly vulnerable group due to their physical, psychological, and social characteristics, which increase their susceptibility to injury, trauma, and long-term mental health consequences during disasters [5]. School disruptions further exacerbate educational inequalities and hinder developmental continuity [6]. While schools play a strategic role as safe spaces and centers for preparedness, existing interventions often focus on knowledge transfer rather than equipping students with practical survival and response skills [7].

Through movement-based learning and ecological dynamics approaches, PE can foster adaptability, decision-making, and resilience in dynamic environments [8].

Emerging evidence also highlights the role of PE in integrating life-saving skills, emergency response training, and survival competencies, thereby extending its function beyond traditional [9-11].

Despite this potential, the integration of PE and DRR in Southeast Asia remains fragmented and underdeveloped. Existing programs predominantly emphasize cognitive understanding, infrastructure preparedness, and basic simulations, with limited focus on embodied learning and physical competencies essential for real-time disaster response [12-15]. Furthermore, structural, cultural, and methodological barriers including limited resources, teacher-centered pedagogies, and a lack of scalable models continue to constrain effective implementation [16]. Therefore, there is a critical need for an integrated, scalable, and context-sensitive model that combines physical literacy with disaster preparedness through experiential and movement-based learning. Such an approach is expected to enhance not only students' knowledge but also their physical competence, situational awareness, and adaptive capacity in emergency contexts, ultimately contributing to more resilient school communities.

This study reconceptualizes disaster preparedness education as an embodied learning system rather than a standalone instructional program. The proposed R-MOVE-ACT-CARE-FIT-REF framework is designed to explain the mechanisms through which physical literacy contributes to adaptive behavior in disaster contexts. Specifically, the model integrates movement-based engagement, cognitive processing, psychosocial regulation, and reflective learning into a dynamic system of behavioral adaptation. Unlike conventional disaster education approaches that emphasize knowledge acquisition, this study focuses on how learning occurs, how behavioral readiness is formed, and under what conditions adaptive responses emerge. Therefore, this study aims not only to develop and evaluate the model but also to explain the underlying learning mechanisms that may support adaptive behavioral responses in disaster contexts.

2. METHODS

This study employed a Research and Development (R&D) design, integrating the Borg and Gall model with the ADDIE framework to systematically develop and validate a DR-PLP. This approach was selected to produce a practical, evidence-based educational product in the form of a module and toolkit for disaster-prone school settings.

2.1 Research design and procedure

The integration of the Borg and Gall developmental model with the ADDIE instructional design framework provides a dual-layer methodological strength: Borg and Gall ensures systematic product development and empirical field-testing cycles, while ADDIE guarantees instructional soundness through iterative Analysis, Design, Development, Implementation and Evaluation stages. This combined approach is particularly well-suited for educational product development in complex, multi-site settings. Each element of the R-MOVE-ACT-CARE-FIT-REF framework performs a distinct functional role within the learning process, enabling identification of how different components contribute to behavioral adaptation and disaster preparedness outcomes.

The study was conducted through seven sequential stages. First, a needs assessment was conducted with students and teachers to examine disaster preparedness levels, physical literacy status, and school readiness. Second, the design phase involved developing a PE-DRR-integrated curriculum, including lesson plans, learning modules, and activity-based scenarios such as evacuation drills and survival tasks. This phase incorporated expert input through focus group discussions. Third, the development phase produced a prototype consisting of instructional materials, movement-based activities, and assessment tools. Fourth, a pilot implementation was conducted in selected schools in Indonesia and the Philippines to evaluate content validity, feasibility, and user response. Fifth, an evaluation phase was performed to refine the product based on quantitative feedback. Sixth, a large-scale field trial was conducted in six disaster-prone schools to evaluate within-group changes following implementation of the DR-PLP. The participating schools comprised three schools in Indonesia and three schools in the Philippines, representing both primary and secondary education levels and located in regions predominantly exposed to earthquakes, typhoons, floods, and volcanic hazards. Finally, a validated, scalable DR-PLP was generated.

2.2 Participants and instruments

Participants consisted of 1,520 students and 98 PE teachers recruited from disaster-prone schools in Indonesia and the Philippines. Schools were selected through purposive multistage sampling from regions characterized by recurrent exposure to multiple natural hazards, including earthquakes, typhoons, floods, volcanic eruptions, and other disaster risks. This multi-hazard context was intentionally selected to evaluate the applicability of the DR-PLP across diverse disaster environments rather than a single-hazard setting. Of these, three were primary schools and three were secondary schools. The Indonesian schools were located in areas with recurrent earthquake, volcanic eruption, and flood hazards, whereas the Philippine schools were situated in regions frequently affected by typhoons and earthquakes. This distribution was intentionally selected to evaluate the applicability of the program across diverse disaster contexts. Student participants were then selected using stratified random sampling by grade level and sex, while teachers were recruited based on their instructional roles and involvement in school physical education programs. Inclusion criteria for students were: (a) officially enrolled in participating schools, (b) aged 10-17 years, (c) medically fit to participate in school physical activity, (d) regular attendance during the intervention period, and (e) parental consent with student assent. Exclusion criteria included: (a) diagnosed medical or musculoskeletal conditions restricting movement participation, (b) prolonged absence during data collection, or (c) incomplete questionnaire and testing data. Inclusion criteria for teachers were: (a) certified physical education teachers, (b) actively teaching during the study period, (c) minimum one year of teaching experience, and (d) willingness to implement the program and complete observations. Exclusion criteria were: (a) temporary teaching status without active instructional duties, (b) absence during intervention delivery, or (c) incomplete monitoring records. For the expert validation phase, 10 specialists in physical education pedagogy, physical activity, and DRR were selected through criterion-based purposive sampling. Inclusion criteria

required: (a) advanced academic qualifications, (b) minimum five years of professional experience, and (c) evidence of expertise through publications, curriculum development, or disaster training practice.

Data were collected using three standardized instruments with acceptable psychometric properties. The Student Health Index [17] was used to assess student health status, including physical fitness, health behavior, and general well-being. Previous validation reported adequate content validity (Aiken's $V = 0.82$), satisfactory construct validity ($CFI = 0.91$; $RMSEA = 0.07$), and good internal consistency (Cronbach's $\alpha = 0.84$). The Physical Literacy Test [18] measured movement competence, coordination, motivation, confidence, and knowledge related to participation in physical activity. The instrument demonstrated acceptable factorial validity, item discrimination within recommended ranges, test-retest reliability ($ICC = 0.81$), and good internal consistency (Cronbach's $\alpha = 0.83$). The Disaster Preparedness Questionnaire [19] assessed disaster knowledge, attitudes, risk awareness, and readiness behaviors among school participants. Prior psychometric testing showed adequate content validity (Aiken's $V = 0.85$), convergent validity ($AVE > 0.50$), and satisfactory reliability (Cronbach's $\alpha = 0.86$). Before the main study, all instruments were pilot tested

in the current sample to ensure contextual suitability across Indonesia and the Philippines. The pilot results indicated acceptable reliability coefficients ($\alpha = 0.79$ - 0.85) and satisfactory item-total correlations, supporting their suitability for cross-national school-based research. Prior to pilot testing, all instruments underwent a standardized cross-cultural adaptation process. The original English versions were translated independently into Bahasa Indonesia and Filipino by bilingual experts. A separate panel of independent translators subsequently performed back-translation into English to verify semantic equivalence. Any discrepancies were resolved through expert consensus involving specialists in physical education, educational measurement, and DRR to ensure conceptual, linguistic, and cultural appropriateness for both countries. Internal consistency was re-evaluated using the current study sample. Cronbach's alpha coefficients demonstrated satisfactory reliability for the Student Health Index, Physical Literacy Test, and Disaster Preparedness Questionnaire, confirming that all instruments maintained acceptable psychometric properties within the Indonesian and Philippine school contexts.

Participant characteristics are summarized in Table 1, including the demographic and professional characteristics of the students, teachers, and expert validators.

Table 1. Participant characteristics

Variable	Students (n = 1,520)	Teachers (n = 98)	Experts (n = 10)
Age (years), Mean $\pm$ SD	13.6 $\pm$ 2.1	38.9 $\pm$ 7.8	46.2 $\pm$ 6.9
Male, n (%)	742 (48.8)	44 (44.9)	6 (60.0)
Female, n (%)	778 (51.2)	54 (55.1)	4 (40.0)
Height (cm), Mean $\pm$ SD	154.8 $\pm$ 12.6	167.3 $\pm$ 8.5	-
Weight (kg), Mean $\pm$ SD	47.9 $\pm$ 11.4	68.7 $\pm$ 12.1	-
BMI (kg/m ²), Mean $\pm$ SD	19.8 $\pm$ 3.4	24.5 $\pm$ 3.7	-
Primary school level, n (%)	688 (45.3)	-	-
Secondary school level, n (%)	832 (54.7)	-	-
Prior disaster drill participation, n (%)	952 (62.6)	69 (70.4)	-
Teaching experience (years), Mean $\pm$ SD	-	11.4 $\pm$ 6.2	-
Master's degree or above, n (%)	-	27 (27.6)	10 (100)
Certified PE teachers, n (%)	-	98 (100)	-
PE Pedagogy experts, n (%)	-	-	4 (40.0)
Sport Science experts, n (%)	-	-	3 (30.0)
Disaster Risk Reduction experts, n (%)	-	-	3 (30.0)
Professional experience (years), Mean $\pm$ SD	-	-	14.8 $\pm$ 5.7

2.3 Conceptual model of learning mechanism

The R-MOVE-ACT-CARE-FIT-REF framework is conceptualized as a dynamic learning system consisting of six interrelated components:

MOVE initiates embodied engagement and situational awareness through physical interaction, ACT facilitates rapid decision-making and action execution, CARE regulates emotional and social responses under stress, FIT supports physical capacity required for sustained performance, REF enables reflective evaluation and consolidation of experience, and READINESS represents the adaptive integration of all components. Although the six components perform distinct functional roles, they can be conceptually organized into four broader learning domains. MOVE and FIT represent the movement domain, ACT represents the cognitive decision-making domain, CARE represents the resilience domain, and READINESS reflects the integrated adaptive outcome, while REF serves as a reflective mechanism that continuously strengthens all domains through feedback and experiential learning.

2.4 The learning process follows a pathway

Figure 1 illustrates the hypothesized pathway through which the intervention promotes behavioral change, beginning with movement based learning experiences, followed by cognitive and psychosocial processing, behavioral adaptation through feedback, and ultimately improvements in disaster preparedness and physical literacy.

2.5 Data analysis

Data were analyzed using quantitative approaches. Content validity was assessed using Aiken's V , with a threshold of $V > 0.70$ indicating acceptable validity. Practicality was evaluated descriptively based on teacher and student responses. Program-related changes were evaluated using paired-sample t-tests. Descriptive statistics (mean $\pm$ standard deviation), t-values, degrees of freedom, 95% confidence intervals of the mean differences, Cohen's d effect sizes, and normalized gain (N-gain) scores were calculated to provide a comprehensive assessment of within-group changes. Given the one-group

pretest-posttest design without a comparison group, these analyses were used to characterize changes over time rather than to establish causal program effectiveness.

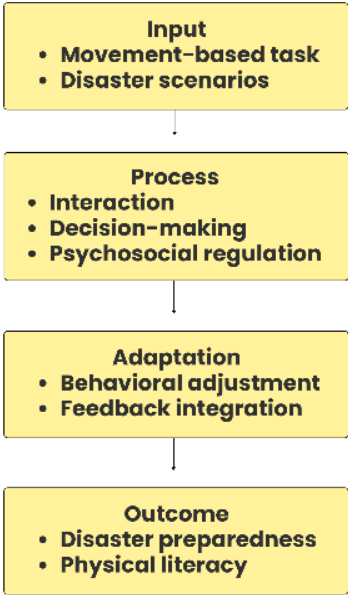


Figure 1. Conceptual framework of the intervention

3. RESULTS AND DISCUSSION

3.1 Result

This section presents the results of expert validation of the DR-PLP, focusing on its theoretical appropriateness, component relevance, pedagogical structure, feasibility, adaptability, and assessment alignment. The evaluation reflects the judgments of expert validators using quantitative indicators, including mean scores, standard deviations, and Aiken’s V, to determine the validity and overall quality of the developed model.

The expert validation results indicate that the DR-PLP demonstrates high content validity. The overall mean score obtained from ten experts was 4.62 out of 5.00, with an average Aiken’s V coefficient of 0.903, indicating that the model is very valid. All evaluated aspects, including conceptual suitability, instructional syntax, school feasibility, and assessment mechanisms, were rated in the very valid category, suggesting that the model is appropriate for implementation in schools located in disaster-prone areas.

The radar chart illustrates the expert validation results across four main aspects of the DR-PLP (Figure 2). The scores show consistently high ratings across all dimensions, ranging from 4.44 to 4.70. The Quality of Syntax (M = 4.70) received the highest evaluation, indicating strong pedagogical coherence of the R-MOVE-ACT-CARE-FIT-REF learning sequence. The Conceptual Suitability (M = 4.63) and School Feasibility (M = 4.59) also demonstrated high levels of agreement among experts, confirming that the model is theoretically grounded and practical for implementation in school settings. Meanwhile, the Assessment and Instrument Evaluation (M = 4.44) still falls within the very valid category, suggesting that the evaluation mechanism is appropriate but may benefit from minor refinement (Table 2).

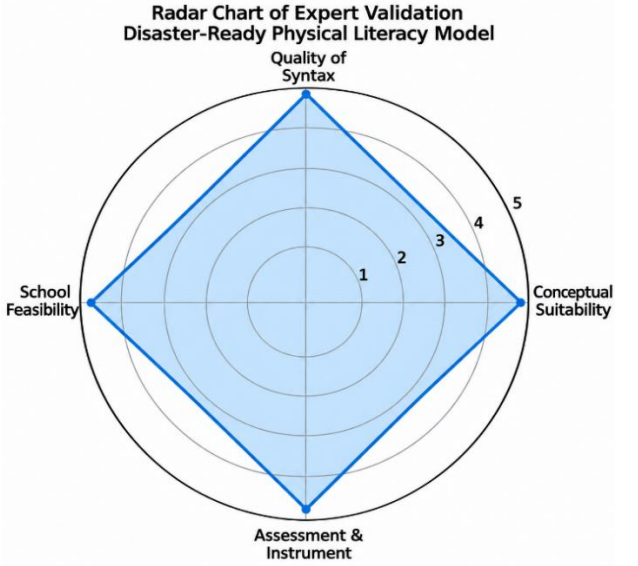


Figure 2. Expert validation of disaster-ready physical literacy model

Table 2. Expert validation summary by aspect

Aspect	Items	Mean Score	Aiken's V	Category
Conceptual Suitability	1–3	4.63	0.907	Very Valid
Quality of Syntax	4–7	4.70	0.924	Very Valid
School Feasibility	8–10	4.59	0.898	Very Valid
Assessment & Instrument Evaluation	11, 12	4.44	0.861	Very Valid

The expert validation results indicate that the DR-PLP demonstrates a strong conceptual and pedagogical foundation for integrating disaster preparedness within school physical education. The overall mean score of 4.62 out of 5.00, with an average Aiken’s V value of 0.903, indicates that the model is very valid, reflecting a high level of agreement among experts regarding its relevance and feasibility (Table 3). The radar chart analysis further illustrates that all validation dimensions, conceptual suitability, instructional syntax, school feasibility, and assessment mechanisms received consistently high evaluations. Among these aspects, the quality of the instructional syntax (M = 4.70) achieved the highest rating, indicating that the structured learning sequence R-MOVE-ACT-CARE-FIT-REF is considered pedagogically coherent and capable of facilitating experiential learning in disaster preparedness contexts. This finding highlights the importance of action-based simulation and movement-oriented activities, which allow students to develop not only cognitive understanding but also practical response skills during emergencies. The high rating for conceptual suitability (M = 4.63) further confirms that integrating physical literacy components, movement competence, cognitive awareness, resilience, and readiness into DRR education represents a meaningful innovation compared with conventional disaster education approaches, which tend to focus primarily on knowledge transmission.

Furthermore, the validation results demonstrate that the proposed model is feasible for implementation in school

environments, as reflected by the strong score on the school feasibility dimension ($M = 4.59$). Experts agreed that the activities can be conducted within regular physical education classes and do not require specialized facilities or equipment beyond what is typically available in schools. This practical feasibility is particularly important for disaster-prone regions such as Indonesia and the Philippines, where educational resources may vary significantly between schools. By embedding disaster preparedness training into existing physical education structures, the model offers a sustainable and scalable approach to strengthening students' preparedness capacities without adding additional curriculum burdens. Although the assessment and evaluation dimension ($M = 4.44$) received slightly lower ratings compared with other aspects, it still falls within the very valid category, suggesting that the

evaluation framework is adequate but may benefit from further refinement, particularly in measuring behavioral readiness and situational response during simulated disaster scenarios. Overall, these findings suggest that the DR-PLP provides a promising framework for supporting school-based disaster preparedness through the integration of physical competence, decision-making skills, and psychosocial resilience.

Table 3. Overall expert validation result

Indicator	Value
Number of Experts	10
Number of Items	12
Mean Score	4.62/5.00
Average Aiken's V	0.903

Table 4. Expert validation results of the disaster-ready physical literacy model

Validation Aspect	Mean	SD	Aiken's V	Category
Integration of Physical Literacy and Disaster Risk Reduction (DRR) is theoretically appropriate.	4.67	0.50	0.917	Very Valid
The six core components (MOVE, ACT, CARE, FIT, REF, and READINESS) are conceptually relevant and collectively support school disaster preparedness.	4.67	0.50	0.917	Very Valid
The model has novelty compared with conventional DRR learning.	4.56	0.53	0.889	Very Valid
The syntax sequence is logical and pedagogically sound.	4.67	0.50	0.917	Very Valid
Physical activities (MOVE & FIT) are age-appropriate and safe to implement.	4.56	0.53	0.889	Very Valid
Action-based simulation (ACT) effectively builds decision-making.	4.89	0.33	0.972	Very Valid
CARE develops students' psychosocial resilience.	4.67	0.50	0.917	Very Valid
The model is realistic to implement within regular PE classes.	4.44	0.53	0.861	Very Valid
Activities can be implemented using common school facilities.	4.56	0.53	0.889	Very Valid
The model is adaptive to local risk contexts (Indonesia-Philippines).	4.78	0.44	0.944	Very Valid
Assessment rubric (knowledge, skills, attitudes) is aligned with the model.	4.44	0.53	0.861	Very Valid
Evaluation mechanism (pre-post, observation, reflection) is adequate to assess program-related changes.	4.44	0.53	0.861	Very Valid

Table 5. Within-group pre-post changes in study outcomes during the large-scale field trial

Variable	Pre-Test Mean $\pm$ SD	Post-Test Mean $\pm$ SD	Mean Difference (95% CI)	t	df	p-Value	Cohen's <i>d</i>	N-Gain	Category
Physical Literacy	52.34 $\pm$ 35.0	81.67 $\pm$ 36.5	29.33 (27.53–31.13)	31.96	1519	<0.001	0.82	0.62	Moderate
Disaster Preparedness	48.91 $\pm$ 39.0	79.45 $\pm$ 41.0	30.54 (28.52–32.56)	29.66	1519	<0.001	0.76	0.60	Moderate
Student Health Index	55.72 $\pm$ 43.0	78.38 $\pm$ 44.2	22.66 (20.46–24.86)	20.20	1519	<0.001	0.52	0.51	Moderate

Detailed item-level results of the expert validation, including mean scores, standard deviations, Aiken's V coefficients, and validity categories, are presented in Table 4.

The observed improvements across all outcome variables indicate substantial within-group changes following implementation of the DR-PLP. Although these findings suggest that the intervention was associated with improvements in physical literacy, disaster preparedness, and student health, the absence of a comparison group precludes definitive causal attribution. Consequently, the observed gains should be interpreted as preliminary evidence of program-related improvement rather than conclusive proof of intervention effectiveness. In addition to statistical significance, the paired-sample *t*-tests demonstrated moderate-to-large effect sizes across all outcome variables, with confidence intervals indicating consistent improvements from pre-test to post-test.

Table 5 presents the detailed within-group pre-post changes for physical literacy, disaster preparedness, and the Student Health Index, including mean differences, confidence

intervals, test statistics, effect sizes, and N-gain categories.

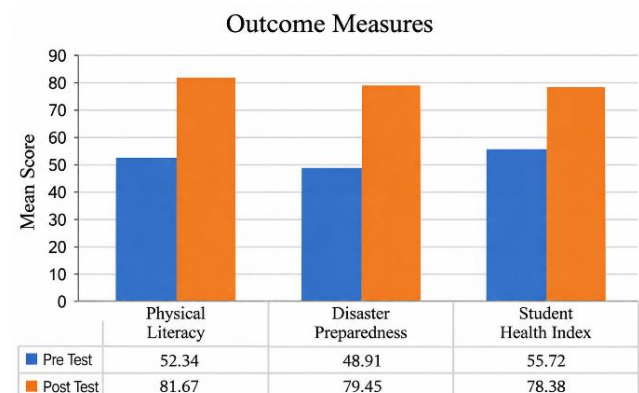


Figure 3. Pre-post score comparison across outcome variables

The DR-PLP was associated with significant

improvements across all outcome variables, with moderate-to-large effect sizes and consistent pre-post gains. However, because the study lacked a comparison group, these findings should be interpreted as preliminary evidence of program-related improvement rather than definitive proof of intervention effectiveness (Figure 3).

3.2 Discussion

The findings of this study, particularly the significant improvement in disaster preparedness scores ($N\text{-gain} = 0.60$), underscore the urgent need to strengthen school preparedness. Climate change and natural disasters such as floods, earthquakes, tsunamis, and tropical cyclones threaten coastal communities, including Mentawai, while increasing environmental risks globally [20-22]. School safety is a core pillar of DRR, combining infrastructure, management, and education. Therefore, disaster education and school preparedness programs are essential to strengthen readiness, lifesaving skills, awareness, and resilience, while promoting a safety-oriented school climate [23, 24]. These activities often address key topics such as disaster risk management, risk assessment, ecosystems, health systems, and climate change [25]. For early childhood and primary education, studies emphasize age-appropriate experiential learning, such as local flood maps, games, and drills, supported by teachers [26]. Importantly, these findings should not be interpreted solely as evidence of program effectiveness, but rather as indicators of an underlying learning process. The results suggest that disaster preparedness emerges from an embodied adaptation mechanism, where physical engagement, cognitive processing, and psychosocial regulation interact dynamically to shape behavioral readiness. Nevertheless, because this study employed a one-group pretest-posttest design, the observed improvements may also have been influenced by factors such as repeated testing, natural maturation, concurrent school activities, or other contextual influences. Therefore, the present findings should be interpreted as evidence of program-associated improvements, while future controlled or randomized studies are needed to establish causal effectiveness more rigorously.

The strong expert validation results (Mean = 4.62/5.00; Aiken's $V = 0.905$) indicate that this model is an innovative multidimensional framework designed to strengthen individual and community preparedness by integrating physical, mental, social, and behavioral capacities in emergency and daily adaptation contexts. MOVE emphasizes movement readiness, including effective body mobilization, motor skills, and rapid situational recognition for emergency response [27-29]. ACT focuses on quick-response behavior through rapid decision-making, situational understanding, and translating information into action, which is essential for effective disaster management [30, 31]. CARE highlights psychosocial support, emotional stability, empathy, and social connectedness as key elements of resilience during crises [32, 33]. FIT refers to physical capacity such as strength, endurance, and general fitness that sustain functional performance under normal and emergency conditions [34, 35]. REF emphasizes reflection and evaluation as continuous learning mechanisms to identify strengths, weaknesses, and future improvements in preparedness systems [36, 37]. Overall, this model provides a comprehensive and adaptive approach to building sustainable resilience through the integration of readiness, action, support, fitness, and learning

cycles.

Each component within the R-MOVE-ACT-CARE-FIT-REF framework performs a distinct functional role in the learning process. MOVE and ACT primarily influence perception-action coupling and rapid decision-making, CARE contributes to emotional stability and social responsiveness, FIT enhances physiological readiness, and REF supports cognitive consolidation of experience. The interaction among these components produces a synergistic effect, suggesting that disaster preparedness is an emergent outcome of a dynamic system rather than the result of isolated instructional inputs.

The overall expert validation score (Aiken's $V = 0.905$) indicates very high content validity, reflecting strong expert agreement on the model's relevance and accuracy. Values close to 1 signify higher validity, with the range $0.89 < V < 1$ categorized as "very valid" [38, 39]. This suggests that the model is theoretically sound, practically applicable in educational contexts, and well-structured. Compared with other R&D studies with lower validity ranges, this result demonstrates stronger validation, supporting its readiness for further empirical testing.

The highest syntax rating ($M = 4.70$) demonstrates strong instructional clarity and practicality. The learning syntax receives the highest rating due to its clarity, practicality, and alignment with physical education needs. Its step-by-step structure makes it easy for teachers to implement, supporting consistency and improving student engagement and learning [40]. Moreover, it fits well within limited instructional time and integrates with existing curricula, allowing effective and flexible application without adding extra burden [41, 42].

The significant within-group improvement in physical literacy outcomes (Pre = 52.34; Post = 81.67; $N\text{-gain} = 0.62$; $p < 0.001$) indicates a substantial change following implementation of the DR-PLP. Previous studies show that such interventions improve motor skills, confidence, motivation, and physical activity levels, particularly when implemented in schools and supported by student-centered approaches [43-45]. Although impacts are often stronger on physical competence, well-designed programs can also foster cognitive and affective development [46, 47]. These findings align with evidence that physical literacy is multidimensional, encompassing motor, cognitive, and affective domains [48, 49]. The strong increase in disaster preparedness scores (Pre = 48.91; Post = 79.45; $N\text{-gain} = 0.60$; $p < 0.001$) indicates a substantial within-group improvement in disaster preparedness following implementation of the R-MOVE-ACT-CARE-FIT-REF program, which integrates knowledge with practical simulation. School-based disaster education improves students' understanding of risks and their ability to respond appropriately [50, 51], while training and simulations strengthen awareness, skills, and response capacity [52, 53]. These approaches also shape students' attitudes and enable faster, more adaptive reactions in emergencies [54] supporting the need for comprehensive and proactive preparedness [32].

The improvement in Student Health Index scores (Pre = 55.72; Post = 78.38; $N\text{-gain} = 0.51$; $p < 0.001$) indicates a substantial within-group improvement in student health-related outcomes following implementation of the R-MOVE-ACT-CARE-FIT-REF program. School-based physical activity is proven to improve fitness, body composition, and overall health [55-57], while structured and consistent exercise increases stamina, strength, and activity levels [58]. These findings are consistent with previous evidence on school-

based physical activity and suggest that the model may provide complementary benefits by integrating health promotion with disaster education [46, 59].

The strong feasibility score ($M = 4.59$) suggests that disaster preparedness can be systematically integrated into the physical education curriculum. From a policy perspective, disaster preparedness should be systematically integrated into the physical education curriculum, adapted to local contexts, and supported by clear frameworks to optimize implementation [60-62]. Therefore, strengthening curriculum design and teacher capacity becomes essential for effective implementation. From a pedagogical standpoint, the DR-PLP provides PE teachers with a structured yet flexible instructional framework that extends beyond conventional fitness-oriented lessons. The program requires teachers to facilitate experiential learning scenarios, guide psychosocial reflection, and assess behavioral readiness-competencies that align with contemporary PE teacher education priorities. Consequently, pre-service and in-service teacher professional development programs should incorporate disaster-integrated PE modules to equip educators with the knowledge, skills, and confidence needed to implement movement-based preparedness learning effectively.

The R-MOVE-ACT-CARE-FIT-REF model shows strong potential for use in disaster-prone countries such as Indonesia and the Philippines. With many regions facing high disaster risk and similar vulnerabilities across contexts [63]. The need for effective preparedness education is universal. Although curricula are adapted to local characteristics, they share common goals of risk reduction and capacity building [64, 65]. This indicates that the model is transferable and can be applied in different settings without losing its core purpose. The findings should therefore be interpreted within a multi-hazard preparedness framework. Although different disaster types require context-specific response strategies, the proposed DR-PLP primarily develops transferable competencies, including movement adaptability, situational awareness, decision-making, psychosocial resilience, and coordinated action, which are applicable across a broad spectrum of natural hazards.

The implementation and potential applicability of this learning model are bounded by several contextual conditions. These include student characteristics such as age and baseline physical literacy, teacher facilitation quality, and environmental factors such as school infrastructure and resource availability. The model is expected to perform optimally under conditions that allow active participation, iterative practice, and contextual relevance of disaster scenarios.

4. LIMITATIONS AND FUTURE RESEARCH

Although disaster risk management is increasingly emphasized, strong evidence of its effectiveness remains limited [66]. Improving individual and community preparedness is essential, as it can enhance disaster response, reduce losses, and strengthen resilience [67]. However, this study has several limitations, including a short intervention duration, which limits the ability to observe long-term impacts and generalizability. In addition, the study did not directly assess students' behavior in real disaster situations, indicating the need for further research to evaluate the program's effectiveness in real-world contexts. To enhance

methodological rigor, future iterations of this study should consider: (i) incorporating inter-rater reliability checks across expert validators using Cohen's kappa to complement Aiken's V; (ii) embedding longitudinal tracking of student preparedness outcomes beyond the immediate post-test phase; and (iii) applying structural equation modeling (SEM) to examine the mediation pathways between physical literacy dimensions and disaster preparedness outcomes, thereby strengthening causal inference and theoretical contribution. An additional limitation is the absence of a control or comparison group. Consequently, improvements observed between pre-test and post-test assessments cannot be attributed exclusively to the intervention, as alternative explanations, including maturation, repeated testing, and concurrent school experiences, cannot be completely ruled out.

Disaster preparedness education requires trained educators and sufficient resources to strengthen resilience and reduce disaster impacts [32, 26]. Studies also show its role in improving students' risk perception and preparedness [24]. while technologies such as AR and VR can enhance engagement and experiential learning [68-70]. However, further research with broader samples and more rigorous controlled designs is needed to establish long-term program effectiveness and optimize implementation.

5. CONCLUSIONS

This study advances disaster education by proposing a mechanism-based learning model that explains how embodied physical literacy facilitates adaptive behavior in disaster contexts. The findings indicate that disaster preparedness is not merely a cognitive outcome but an emergent property of integrated physical, cognitive, and psychosocial processes. By shifting the focus from outcome effectiveness to learning mechanisms, this study provides a theoretical foundation for understanding how behavioral readiness is formed and sustained. The proposed model offers a scalable and adaptable framework for integrating disaster preparedness into physical education through a systems-based learning approach.

ACKNOWLEDGEMENT

This research is funded by the Indonesian Endowment Fund for Education (LPDP) on behalf of the Indonesian Ministry of Higher Education, Science and Technology, and managed under the EQUITY Program (Contract No.: 4311/B3/DT.03.08/2025), under Grant No.: 14.11.11/UN37/PPK.RO1/2025.

ETHICAL APPROVAL

The research followed the ethical standards of the Declaration of Helsinki and received ethical approval from the Ethics Committee of Universitas Negeri Semarang (Ethical Clearance No. B/5651/UN37.3.1/KEP.00/2026).

REFERENCES

- [1] Pal, A., Tsusaka, T.W., Nguyen, T.P.L., Ahmad, M.M. (2023). Assessment of vulnerability and resilience of

- school education to climate-induced hazards: A review. *Development Studies Research*, 10(1): 2202826. <https://doi.org/10.1080/21665095.2023.2202826>
- [2] Partini, D., Hidayat, A.N. (2024). Disaster risk reduction efforts through education in Indonesia: A literature review. *IOP Conference Series: Earth and Environmental Science*, 1314(1): 012049. <https://doi.org/10.1088/1755-1315/1314/1/012049>
- [3] Hoffmann, R., Blecha, D. (2020). Education and disaster vulnerability in Southeast Asia: Evidence and policy implications. *Sustainability*, 12(4): 1401. <https://doi.org/10.3390/su12041401>
- [4] Amri, A., Lassa, J.A., Tebe, Y., Hanifa, N.R., Kumar, J., Sagala, S. (2022). Pathways to disaster risk reduction education integration in schools: Insights from SPAB evaluation in Indonesia. *International Journal of Disaster Risk Reduction*, 73: 102860. <https://doi.org/10.1016/j.ijdr.2022.102860>
- [5] Choi, S., Choi, M.J., Shamrova, D.P., Hong, J.Y., Kim, Y.J., Mullan, S.N. (2024). Challenges and coping strategies of families with young children amid hurricanes: A qualitative inquiry. *Families in Society: The Journal of Contemporary Social Services*, 106(1): 86-101. <https://doi.org/10.1177/10443894231217327>
- [6] Shah, A.A., Ajiang, C., Gong, Z.W., et al. (2022). Reconnoitering school children vulnerability and its determinants: Evidence from flood disaster-hit rural communities of Pakistan. *International Journal of Disaster Risk Reduction*, 70: 102735. <https://doi.org/10.1016/j.ijdr.2021.102735>
- [7] Kaya, H., Tezcan, A., Bakır, M.Ş., İlhan, M., Yiğit, E., Dağ, Ö. (2023). An analysis of primary school students' earthquake awareness. *International Journal for Multidisciplinary Research*, 5(1): 1-8. <https://doi.org/10.36948/ijfmr.2023.v05i01.1394>
- [8] Rudd, J.R., Pesce, C., Strafford, B.W., Davids, K. (2020). Physical literacy—A journey of individual enrichment: An ecological dynamics rationale for enhancing performance and physical activity in all. *Frontiers in Psychology*, 11: 1-13. <https://doi.org/10.3389/fpsyg.2020.01904>
- [9] Guangde, Z. (2022). Physical education and emergency response system using deep learning: A step toward sustainable development of physical education environment. *Frontiers in Environmental Science*, 10: 1-11. <https://doi.org/10.3389/fenvs.2022.974291>
- [10] Louis, C.J., Beaumont, C., Velilla, N., Greif, R., Fernandez, J., Reyero, D. (2022). The "ABC SAVES LIVES": A schoolteacher-led basic life support Program in Navarra, Spain. *Sage Open*, 12(3). <https://doi.org/10.1177/21582440221124478>
- [11] Santos, A.J., Baptista, L., Amoroso, J., Pedroso de Lima, C., Furtado, G., Teixeira, M. (2025). Beyond the gym floor and the classroom: Physical education as a catalyst for transdisciplinary physically active learning in the Portuguese educational landscape. In *Education and Human Development*. IntechOpen. <https://doi.org/10.5772/intechopen.1008145>
- [12] Opabola, E.A., Galasso, C., Rossetto, T., Meilianda, E., Idris, Y., Nurdin, S. (2023). Investing in disaster preparedness and effective recovery of school physical infrastructure. *International Journal of Disaster Risk Reduction*, 90: 103623. <https://doi.org/10.1016/j.ijdr.2023.103623>
- [13] Nasution, R.F., Lestari, E.B., Usiono, U. (2024). Peran pendidikan kesiapsiagaan bencana dalam meningkatkan kesadaran pada remaja. *Jurnal Bintang Pendidikan Indonesia*, 3(1): 119-128. <https://doi.org/10.55606/jubpi.v3i1.3491>
- [14] Yunanto, R.A., Haristiani, R., Setioputro, B., Rokhmah, D. (2024). Optimizing the level of disaster preparedness for coastal children in creating a disaster resilient generation. *Abdimas: Jurnal Pengabdian Masyarakat Universitas Merdeka Malang*, 9(2): 223-236. <https://doi.org/10.26905/abdimas.v9i2.12746>
- [15] Sari, L.A. (2019). School in earthquake threat: School based disaster preparedness model in Indonesia. Preprints. <https://doi.org/10.20944/preprints201902.0253.v1>
- [16] Mufit, F., Asrizal, A., Hanum, S.A., Fadhillah, A. (2020). Preliminary research in the development of physics teaching materials that integrate new literacy and disaster literacy. *Journal of Physics: Conference Series*, 1481(1): 012041. <https://doi.org/10.1088/1742-6596/1481/1/012041>
- [17] Cahyati, W.H., Adi, S., Armini, L.N., et al. (2025). Developing the Indonesian student health index as an instrument for monitoring and evaluating student health in physical education. *Physical Education Theory and Methodology*, 25(5): 1062-1069. <https://doi.org/10.17309/tmf.2025.5.05>
- [18] Permana, R., Isti'adah, F.N., Dewi, R.S., et al. (2024). Instrument for assessing physical literacy skills competence in Primary School Tasikmalaya, Indonesia. *Retos Nuevas Perspect Educ Física Deporte Recreación*, 58: 477-484. <https://doi.org/10.47197/retos.v58.107671>
- [19] Budhiana, J., Elengoe, A., Said, M.S.M. (2024). Determinants of community preparedness for earthquake and Tsunami Disasters. *Malaysian Journal of Medicine and Health Sciences*, 20(Suppl. 7): 64-68.
- [20] Baldwin, J., Lee, C.Y., Walsh, B.J., Camargo, S.J., Sobel, A.H. (2023). Vulnerability in a tropical cyclone risk model: Philippines case study. *Weather, Climate, and Society*, 15(3): 503-523. <https://doi.org/10.1175/wcas-d-22-0049.1>
- [21] Cabello, V., Véliz, K., Moncada-Arce, A., García-Huidobro, M.I., Juillerat, F. (2021). Disaster risk reduction education: Tensions and connections with sustainable development goals. *Sustainability*, 13(19): 10933. <https://doi.org/10.3390/su131910933>
- [22] Markolinda, Y., Sawirman, S., Ramadani, M., et al. (2025). Indigenous knowledge for disaster mitigation and climate threats in Mentawai, Indonesia. *Jambá Journal of Disaster Risk Studies*. 17(1): a1877. <https://doi.org/10.4102/jamba.v17i1.1877>
- [23] Seddighi, H., Sajjadi, H., Yousefzadeh, S., et al. (2022). School-based education programs for preparing children for natural hazards: A systematic review. *Disaster Medicine and Public Health Preparedness*, 16(3): 1229-1244. <https://doi.org/10.1017/dmp.2020.479>
- [24] Yildiz, A., Dickinson, J., Priego-Hernández, J., Teeuw, R., Shaw, R. (2023). Effects of disaster education on children's risk perception and preparedness: A quasi-experimental longitudinal study. *Geographical Journal*, 190(2): e12556. <https://doi.org/10.1111/geoj.12556>
- [25] Scolobig, A., Balsiger, J. (2024). Emerging trends in disaster risk reduction and climate change adaptation higher education. *International Journal of Disaster Risk*

- Reduction, 105: 104383. <https://doi.org/10.1016/j.ijdr.2024.104383>
- [26] Yang, M., Sarker, M.N.I., Rahman, M.N. (2025). Integrating disaster preparedness into education policy and management in the face of multi-hazard risks. *Environmental Research Communications*, 7(9): 092003. <https://doi.org/10.1088/2515-7620/ae0785>
- [27] Gray, B., Hanna, F., Reifels, L. (2020). The integration of mental health and psychosocial support and disaster risk reduction: A mapping and review. *International Journal of Environmental Research and Public Health*, 17(6): 1900. <https://doi.org/10.3390/ijerph17061900>
- [28] Lin, C.H., Tzeng, W.C., Chiang, L.C., Lu, M.C., Lee, M.S., Chiang, S. (2024). Effectiveness of a structured disaster management training program on nurses' disaster readiness for response to emergencies and disasters: A randomized controlled trial. *Journal of Nursing Management*, 2024: 5551894. <https://doi.org/10.1155/2024/5551894>
- [29] Richardson, J., Kelly, L., Mackay, A. (2023). Australian red cross psychosocial approach to disaster preparedness. *Australian Journal of Emergency Management*, 38(3): 31-36. <https://doi.org/10.47389/38.3.31>
- [30] Khatri, R.B., Endalamaw, A., Erku, D., et al. (2023). Preparedness, impacts, and responses of public health emergencies towards health security: Qualitative synthesis of evidence. *Archives of Public Health*, 81: 208. <https://doi.org/10.1186/s13690-023-01223-y>
- [31] Zhang, D., Zhang, L., Zhang, K.H., Zhang, H., Zhang, H., Zhao, K. (2024). Disaster literacy in disaster emergency response: A national qualitative study among nurses. *BMC Nursing*, 23. <https://doi.org/10.1186/s12912-024-01911-2>
- [32] Guo, L., Fang, M.W., Liu, L., Chong, H.Y., Zeng, W., Hu, X.Y. (2025). The development of disaster preparedness education for public: A scoping review. *BMC Public Health*, 25: 645. <https://doi.org/10.1186/s12889-025-21664-0>
- [33] Mtiraoui, A., Mahjoubi, H., Achour, A., Ghardallou, M., Nakhli, J. (2025). The impact of psychological first aid training (RAPID-PFA) on self-efficacy, perceived competencies and disaster preparedness of nursing students in Tunisian public institutions: A randomized controlled trial. *Journal of Contingencies and Crisis Management*, 33: e70019. <https://doi.org/10.1111/1468-5973.70019>
- [34] Shibesh, B.F., Nagabhatla, N. (2025). Addressing climate resilience in the African region: Prioritizing mental health and psychosocial well-being in disaster preparedness and response planning for mainstream communities and migrants. *Climate*, 13(7): 139. <https://doi.org/10.3390/cli13070139>
- [35] Bahadır Yılmaz, E. (2025). Evaluating the effectiveness of psychological first aid training for disaster nursing: A mixed-method study. *BMC Nursing*, 24: 1355. <https://doi.org/10.1186/s12912-025-03995-w>
- [36] Jin, Y., Coombs, W.T., Wang, Y., van der Meer, T.G.L.A., Shivers, B.N. (2024). "READINESS": A keystone concept beyond organizational crisis preparedness and resilience. *Journal of Contingencies and Crisis Management*, 32(1): e12546. <https://doi.org/10.1111/1468-5973.12546>
- [37] Said, N.B., Molassiotis, A., Chiang, V.C.L. (2022). Psychological first aid training in disaster preparedness for nurses working with emergencies and traumas. *International Nursing Review*, 69(4): 548-558. <https://doi.org/10.1111/inr.12749>
- [38] Siagian, A.F., Ibrahim, M., Supardi, Z.A.I. (2023). Creative-scientific decision-making skills learning model for training creative thinking skills and student decision making skills. *Nurture*, 17(1): 10-17. <https://doi.org/10.55951/nurture.v17i1.141>
- [39] Yuwono, C., Adi, S., Soenyoto, T., et al. (2025). The development and educational evaluation of a smart IoT relay baton with accelerometer technology. *Physical Education Theory and Methodology*, 25(6): 1389-1397. <https://doi.org/10.17309/tmf.2025.6.09>
- [40] Priyohutomo, A., Komarudin, Sridadi. (2025). The perspective of physical education teachers: Challenges within the project-based learning model. *Physical Education Theory and Methodology*, 25(3): 511-517. <https://doi.org/10.17309/tmf.2025.3.05>
- [41] Fernández-Río, J., Iglesias, D. (2022). What do we know about pedagogical models in physical education so far? An umbrella review. *Physical Education and Sport Pedagogy*, 29: 190-205. <https://doi.org/10.1080/17408989.2022.2039615>
- [42] MacPhail, A., Tannehill, D., Leirhaug, P.E., Borghouts, L. (2021). Promoting instructional alignment in physical education teacher education. *Physical Education and Sport Pedagogy*, 28: 153-64. <https://doi.org/10.1080/17408989.2021.1958177>
- [43] Wilhite, B.C., Chui, K., Sacheck, J.M., et al. (2025). Getting an active start: Assessing the impact of a physical literacy-based intervention on preschool-aged children's fundamental movement skills, motor competency and behavioral self-regulation. *International Journal of Environmental Research and Public Health*, 22(12): 1861. <https://doi.org/10.3390/ijerph22121861>
- [44] Jerebine, A., Arundell, L., Watson-Mackie, K., et al. (2024). Effects of holistically conceptualised school-based interventions on children's physical literacy, physical activity, and other outcomes: A systematic review. *Sports Med-Open*, 10: 105. <https://doi.org/10.1186/s40798-024-00766-w>
- [45] Telford, R.M., Olive, L.S., Keegan, R.J., Keegan, S., Barnett, L.M., Telford, R.D. (2021). Student outcomes of the physical education and physical literacy (PEPL) approach: A pragmatic cluster randomised controlled trial of a multicomponent intervention to improve physical literacy in primary schools. *Physical Education and Sport Pedagogy*, 26: 97-110. <https://doi.org/10.1080/17408989.2020.1799967>
- [46] Carl, J., Barratt, J., Wanner, P., Töpfer, C., Cairney, J., Pfeifer, K. (2022). The effectiveness of physical literacy interventions: A systematic review with meta-analysis. *Sports Medicine*, 52: 2965-2999. <https://doi.org/10.1007/s40279-022-01738-4>
- [47] Son, H. (2025). The impact of movement-integrated instruction on physical literacy development in elementary students. *Education Sciences*, 15(5): 545. <https://doi.org/10.3390/educsci15050545>
- [48] Bremer, E., Graham, J., Cairney, J. (2020). Outcomes and feasibility of a 12-week physical literacy intervention for children in an afterschool program. *International Journal of Environmental Research and Public Health*, 17(9): 3129. <https://doi.org/10.3390/ijerph17093129>

- [49] Romero-Martínez, J., Menescardi, C., Ortega-Benavent, N., et al. (2025). Effects of a classroom-based intervention to promote physical literacy in children: The randomized and controlled ALPHYL Study. *Journal of Science and Medicine in Sport*, 28(10): 833-839. <https://doi.org/10.1016/j.jsams.2025.05.006>
- [50] Prodyanasari, A., Jayanti, K.D., Fernanda, J.W. (2025). Preparing for disasters: Practical training for elementary school students. *Darmabakti Cendekia: Journal of Community Service and Engagements*, 7(1): 67-75. <https://doi.org/10.20473/dc.v7.i1.2025.67-75>
- [51] Herdiansyah, H., Husein, S., Asrofani, F., Simamora, P., Kholila, B. (2020). Disaster awareness through disaster preparedness education for primary schools. *IOP Conference Series: Earth and Environmental Science*, 519(1): 012016. <https://doi.org/10.1088/1755-1315/519/1/012016>
- [52] Pranata, S., Vranada, A., Kurnia, A., et al. (2022). Improving school disaster preparedness through teacher, cadre training and disaster simulation for students at public elementary school. *Community Development Journal*, 7(2): 76-83. <https://doi.org/10.33086/cdj.v7i2.3805>
- [53] Basri, T.H., Ilyas, I., Akob, B., Nuraini, N. (2025). Edukasi dan simulasi mitigasi bencana untuk siswa smpn 1 kejuruan muda. *Mitra Abdimas: Jurnal Pengabdian kepada Masyarakat*, 5(1): 8-13. <https://doi.org/10.57251/mabdimas.v5i1.1699>
- [54] Ibrahim, S., Kiran, S., Humna, H., Mahnaz, W. (2025). The role of disaster preparedness training in shaping students' attitudes toward earthquake response. *The Critical Review of Social Sciences Studies*, 3(1): 3610-3631. <https://doi.org/10.59075/0vd1r855>
- [55] Stojanović, D., Momčilović, V., Zdražnik, M., et al. (2023). School-based TGfU volleyball intervention improves physical fitness and body composition in primary school students: A cluster-randomized trial. *Healthcare*, 11(11): 1600. <https://doi.org/10.3390/healthcare11111600>
- [56] Olsen, H.W., Sjørðarson, T., Danielsen, B.B., et al. (2024). A 10-week implementation of the FIT FIRST FOR ALL school-based physical activity concept effectively improves cardiorespiratory fitness and body composition in 7-16-year-old schoolchildren. *Frontiers in Public Health*, 12: 1419824. <https://doi.org/10.3389/fpubh.2024.1419824>
- [57] Lee, E.J., So, W.Y., Youn, H.S., Kim, J. (2021). Effects of School-based physical activity programs on health-related physical fitness of Korean adolescents: A preliminary study. *International Journal of Environmental Research and Public Health*, 18(6): 2976. <https://doi.org/10.3390/ijerph18062976>
- [58] Huang, G.J.K., Yao, J.B., Deng, L.N., Huang, P.X., Hong, P., Li, X.M. (2026). Effects of a structured after-school physical activity program on physical fitness, body composition, and sleep in primary school students: A pilot quasi-experimental study. *BMC Public Health*, 26: 123. <https://doi.org/10.1186/s12889-025-25843-x>
- [59] Jarnig, G., Kerbl, R., Jaunig, J., van Poppel, M.N.M. (2023). Effects of a daily physical activity intervention on the health-related fitness status of primary school children: A cluster randomized controlled trial. *Journal of Sports Sciences*, 41(11): 1073-1082. <https://doi.org/10.1080/02640414.2023.2259210>
- [60] Nopembri, S., Saryono, S., Muktiani, N.R., Listyarinni, A.E., Shahril, M.I.B. (2022). Digital technology in physical education distance learning during pandemic: Teachers' perspective. *Jurnal Keolahragaan*, 10(1): 71-82. <https://doi.org/10.21831/jk.v10i1.48374>
- [61] Tae, P.M.S.Y., Indarwati, R., Armini, N.K.A. (2024). Implementasi satuan pendidikan aman bencana terhadap kesiapsiagaan bencana gempa bumi pada siswa. *Journal of Telenursing (JOTING)*, 6(1): 568-577. <https://doi.org/10.31539/joting.v6i1.9064>
- [62] Libayao, H.G.C., Navaluna Jr, C.A., Allosada, J.L., Tacadena, J.E. (2024). Disaster education in elementary school curriculum: Basis for framework designing. *Journal of Learning and Educational Policy*, 4(3): 15-22. <https://doi.org/10.55529/jlep.43.15.22>
- [63] Dariagan, J.D., Atando, R.B., Asis, J.L.B. (2020). Disaster preparedness of local governments in Panay Island, Philippines. *Natural Hazards*, 105: 1923-1944. <https://doi.org/10.1007/s11069-020-04383-0>
- [64] Pohan, R.A., Ramadhani, E., Marimbun, M., Chalidaziah, W., Nengsih, N., Marhaban, M. (2024). Disaster preparedness and safety curriculum for early childhood education in Indonesia. *Prehospital Disaster Med*, 39: 228-229. <https://doi.org/10.1017/s1049023x24000177>
- [65] Ghaffarian, S., Roy, D., Filatova, T., Kerle, N. (2021). Agent-based modelling of post-disaster recovery with remote sensing data. *International Journal of Disaster Risk Reduction*, 60: 102285. <https://doi.org/10.1016/j.ijdr.2021.102285>
- [66] Sarabia, M.M., Kägi, A., Davison, A.C., et al. (2020). The challenges of impact evaluation: Attempting to measure the effectiveness of community-based disaster risk management. *International Journal of Disaster Risk Reduction*, 49: 101732. <https://doi.org/10.1016/j.ijdr.2020.101732>
- [67] Fazeli, S., Haghani, M., Mojtahedi, M., Rashidi, T.H. (2024). The role of individual preparedness and behavioural training in natural hazards: A scoping review. *International Journal of Disaster Risk Reduction*, 105: 104379. <https://doi.org/10.1016/j.ijdr.2024.104379>
- [68] Lu, S.J., Lin, Y.C., Tan, K., Liu, Y.C. (2022). Revolutionizing elementary disaster prevention education and training via augmented reality-enhanced collaborative learning. *International Journal of Engineering Business Management*, 14. <https://doi.org/10.1177/18479790211067345>
- [69] Magi, C.E., Bambi, S., Iovino, P., et al. (2023). Virtual reality and augmented reality training in disaster medicine courses for students in nursing: A scoping review of adoptable tools. *Behavioral Sciences*, 13(7): 616. <https://doi.org/10.3390/bs13070616>
- [70] Jung, H., Park, S.W., Kim, H.S., Park, J. (2021). The effects of the regulated learning-supported flipped classroom on student performance. *Journal of Computing in Higher Education*, 34: 132-153. <https://doi.org/10.1007/s12528-021-09284-0>