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# SPATIAL COGNITION-BASED LEARNING FOR DISASTER PREPAREDNESS: AN EDUCATIONAL MAZE APPROACH TO EVACUATION TRAINING IN PRIMARY SCHOOLS

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## ABSTRACT

*This study examines the integration of the Educational Maze (Larindu) as a spatial cognition-based learning approach to strengthen disaster education in primary schools, particularly in enhancing students' disaster knowledge, spatial understanding, and adaptive response skills during evacuation. A qualitative approach with an instrumental case study design was employed at SD Muhammadiyah Insan Kreatif Bantul, Indonesia. Data were collected through in-depth interviews with the school principal, teachers, and the game designer, complemented by observations and document analysis. Data were analyzed using the interactive model of Miles and Huberman. The findings reveal that Larindu facilitates students' understanding of evacuation routes by supporting the development of cognitive maps through active navigation. The modular maze design enables dynamic route simulation, encouraging students to evaluate alternative pathways and develop adaptive decision-making skills when encountering obstacles. The study concludes that integrating authentic spatial representations into a manipulable learning medium transforms disaster education from a predominantly informational approach into a more experiential and spatial cognition-based learning process, thereby enhancing students' preparedness.*

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**KEYWORDS:** Disaster Education; Spatial Cognition; Educational Games; Evacuation Routes; Disaster Preparedness.

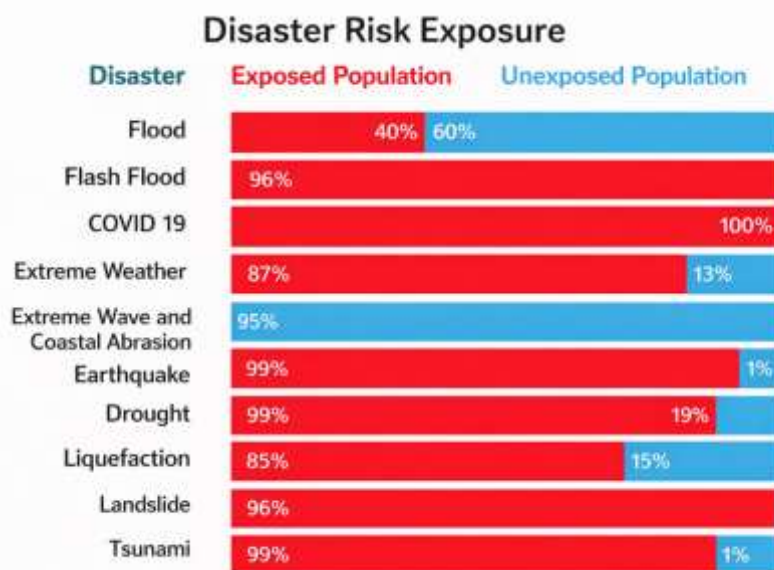
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## 1. INTRODUCTION

The increasing frequency and complexity of natural disasters over recent decades have positioned disaster education as a critical component of the global disaster risk reduction agenda (Shah et al., 2024; Suarmika et al., 2022). The Sendai Framework for Disaster Risk Reduction emphasizes that cultivating a risk-aware culture must begin at an early age through formal education systems. Primary schools represent strategic spaces for fostering knowledge, developing understanding, and strengthening students' adaptive skills in responding to emergency situations (Mai & Kato, 2025; Yildiz et al., 2024). Disaster education is therefore no longer understood merely as the transmission of safety information, but as a broader learning process that develops cognitive, spatial, and behavioral capacities enabling individuals to make timely and appropriate decisions during disasters (Bai et al., 2025; Cho & Kwon, 2025; Guo et al., 2025). Consequently, the development of contextual, participatory, and experiential learning approaches has become

increasingly important, particularly in regions characterized by high and dynamic disaster risk.

Indonesia is among the countries facing significant disaster risk due to its geographical location at the convergence of active tectonic plates (Hutchings & Mooney, 2021; Muzani et al., 2024; Windupranata et al., 2025). Bantul Regency in the Special Region of Yogyakarta represents one of the areas with considerable disaster vulnerability. Trend data for the 2025 disaster risk index indicate fluctuations that remain within moderate to high-risk categories (see Figure 1). Although a slight decline is observed in the most recent year, the overall index continues to reflect persistent exposure to potential hazards. These fluctuations suggest that disaster risk is inherently dynamic and requires continuous mitigation strategies. Within the educational context, such conditions necessitate ongoing updates to school preparedness systems, including adjustments to evacuation routes, learning materials, and disaster mitigation strategies aligned with changing environmental conditions (Widowati et al., 2021).



*Figure 1. Percentage of Exposed and Non-Exposed Population by Disaster Type in Bantul Regency (2025). Source: inaRISK BNPB, 2025.*

Beyond the overall disaster risk index, variations in hazard types further reinforce the urgency of contextualized disaster education (Triastari et al., 2021; Wahyono et al., 2022). Data on the percentage of exposed populations by disaster type indicate that threats are not singular but diverse, ranging from earthquakes and floods to extreme weather events. These variations highlight that each region possesses distinct risk characteristics, making standardized disaster mitigation approaches insufficient for

school-based learning environments. For schools located in earthquake-prone regions such as Bantul, understanding evacuation routes and assembly points becomes a crucial component of self-protection efforts. Consequently, disaster education should not be delivered solely as generalized information but should be designed to reflect the specific spatial and environmental contexts in which students live and learn.

Children constitute one of the most vulnerable

groups in disaster situations, both physically and cognitively (Torani et al., 2019). This vulnerability is not only related to limited physical capacity but also to the developmental stage of children's spatial orientation, environmental awareness, and decision-making abilities. Research in developmental psychology suggests that elementary school children often rely heavily on landmark-based navigation and may encounter difficulties when interpreting complex spatial configurations or identifying alternative pathways (Lestari, 2024). Within school environments, modifications to evacuation maps or structural changes in buildings often require considerable time for students to adapt. Under such conditions, disaster education approaches that rely primarily on the dissemination of evacuation maps or periodic drills may not sufficiently strengthen students' spatial memory and navigational reflexes (Hasrian Hasrian et al., 2025; Jeremy Putra Pratama et al., 2025). These limitations indicate the need for pedagogical strategies that move beyond procedural instruction toward learning experiences that actively develop children's spatial cognition and adaptive navigation skills.

Previous studies have introduced various disaster mitigation educational games aimed at enhancing children's awareness and preparedness. Board games, digital simulations, and mobile-based applications have been shown to improve students' understanding of disaster risks and promote preventive behaviors (Jeremy Putra Pratama et al., 2025; Mystakidis et al., 2022). However, many of these learning media primarily emphasize conceptual knowledge about disasters rather than explicitly training spatial cognition related to evacuation navigation (Ducatti et al., 2025; Mystakidis et al., 2022). In particular, the ability to interpret route configurations, recognize branching pathways, and identify alternative evacuation routes remains relatively underexplored in disaster education research (Lestari, 2024; Libayao et al., 2024). Moreover, many disaster education games are designed as generic simulations that are not directly connected to the actual spatial structure of school environments. As a result, the learning experience may remain abstract and detached from the real evacuation routes students must navigate during emergencies (Mitsuhara et al., 2023; Uz Zaman et al., 2024). Considering that effective evacuation requires rapid interpretation of spatial layouts and adaptive navigation decisions, the limited integration between spatial cognition training and authentic spatial environments represents an important research gap in disaster education literature. Therefore, there is a

need for learning approaches that explicitly integrate spatial cognition with authentic environmental contexts to support effective evacuation training in schools.

## 2. PURPOSE OF THE STUDY

In response to the limitations identified in previous research, integrating spatial cognition principles into disaster education offers a promising approach to strengthen children's preparedness. By embedding spatial exploration and navigation-based problem solving within learning activities, students can develop cognitive maps that support flexible decision-making during emergency situations. Nevertheless, empirical studies examining how spatial cognition can be integrated into school-based evacuation learning remain limited, particularly through manipulable and context-specific learning media. Therefore, this study aims to analyze the integration of spatial cognition within disaster education through the implementation of an Educational Maze known as Larindu. The study explores how the use of Larindu contributes to strengthening three key indicators of disaster preparedness among primary school students: disaster knowledge, spatial understanding, and adaptive response skills. By examining the implementation of Larindu within a real school environment, this study seeks to provide empirical insights into how spatially oriented learning media can support more contextualized disaster education practices.

## 3. THE CONCEPTUAL FRAMEWORK OF THE STUDY

From the perspective of spatial cognition, learning to navigate an environment involves the gradual construction of mental representations of spatial structures. Environmental psychology literature suggests that spatial knowledge develops progressively through three stages: landmark knowledge, route knowledge, and survey knowledge (Kim et al., 2025; Mallek et al., 2024; Uz Zaman et al., 2024). Landmark knowledge involves recognizing significant environmental reference points, route knowledge refers to understanding sequences of paths connecting locations, and survey knowledge represents a comprehensive mental map of spatial relationships within an environment (Cho & Kwon, 2025; Uz Zaman et al., 2024). In evacuation contexts, these cognitive processes enable individuals to interpret spatial layouts, anticipate obstacles, and identify alternative routes when primary pathways become inaccessible.

In this study, the theoretical framework of disaster education is operationalized through three interconnected indicators: disaster knowledge, spatial understanding, and adaptive skills (Sung-Chin Chung & Cherng-Jyh Yen, 2016). These components represent a progressive learning structure in which declarative knowledge forms the foundation for relational spatial comprehension, which subsequently supports adaptive behavioral responses. By embedding spatial exploration within

the Larindu game design, this study applies principles of spatial knowledge acquisition that move from landmark recognition to route understanding and ultimately to survey-level comprehension. Therefore, the integration of spatial cognition is not treated merely as a conceptual perspective but is translated directly into the instructional design and analytical framework of the research.

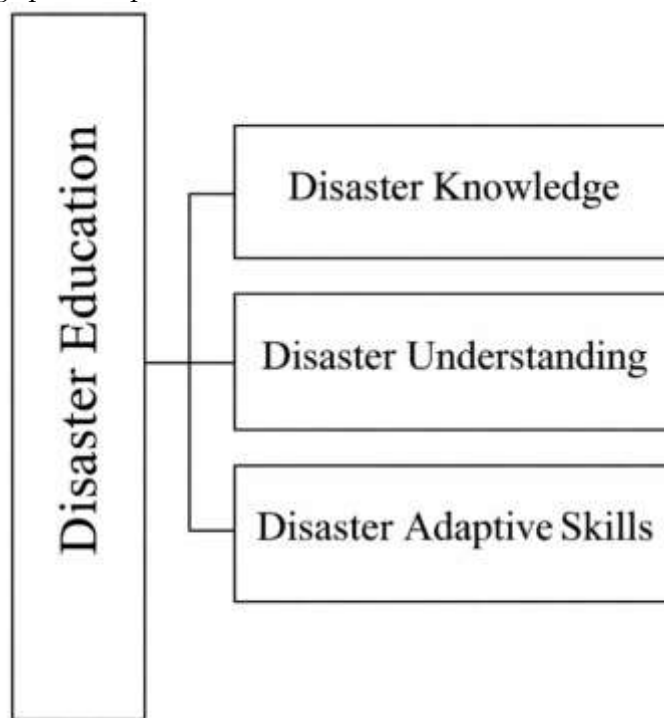


Figure 2. Conceptual Framework of Disaster Education Indicators  
Source. Chung & Yen, 2016

As illustrated in Figure 2, disaster education in this study is conceptualized as a hierarchical yet interconnected structure comprising disaster knowledge, spatial understanding, and adaptive skills. Rather than functioning as separate competencies, these indicators form a progressive continuum in which each stage reinforces the next. Knowledge provides informational grounding, spatial understanding develops relational mapping of the environment, and adaptive skills translate cognitive structures into responsive action. This framework guided both data analysis and interpretation, ensuring that the evaluation of Larindu's implementation remained aligned with a theoretically informed model of preparedness development.

## 4. METHODS OF THE STUDY

### 4.1 Research Design

This study employed a qualitative approach using an instrumental case study design to explore the integration of spatial cognition in disaster education through the Educational Maze (Larindu) (Creswell, 2013). An instrumental case study was selected because it enables an in-depth examination of a particular educational practice within a specific and bounded context. The purpose of the study was not to achieve statistical generalization but to generate a contextualized understanding of how spatially oriented learning media can support evacuation route learning in primary school environments. The unit of analysis focused on instructional practices involving Larindu within disaster education activities implemented at SD Muhammadiyah Insan Kreatif Bantul. Through this design, the study sought

to investigate how the game-based spatial learning approach contributes to strengthening students' disaster knowledge, spatial understanding, and adaptive response skills related to evacuation routes.

#### 4.2. Implementation Of The Educational Maze (Larindu)

The implementation of Larindu in disaster education was conducted through structured learning sessions integrated into classroom activities. The process consisted of three main stages: introduction, exploration, and reflection. In the introduction stage, teachers explained the basic concept of evacuation routes using the official school evacuation map. Students were introduced to key locations such as classrooms, corridors, exits, and assembly points. This stage aimed to establish initial disaster knowledge and spatial awareness.

In the exploration stage, students interacted directly with the Larindu educational maze. The maze was designed based on the actual spatial layout of the school, where pathways represented corridors and exits corresponded to the official assembly point. Students were asked to navigate the maze individually or in small groups to find the safest route to the exit. During this process, teachers introduced variations in route configurations by modifying the maze structure, such as adding obstacles or blocking certain pathways. In the reflection stage, students discussed their navigation experiences, including the strategies used, difficulties encountered, and alternative routes identified. Teachers facilitated discussions to help students connect their experiences in the maze with real evacuation scenarios. Through this structured implementation, Larindu functioned not only as a learning medium but also as a simulation tool that supports experiential and spatially oriented disaster education. The maze size, layout, and level of complexity were adjusted according to students' grade levels and learning objectives.

#### 4.3 Research Site

The research was conducted at SD Muhammadiyah Insan Kreatif (Muhika) Bantul, located in the Special Region of Yogyakarta, Indonesia. The school was purposively selected due to its geographical context and historical exposure to disaster events. Bantul Regency was significantly affected by the 2006 Yogyakarta earthquake and continues to be categorized as a region with relatively high disaster risk levels. The selection of this research site was therefore based on its relevance to the objectives of the study, particularly in

examining disaster education practices in schools located within disaster-prone environments. In addition, the school had recently updated its official evacuation map, making it an appropriate setting to analyze how students adapt to new evacuation route configurations through spatial learning activities. The study was conducted during the ongoing academic semester observation period.

#### 4.4. Participants

Research participants were selected using purposive sampling based on their direct involvement in the design, implementation, or experience of disaster education activities within the school environment. This sampling approach aimed to obtain information-rich cases that could provide diverse perspectives regarding the implementation of Larindu. The informants consisted of four main groups: the school principal (1), classroom teachers who implemented Larindu in disaster education learning activities (2), a disaster volunteer who designed the Larindu educational maze (1), and students who participated in Larindu learning sessions (6). Student participants were selected heterogeneously across grade levels and participation intensity in order to capture varied learning experiences and perspectives related to evacuation route understanding. Table 1 presents the characteristics of the study informants and the types of data obtained from each participant category. In addition, students participated in multiple Larindu sessions (3–5 sessions), each lasting approximately 30–45 minutes.

**Table 1: Characteristics of Research Informants.**

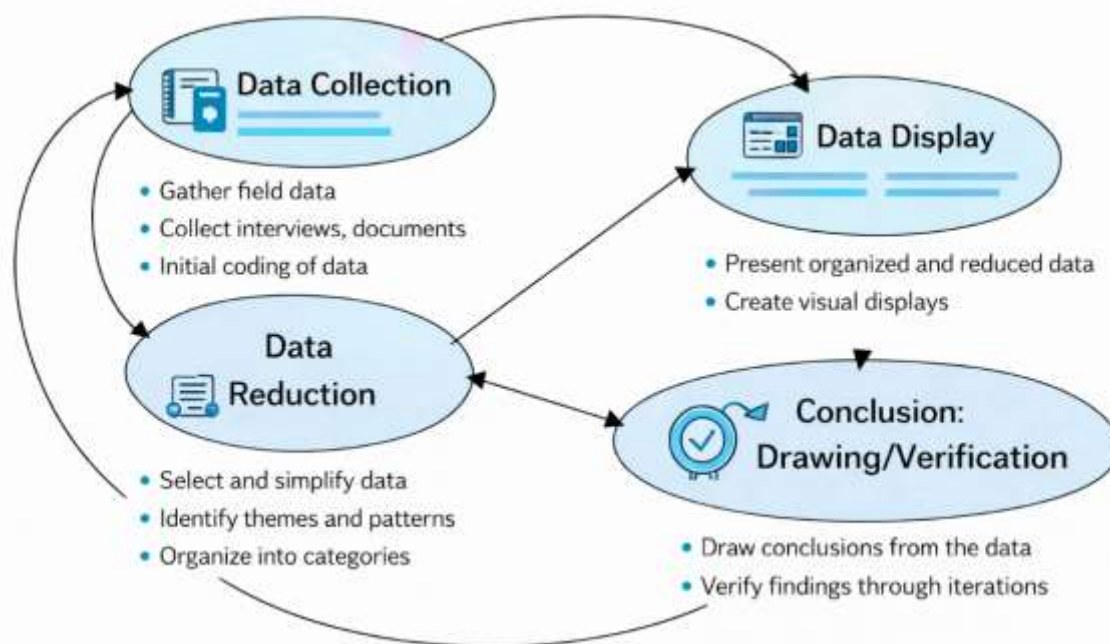
Code	Role	Number	Selection Criteria	Type of Data Obtained
I1	School Principal	1	Responsible for disaster education policy and institutional decision-making	Policy perspectives, program integration
I2-I3	Classroom Teachers	2	Implemented Larindu in classroom instruction	Instructional strategies, evaluation practices
I4	Disaster Volunteer	1	Designer and facilitator of Larindu	Technical design, pedagogical objectives
S1-S6	Students	6	Participated in Larindu	Learning experiences, evacuation

			learning sessions	route understanding
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### 4.5. Data Analysis

Data analysis in this study followed the interactive model proposed by Miles & Huberman (2014), which consists of four interconnected components: data collection, data reduction, data display, and conclusion drawing or verification. The analysis process began concurrently with data collection and continued iteratively throughout the research. During the data reduction stage, interview transcripts, observation notes, and documentary materials were carefully reviewed and organized

through thematic coding. A deductive coding approach was applied based on the three indicators of disaster education used in this study: disaster knowledge, spatial understanding, and adaptive skills. These categories served as the analytical framework for identifying patterns and relationships within the data. The coded data were then organized into matrices and descriptive analytical displays in order to facilitate comparison between different data sources. The final stage involved iterative interpretation and verification of emerging themes by repeatedly comparing the findings with the original data to ensure interpretive consistency and analytical coherence.



*Figure 3. Interactive Data Analysis Model by Miles and Huberman*  
 Source: Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative Data Analysis: A Methods Sourcebook (3rd ed.)*. Sage Publications.

### 4.6 Trustworthiness

To ensure the credibility and dependability of the findings, several strategies were applied. Source triangulation was conducted by comparing information obtained from interviews, observations, and documentary materials. This approach allowed the researchers to validate findings through multiple perspectives. Member checking was also carried out by presenting summarized interpretations of the findings to several key informants, including teachers and the game designer, in order to confirm the accuracy of the researchers' interpretations. In addition, the entire analytical process was documented in an audit trail that recorded the coding procedures, category development, and analytical

reflections during the study.

### 4.7 Ethical Considerations

The study was conducted after obtaining formal approval from the school administration. All participants were informed about the objectives of the research and their voluntary participation in the study. The confidentiality of participants' identities was maintained throughout the research process. Student participation was conducted with the permission of school authorities and in accordance with ethical research principles involving minors. All data were anonymized during the analysis and reporting stages to ensure participant protection.

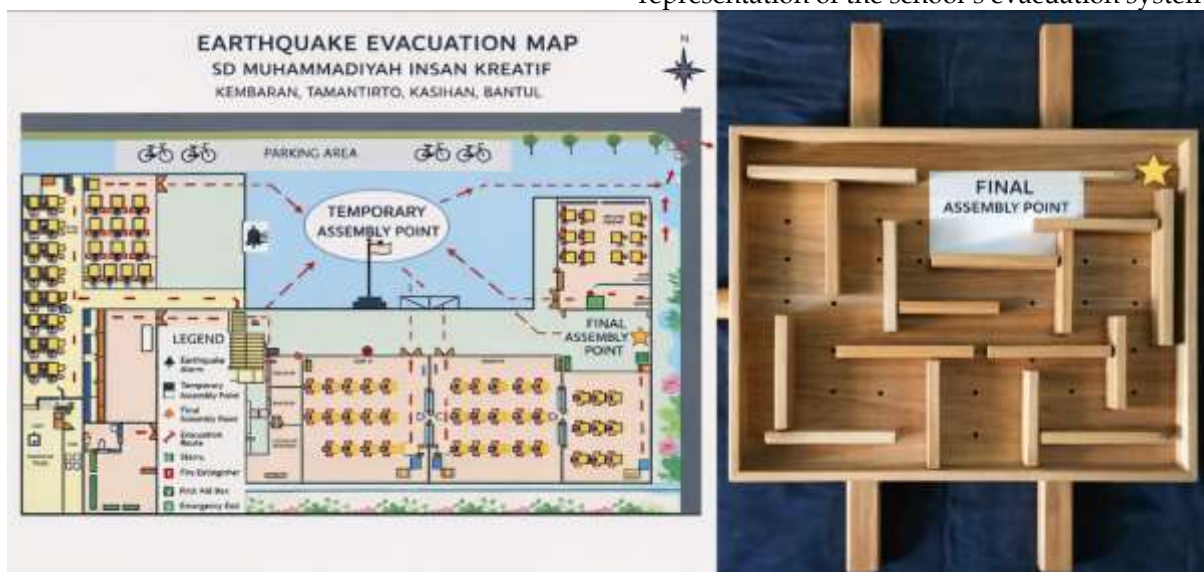
## 4.8. Results

### 4.8.1. Strengthening Disaster Knowledge

Following the revision of the school evacuation map at SD Muhammadiyah Insan Kreatif, students were required to adapt to the newly configured evacuation routes. Interview findings revealed that several students initially continued to recall the previous evacuation paths and experienced difficulties explaining alternative routes when asked spontaneously. The school principal explained that although evacuation drills and classroom explanations had been conducted, students' understanding of the spatial relationships between rooms and corridors remained limited. These

findings indicate that previously formed disaster knowledge tended to be procedural and linear rather than flexible enough to accommodate potential obstacles during emergency situations.

In response to this condition, the Educational Maze (Larindu) was designed by integrating the actual evacuation route configuration of the school into a maze-based exploratory format. According to the game designer, the exit point within the maze corresponds directly to the official assembly point indicated on the school evacuation map, while the branching pathways represent real corridors and classroom access points within the school building. Consequently, the maze does not function as an abstract game but rather as a simplified spatial representation of the school's evacuation system.



*Figure 5. Integration of the School Earthquake Evacuation Map and the Educational Maze (Larindu)*  
 Source: School documentation and researchers' design (2025).

The comparison between the evacuation map and the maze configuration illustrates how the static representation of evacuation routes was transformed into an interactive learning medium. The branching pathways and dead ends embedded in the maze simulate possible disruptions that may occur during emergency situations, such as blocked corridors or limited access points. Through repeated gameplay sessions, students were required to actively explore route options in order to reach the assembly point. Teachers reported that this activity gradually encouraged students to move beyond memorizing a single evacuation path. After several sessions, students were able to identify more than one route leading to the assembly point without relying on the printed evacuation map. This shift suggests the emergence of a more flexible understanding of route structures and spatial relationships within the school

environment.

From a theoretical perspective, these findings align with Tolman's concept of cognitive maps, which proposes that individuals construct internal representations of spatial environments through active exploration (Bouchekioua et al., 2021; Igarashi et al., 2022). Navigation within the maze environment encourages processes of spatial encoding and route rehearsal, as described in spatial knowledge acquisition theory (Ishikawa, 2023). By repeatedly evaluating route choices and navigating intersections within the maze, students begin to develop mental representations of spatial interconnections between different areas of the school. Compared with passive instruction, this interactive engagement supports stronger retention of spatial information because students are actively involved in the decision-making process.

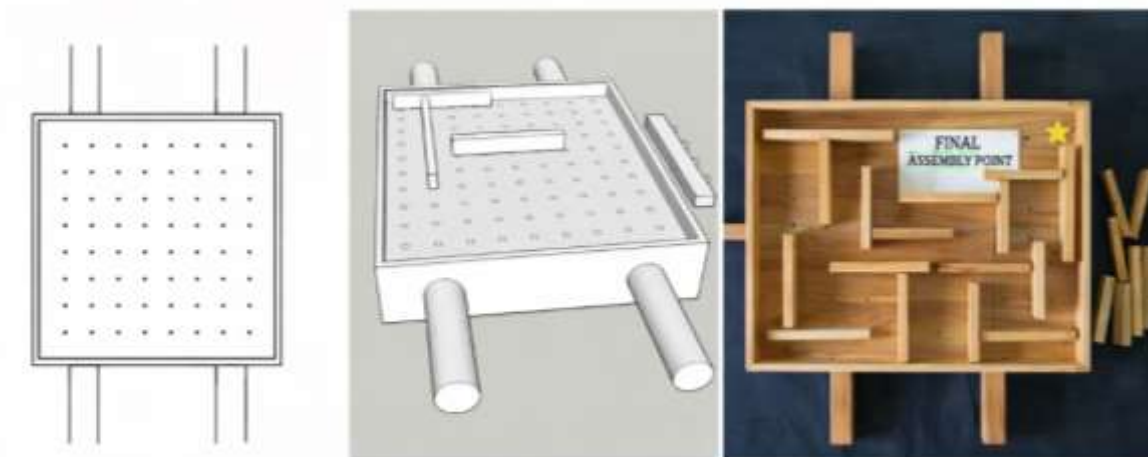
Overall, the findings indicate that Larindu contributes not only to strengthening students' disaster knowledge but also to transforming procedural route memorization into a more flexible spatial understanding of evacuation pathways. By integrating real spatial representations into a manipulable learning medium, the game extends disaster education practices beyond informational approaches toward spatial cognition-based learning experiences.

#### 4.9. Developing Spatial Understanding

While the previous indicator focused primarily on strengthening students' recognition of evacuation routes, the second indicator emphasizes the development of deeper spatial understanding of the school's structural layout. Spatial understanding in this context involves not only identifying the location of the assembly point but also comprehending the relationships between classrooms, corridors, and

possible alternative pathways. Interview data from classroom teachers indicated that after several Larindu sessions, students began demonstrating the ability to explain the reasons behind their route choices rather than simply following directional cues. Instead of relying solely on memorized paths, students increasingly referred to their understanding of spatial connections between rooms and corridors when selecting routes within the maze.

One of the key pedagogical features supporting this development lies in the pegboard-based design of Larindu. The wooden partitions that form the maze pathways can be repositioned easily, allowing the route configuration to be modified dynamically. These modifications may create dead ends, redirect pathways, or simulate obstacles that might occur during actual emergency situations. The flexibility of the maze structure enables teachers to introduce variations in spatial configurations, thereby encouraging students to explore different navigation strategies.



*Figure 6. Development Stages of the Educational Maze (Larindu) Design*  
 Source: School documentation and researchers' design (2025).

Within the framework of spatial knowledge acquisition theory, learning to navigate an environment occurs progressively through three stages: landmark knowledge, route knowledge, and survey knowledge. Through repeated engagement with varied maze configurations, students gradually transition from recognizing specific reference points to understanding sequences of pathways and, eventually, to constructing broader representations of spatial relationships within the environment (Kim et al., 2025; Mallek et al., 2024; Uz Zaman et al., 2024). This process enables students to develop orientation skills that support more flexible navigation within the school environment.

Furthermore, the modifiable structure of the maze requires students to revise previously formed spatial representations whenever route configurations change. When encountering altered pathways or unexpected dead ends, students must reassess their navigation strategies and reconsider spatial relationships between different sections of the maze. This revision process contributes to deeper spatial learning because it encourages students to actively reconstruct their mental maps rather than relying on static spatial information (Ducatti et al., 2025; Mystakidis et al., 2022).

These findings suggest that Larindu functions as a manipulable spatial learning medium that facilitates the development of relational spatial

understanding. Through repeated exploration and problem-solving within varied route configurations, students gradually construct more comprehensive mental representations of the school's spatial structure. As a result, spatial understanding is strengthened not only through memorization of routes but through active cognitive engagement with the spatial environment.

#### **4.10. Strengthening Adaptive Response Skills**

The third indicator examined in this study concerns students' adaptive skills when responding to unexpected conditions during evacuation. Adaptive skills refer to the ability to make decisions and adjust navigation strategies when encountering obstacles or disruptions within evacuation routes. Interview findings revealed that when maze configurations were altered during Larindu sessions, students did not simply stop when encountering blocked pathways. Instead, they attempted to evaluate alternative routes leading toward the exit point. Teachers observed that students increasingly demonstrated problem-solving behaviors, such as reconsidering previous path choices or discussing possible route alternatives with peers.

The modular structure of Larindu allows teachers to reconfigure pathways in ways that simulate dynamic emergency conditions. For example, certain pathways may be intentionally blocked to represent obstacles such as debris, congestion, or inaccessible corridors. Under these circumstances, students must identify alternative routes that still lead to the assembly point. This process requires students to combine spatial understanding with situational decision-making. Beyond individual navigation strategies, the gameplay environment also encourages collaborative interaction among students. Observations during Larindu sessions showed that students frequently discussed route options before making navigation decisions. These discussions often involved evaluating different pathways and predicting which direction might lead to the exit point. Such interactions demonstrate the development of collective problem-solving strategies within the learning environment (George et al., 2021; Liu et al., 2025)

From an educational perspective, these activities reflect principles of experiential learning, where knowledge and skills develop through direct experience and reflective action. When students encounter altered pathways within the maze, they engage in trial-and-error processes that require them to evaluate spatial conditions and adjust their strategies accordingly (Bouchekioua et al., 2021; Ho

et al., 2022; Ishikawa, 2023). These experiences foster cognitive flexibility and enhance students' ability to respond to situational changes. Overall, the findings demonstrate that Larindu contributes to the development of adaptive response skills by encouraging students to navigate complex spatial situations and evaluate alternative solutions. Through the combination of spatial exploration, decision-making, and collaborative interaction, the game provides learning experiences that resemble the dynamic conditions of real evacuation scenarios. Consequently, the integration of spatial learning and problem-solving within the Larindu environment supports a more comprehensive form of disaster preparedness among primary school students.

#### **4.11. DISCUSSION**

The findings of this study indicate that the integration of the Educational Maze (Larindu) into disaster education creates a progressive relationship among disaster knowledge, spatial understanding, and adaptive response skills. Rather than functioning as separate learning outcomes, these three indicators form an interconnected process through which students gradually develop preparedness competencies. Strengthening knowledge of evacuation routes serves as an initial stage that enables students to recognize the basic spatial structure of the school environment. This foundational understanding subsequently evolves into relational spatial comprehension, which then supports the development of adaptive responses when students encounter route variations or obstacles during navigation activities.

These findings reinforce the importance of spatial cognition as a critical dimension of disaster education. Traditional disaster education in schools has often emphasized procedural instructions and awareness of potential hazards. However, the results of this study demonstrate that learning experiences grounded in real spatial representations allow students to construct more flexible cognitive structures related to evacuation navigation. Processes such as mental mapping, spatial encoding, and navigational rehearsal that occur during gameplay contribute to the development of internal representations of the school environment. These cognitive processes provide a stronger basis for evacuation decision-making compared to one-directional instructional approaches.

The results are consistent with previous studies highlighting the role of experiential learning in improving disaster preparedness among students. Educational simulations and game-based learning

environments have been shown to enhance students' engagement and understanding of disaster-related knowledge (Ducatti et al., 2025; Mystakidis et al., 2022). However, many existing disaster education games primarily emphasize conceptual knowledge about disaster risks rather than explicitly training spatial navigation skills. In contrast, the Larindu educational maze integrates spatial exploration directly with the real evacuation map of the school environment. This integration enables students not only to learn about evacuation procedures but also to practice interpreting spatial layouts and identifying alternative evacuation pathways.

Another important finding of this study relates to the role of manipulable spatial environments in supporting adaptive learning. The modular design of the Larindu maze allows route configurations to be modified easily, creating opportunities for students to encounter unexpected spatial conditions. When pathways are altered or blocked, students are required to reassess navigation strategies and evaluate alternative routes. Such experiences stimulate cognitive flexibility and encourage problem-solving behaviors that are essential during real emergency situations. These findings align with spatial knowledge acquisition theory, which suggests that spatial understanding develops progressively through exploration and repeated interaction with environmental structures.

From a practical perspective, the findings suggest that disaster education in schools can benefit from the integration of contextual and spatially grounded learning media. Compared with static evacuation maps or periodic evacuation drills, the Larindu educational maze provides a more interactive and exploratory learning environment. Although technically simple, the use of a manipulable physical model allows students to engage directly with the spatial structure of their school environment. This approach may be particularly relevant for schools located in disaster-prone regions where preparedness education plays an important role in strengthening community resilience.

Conceptually, this study contributes to the disaster education literature in several ways. First, it demonstrates how spatial cognition can be integrated into disaster education practices through experiential navigation-based learning. Second, it introduces a manipulable spatial learning medium that connects real evacuation route structures with interactive educational activities. Third, it highlights the progressive relationship between disaster knowledge, spatial understanding, and adaptive response skills as a framework for developing

student preparedness. By positioning spatial cognition as a central component of disaster education, this study expands existing approaches that have primarily focused on conceptual risk awareness.

Overall, the findings suggest that integrating spatial exploration and navigation-based learning into disaster education can support a more comprehensive form of preparedness development among primary school students. Through the combination of spatial representation, experiential learning, and adaptive problem-solving, the Larindu educational maze offers a promising pedagogical approach for strengthening evacuation preparedness in school environments.

## 5. CONCLUSION

This study demonstrates that integrating the Educational Maze (Larindu) into primary school disaster education can strengthen three key dimensions of preparedness: disaster knowledge, spatial understanding, and adaptive response skills. Through navigation-based learning activities, students were not only able to recognize evacuation routes but also develop mental representations of the school's spatial structure and evaluate alternative pathways when encountering route variations. The exploratory nature of the maze-based learning environment enabled students to actively engage with spatial problems and decision-making processes that resemble real evacuation conditions.

From a theoretical perspective, this study highlights the importance of spatial cognition as a central component of disaster education for children. While disaster education in schools has traditionally focused on risk awareness and procedural knowledge, the findings suggest that spatially oriented learning experiences play a crucial role in developing adaptive preparedness capacities. By integrating principles of spatial knowledge acquisition and experiential learning, this research proposes a conceptual linkage between spatial representation, active exploration, and adaptive response development in disaster education contexts.

From a practical standpoint, the findings indicate that schools located in disaster-prone areas can strengthen preparedness education through the use of contextual and manipulable learning media. As a non-digital educational tool, the Larindu maze offers flexibility, accessibility, and adaptability to different spatial environments within schools. This approach enables teachers to simulate multiple evacuation scenarios without requiring advanced technological

infrastructure. Consequently, spatial navigation-based learning can complement conventional evacuation drills and contribute to more comprehensive preparedness education.

Nevertheless, several limitations should be acknowledged. First, the study was conducted within a single school context characterized by specific geographical conditions, which may limit the generalizability of the findings. Second, improvements in spatial understanding and adaptive skills were primarily assessed through qualitative methods, including interviews and observations, without quantitative performance measurements. Third, the relatively short implementation period prevented an examination of the long-term impact of the Larindu learning model

on students' preparedness during real emergency simulations.

Future research may expand this work by employing mixed-method approaches to quantitatively evaluate improvements in students' navigation abilities and evacuation decision-making. Comparative studies across schools with different spatial layouts may also provide broader insights into the adaptability of spatial learning models in disaster education. In addition, further research may explore the integration of digital technologies, such as augmented reality or virtual simulations, in comparison with non-digital manipulable learning media in order to evaluate their relative effectiveness in strengthening disaster preparedness among students.

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