CHAPTER I
INTRODUCTION

1.1 Research Background

In 2024, natural disasters caused an estimated USD 417 billion in damages to infrastructure and society (NCSR, 2025). Moreover, Bilak and Anzellini (2025) stated that nearly 1.2 billion people could be displaced by 2050 as a result of climate change and natural disasters. These figures highlight the urgency of strengthening disaster risk reduction (DRR) strategies to effectively address the needs of the approximately one billion people at risk of displacement.

Indonesia's circumstances are inevitably associated to its position within the range of Pacific Ring of Fire, a vast region that dominates much of its geological state. This placement of the region, is at the dynamic convergence point of three major tectonic plates the Eurasian, Indo-Australian, and Pacific creates a landscape of bizarre, yet hazardous, natural activity (Putranto et al., 2023). Consequently, the nation is constantly exposed to a spectrum of geological hazards, ranging from powerful earthquakes and devastating tsunamis to frequent landslides and explosive volcanic eruptions. The scale of these events is not solely theoretical; the National Disaster Management Agency (2025) reported a distressing 3,253 natural disasters throughout 2024, each causing a cost of significant damage and tragic loss of life.

However, the country's vulnerability is not only due to geological condition alone. It is critically magnified by a complex web of socioeconomic factors. Inherent issues like poverty, coupled with the pressures of rapid, often unplanned, urbanization and the persistence of inadequate infrastructure, create a fragile social structure that is easily fractured by disasters (Dewi et al., 2023). Managing these crises becomes an even more challenging task because of Indonesia's vast archipelagic geography and its incredibly diverse population. The 2018 earthquake and tsunami that struck Palu serve as a stark reminder of Indonesia’s complex disaster risks (Supendi et al., 2020). Similarly, regions with historically lower seismic activity, such as the Lembang Fault area in West Java, now present significant threats due to their proximity to densely populated urban centers like Bandung (Daryono et al., 2019). These cases emphasize that disaster risk is widespread and that no part of the nation can be considered entirely safe.

In essence, the Disaster Risk Reduction (DRR) initiative is a proactive framework with the objective of reducing, or even eliminating, the negative impact of disasters that have occurred (Alexander, 2020). The effective DRR implementation strategy is not only a proof of significantly increasing the budget, but also enhancing the capacity for disaster risk reduction (Deelstra & Bristow, 2023). In this effort, strengthening the community's resilience, especially by enhancing awareness and preparedness among the youth generation, is a key element (Tay et al., 2022). Because of that, education holds the central role where various research have been confirmed that the effective disaster education are capable to sharpen students' risk perception (Yildiz et al., 2024), expand their knowledge about the hazard of the nature (Cerulli et al., 2020), and finally to reinforce the student perseverance as a whole (Wang et al., 2023).

However, apart from the urgency, the implementation of disaster mitigation education in several Indonesian schools still faced various fundamental challenges. Those challenges including the lack of material integration into the curriculum, the domination of passive learning method and less encourage student involvement, the preparation of the teacher that have not adequate, and also the lack of emphasize to the development of 21st century skills such as problem solving and critical thinking (Amri et al., 2022; Mulianingsih et al., 2025). Prior studies have shown that these gaps reduce students' ability to make independent and rational decisions during real disaster situations, thereby weakening the core objective of disaster preparedness (Sibualamu et al., 2024)

To bridge this gap, the development of students' scientific literacy becomes a fundamental target, as it enables students to understand disaster phenomena, evaluate risks, and make informed decisions during emergency situations. By integrating disaster mitigation into science education, students not only gain knowledge about natural hazards but also develop critical thinking and problem-solving skills that are essential for effective disaster preparedness. Scientific literacy, which extends far beyond memorization, can be translated into the ability to comprehend scientific concepts, apply this knowledge in daily life contexts, and make decisions based on data (Bybee et al., 2009).

A significant challenge in modern education is the persistently low level of scientific literacy among students, as consistently reported by international assessments such as the PISA surveys (OECD, 2019). This gap is especially critical in disaster-prone regions, where a limited understanding of scientific information about hazards can result in low risk perception and inadequate preparedness (Paton, 2003). Addressing this issue requires a deliberate effort to facilitate scientific literacy. Scientific literacy itself is built on three interdependent core pillars. The first pillar is scientific knowledge, which refers to the fundamental comprehension of facts, concepts, and relevant theory in every learning domain. Then the second pillar is scientific competence, which includes these practical abilities to conduct scientific investigations, analyze data critically, and draw conclusions based on the data. Lastly, the third pillar is scientific context, which is the ability to connect scientific knowledge with practical problems in real life, for example, in the scenario of disaster mitigation (Bybee et al., 2009; Figueroa et al., 2018)

While real-world experience is often considered the most effective form of learning, in situations where such experience is unsafe or impossible such as during an actual earthquake simulation games can serve as a useful alternative. A simulation game is an interactive learning tool designed to imitate real-world situations in a safe virtual environment (Solinska et al., 2018). Within this setting, students can take part in decision-making and problem-solving, helping them to explore disaster scenarios, understand the related scientific concepts, and try different mitigation strategies without risk (Bai et al., 2024). Previous studies also suggest that game-based learning can increase students' motivation, support the development of critical thinking, and improve learning outcomes (Misra et al., 2022; Pang et al., 2025; Yu et al., 2021).

Several disaster simulation games have been developed globally to enhance awareness and community preparedness, especially among students. For example, is Stop Disasters! A game initiated by the United Nations Office for Disaster Risk Reduction (UNDRR). In this game, players are challenged to manage town planning and resource allocation to face various disaster scenarios, including earthquakes, floods, wildfires, tsunamis, and hurricanes.

In addition to that, there are also various other game examples with diverse focuses. FloodSim, for instance, focuses on flood risk management through policy-making (Rebolledo et al., 2009). Additionally, there is Hazagora, which is displayed in a board game format to simulate a volcanic eruption, and Earth Girl: The Natural Disaster Fighter, a role-playing game where players help implement mitigation strategies (Kerlow et al., 2012). The existence of other games such as Evacuation Challenge Game, Crossroads: Kobe, and Buzz About Dengue is making more substantial proof that the interactive simulation game can be an effective educational tool in the effort of mitigating disaster risk (Clerveaux et al., 2008).

In a simulation game, players usually take the role of a decision-maker who is responsible for protecting a virtual community, managing limited resources, and reducing possible risks. The choices they make will influence the outcomes shown in the game. These outcomes are presented through game features that highlight simple cause-and-effect, give feedback, and involve resource use, which are common elements in simulation-based learning(Aldrich, 2009).Thus, the interactive process encourages students to deeply reflect on the impact of every action they take, enabling them to build a comprehensive understanding of an effective disaster mitigation strategy (Hutama & Nakamura, 2023; Sunarharum et al., 2021).

Although interest in game-based learning is growing (e.g., Wijaya et al., 2021), only a few studies in Indonesia have looked at how simulation games can be used in disaster mitigation education and in supporting students' scientific literacy. Most of the learning tools for disaster mitigation still use passive methods such as lectures, videos, or comics (Amri et al., 2022). These methods can give information, but they do not always give enough space for students to practice interactive or higher-level thinking skills that are important in disaster situations (Mayer, 2019).

This study tries to respond to that gap. Since simulation games in other contexts have been shown to help students improve their scientific literacy (Squire, 2011), this research aims to design and test a simulation game for Indonesian junior high school students, focusing on earthquake disaster mitigation. Different from many existing games that use general global content, this game will be adjusted to the local context, which is important for meaningful learning (Vygotsky, 1978), and will highlight disasters that are most common in Indonesia.

1.2 Research Problem

Based on the background that has already been stated, the research problem of this research is "How to develop simulation games as learning media on disaster mitigation topics that facilitate students' scientific literacy?"

1.3 Research Questions

In line with the research problem, this study aims to explore the following questions:

1. How are the development stages of the simulation game that facilitates students' scientific literacy?
2. How is the validity of the simulation games in disaster mitigation topics based on expert judgment?
3. What are the students' responses to the developed simulation game on disaster mitigation that can facilitate student scientific literacy?

1.4 Research Objectives

Based on the problem formulation that will be answered in this research, the research objectives are:

1. To develop the simulation game as learning media on disaster mitigation topics that facilitates students' scientific literacy.
2. To gather expert evaluations from teachers and lecturers on the effectiveness of the simulation game in facilitating students' scientific literacy.
3. To gather student feedback on the simulation game on disaster mitigation learning that can facilitate students' scientific literacy.

1.5 Scope of Research

The media used in this study is a simulation game that can be accessed on both PCs and mobile phones. This interactive media allows students to actively engage in realistic disaster scenarios, promoting experiential learning. The study focuses on disaster mitigation, with particular emphasis on earthquakes, and aligns with the eighth-grade science curriculum. The material covers earthquake science, including its causes, effects, and strategies for reducing risks, aiming to enhance students' knowledge and awareness regarding earthquake preparedness and effective mitigation techniques.

The subjects of this research are eighth-grade junior high school students, specifically those learning about disaster mitigation with a focus on earthquakes. In addition, the study examines how the simulation game can influence students' scientific literacy. Scientific literacy is measured through students' ability to understand the principles behind disaster phenomena, apply this knowledge to take appropriate actions during emergency scenarios, and recognize the role of science in supporting disaster risk reduction efforts.

1.6 Operational Definition

To prevent misunderstandings and ensure clarity for readers, the variables involved in this research will be explained in more detail. The variables in question are:

1.6.1 The Development stages of the simulation game

The development of the simulation game in this research adopts the ADDIE framework, which is a systematic instructional design process that includes five main stages that are sequential. This process begins with Analysis, where the researcher examines the Analysis of students, target user characteristics, and learning objectives. The results from this Analysis Become the foundation for the design stages, where researchers develop a product blueprint through storyboarding and flowchart making. Moreover, during the Development stage, this blueprint will be realized as the actual product by designing and programming the simulation game until it becomes a functional prototype, after which the expert will validate the media. The prototype that has been developed will then undergo a trial in the implementation stage, where students will play the game to collect their responses. And finally, all the collected data will continue in the evaluation stage, where the expert's validation and the student's response will be analyzed comprehensively to inform the main core improvement of the final product.

1.6.2 Expert Validity

Expert judgment in this research is done by spreading a rubric in a questionnaire form that has a 5-range score with 1 being the lowest score and 5 being the highest score. The expert judgment from the lecturer is a rubric developed by the researcher that consisted of 1 to 5 score. The data obtained from the expert (lecturer) judgment were proceeded using an index Aiken validity. Teacher completed the same questionnaire distributed to lecturers, allowing for comparative expert evaluations. The expert judgment from the teacher is a rubric developed by the researcher that consisted of 1 to 5 score.The data obtained from the teacher questionnaire are also be proceeded by using an index Aiken validity. Additionally, the experts also give qualitative assessments with comments and feedback to improve the media.

1.6.3 Students Responses

Student responses in this research are a judgment towards the simulation game. Students' judgment is being used as a further recommendation for the next research that will take the same field. Students' judgment is in the form of questionnaires that contain 5 options as the answer. The five-range score of the option has 1 as the lowest score means strongly disagreeing with the specific statement given, and 5 as the highest score means strongly agreeing with the specific statement given. The 5 scale is a Likert scale that is a psychometric response scale commonly used in a survey to obtain participants' preferences or extent of agreement with the specific statement given. Likert scales represent a form of non-comparative scaling method and possess a unidimensional quality (only assessing one characteristic). Furthermore, besides quantitative data, the students also give comments and feedback to improve the media and also some of the students be interviewed to gather more data.

Scientific literacy refers to the ability to understand and apply scientific concepts and processes in everyday life, particularly in disaster-related contexts. It includes the ability to make informed decisions based on evidence, understand the natural hazards and their impacts, and apply disaster mitigation strategies. The learning content in this study will focus on disaster mitigation, particularly in the context of earthquakes. Through active interaction with this educational game, students can build a comprehensive understanding of earthquake triggers and their significant impact on society. The experience of playing the game is specifically designed to equip students with various effective strategies for disaster risk reduction and practical preparedness skills. To ensure the objectives are achieved and to perfect the game, the interaction from the students during the implementation of the game is analyzed using descriptive statistics and thematic analysis as a foundation for future improvements to the game.

1.7 Research Benefit

1.7.1 The Benefits for Students

This simulation game is designed to bring science learning from theoretical book texts and place the student directly in the middle of an earthquake disaster. The experience being offered is not a passive one; on the contrary, this game requires students to actively apply principles of disaster mitigation to overcome every challenge they encounter. In every scene, the player will be faced with choices that encourage them to think critically about the consequences of every action. This interactive process effectively bridges the gap between abstract scientific concepts and their applications in the real world, equipping individuals to take clever and effective action and build their self-safety and community resilience to face disasters.

1.7.2 The Benefits for Teachers

The results of this research will provide valuable knowledge to teachers about the potential of simulation games as a disaster mitigation learning medium. The teacher will benefit from the findings of this study as a foundation for not only integrating the game into the curriculum, but also to comprehend how the interactive virtual environment effectively facilitates student scientific literacy. Additionally, this research demonstrates how the visual element in the game can serve as a tool to simplify the explanation of complex scientific concepts, thereby creating a learning environment that is both meaningful and engaging.

1.7.3 The Benefits for Other Researchers

For other researchers, this study will provide a strong foundation. The data, findings, and limitations identified in this research can be utilized as a starting point for further exploration of the effectiveness of game-based learning in various contexts and educational stages. Additional research can be conducted to study the role of the simulation game, which is not only in the teaching of disaster mitigation but also in other topics. Moreover, this study opens up the opportunity to evaluate how the simulation game can be made broader and more profound in facilitating student scientific literacy in diverse learning situations.

1.8 Research Organization Structure

This research stems from one primary objective: to explore how the simulation game can serve as a practical tool in the disaster mitigation topic, facilitating student scientific literacy. To achieve this objective thoroughly, the discussion in this thesis is presented in a five-chapter, structured, and systematic flow. Each chapter is designed to analyze in depth various aspects of the study, including the theoretical framework, methodology, data analysis, and conclusions and recommendations related to the development of the simulation game as an educational tool for disaster mitigation.

Chapter I: Introduction

This chapter serves as a foundation for the entire study. Here, the crucial problem in society, which is the gap in students' scientific literacy about disaster mitigation topics, is explained, and the idea of the simulation game as a potential solution is introduced, bridging the gap between the problem and the solution. Based on this background, the research problem is formulated as: *How to develop simulation games as learning media on disaster mitigation topics that facilitate students' scientific literacy?*

Chapter II: Literature Review

After the problem foundation is explained, this chapter invites the reader to a deep dive into the theoretical foundation that serves as the backbone of the entire argument. This will not only summarize but also critically dissect various relevant learning theories, such as constructivism and experiential learning, to explain the pedagogical core of the simulation game. Furthermore, it will also serve as a comprehensive review of previous research to map the current state of research development, identify the research gap, and position this study within a broader academic landscape. From the synthesis of theory and scientific research, a strong conceptual framework is built as a research foundation.

Chapter III: Research Methodology

This chapter outlines the research design, where this chapter consists of the research method and design, population and sampling, operational definition, hypothesis and assumption, research instrument, data analysis, and the procedure of this research.

Chapter IV: Results and Discussion

This chapter will explain the results and discussion of the research which consist of 5 phases, which is Analysis phase, Design phase, Development phase, Implementation phase, and Evaluation phase.

Chapter V: Conclusion, Implications, and Recommendations

This final chapter summarizes the main findings of the research, emphasizing how the use of the simulation game facilitates students' scientific literacy. It provides practical recommendations for teachers on integrating simulation games into disaster education. Additionally, the chapter offers suggestions for future research on using interactive learning tools to enhance other areas of scientific literacy.