Game Based Volcanic Eruption Mitigation Tutorial

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***Abstract*—Indonesia is located in a ring of fire, where there are many volcanoes. This fact makes Indonesia must go through many disasters caused by volcanic eruptions, which caused many casualties. This reality becomes the background of this research. The objective is to produce a game based volcanic eruption disaster mitigation tutorial. The game is created as a learning tool using animated three-dimensional (3D) that resembles the real situation. The media was developed in the form of a game that tells players about the risks accepted if the player does not follow the guidelines for mitigation. The game based tutorial was developed using the unity game engine.**

***Index Terms*—Game, mitigation, tutorial, volcanic eruption.**

I. Introduction

Disaster is an event or series of events that threaten and disrupt people's lives and livelihoods. Disasters can be caused by various factors, such as natural, non-natural and human factors. Disasters affect people's lives, causing environmental damage, loss of property, and psychological impact. One form of disasters caused by volcanic activity is known as the volcanic eruptions. Danger volcanic eruptions can be either hot clouds, exploding materials (incandescent), heavy ash, lava, poisonous gases, tsunamis, and lava floods [1].

Volcanic eruptions leave a record of its own history of disasters in Indonesia. Some of the massive eruption not only have an impact in Indonesia but also in the area located on another continent. Among other strong volcanic eruption was Mount Tambora (1815), and Krakatoa (1883). Indonesia is located in the circle of volcanoes, known as the Ring of Fire with 29 active volcanoes [2].

UNISDR (United Nations. International Strategy for Disaster Reduction) mentioned that the exposure to the population or the number of people who live in areas that may lose their lives due to disaster, and the disaster risks faced by Indonesia is supremely high [2], [3].

People-centered early warning is the result of the Third International Conference on Early Warning on 27-29 March 2006 in Bonn, Germany. An early warning system is centralized to the community is a complete and effective system of interrelated elements, from knowledge of hazards and vulnerabilities, through to preparedness and capacity to respond to hazards [4].

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This research develops instructional media to give knowledge and raise awareness of people about volcanoes eruptions mitigation. The media developed is based on game based learning concept. Studies on game based learning consistently found that game based learning can impact positively on the motivation to broader knowledge acquisition and engagement [5], [6]. Instructional media developed in this research is a three dimensional (3D) media. The story on set is village on foothills area around an active volcano.

II. Game Design

Game is a structured playing, usually undertaken for enjoyment and now used as an educational tool. Simulation games simulate one aspect or reality that cannot be taught in any other way: the feelings and emotions associated with different processes. Objective of a simulation are teaches the structure and dynamics of a system: hence a more accurate version of reality, teaches decision-making skills (i.e. cooperation, interaction, problem-solving, etc), motivates: motivation should simulate the real world. Emotions should be similar to those experienced in the real world being simulated [7].

A. The Stages of the Design Process

The design process divided into three major parts: the concept stage, the elaboration stage, and the tuning stage. Each of the stages included a number of design tasks. The concept stage of game design establishes things about the game that are so fundamental, changing them later would wreak havoc on the development process because a great deal of work to be done to implement the game would have to be thrown away. This stage includes getting the concept, determining the audience, determining the player's role, and fulfilling the goals [8], [9].

B. Disaster Mitigation

The disaster risk reduction also can be called mitigation. Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. The purpose of the volcanic eruption mitigation is to develop various actions which can do to reduce victim risk, injures and disease, environmental damage, loss property, and disruption of the community's economy. Mitigation divided into two kinds. The first one is structural mitigation and the second one is non- structural mitigation. Structural mitigation are actions for manipulate the building to be able to withstand earthquake vibrations, heat clouds, and lava flows due to volcanic eruption. Structural mitigation also includes the construction of dams on rivers to anticipate the threat of cold lava flood, as well as installing a monitoring early warning and style of volcanic

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activity. Different from structural mitigation, non-structural mitigation are actions to improve community's ability for reduce risk of volcanic eruption disaster. Various kind of actions of non-structural mitigation are education and training about volcanic eruption disaster, simulation escape, how to handling victims, and others. Mitigation includes all protections from preparing adequate physical facilities, education and training for community, and gives an information and also early warning. To improve awareness, knowledge, and skills of volcanic eruption mitigation, there need do education, training, and simulation [10]. The preparedness of volcanic eruption disaster is preparedness before volcanic eruption happens, preparedness when the volcanic eruption happen, and preparedness after volcanic eruption happen [10]-[12].

III. Developing the Game Tutorial

The Volcanic Eruption Mitigation Tutorial Game developed following the pipe line diagram as in Fig. 1.

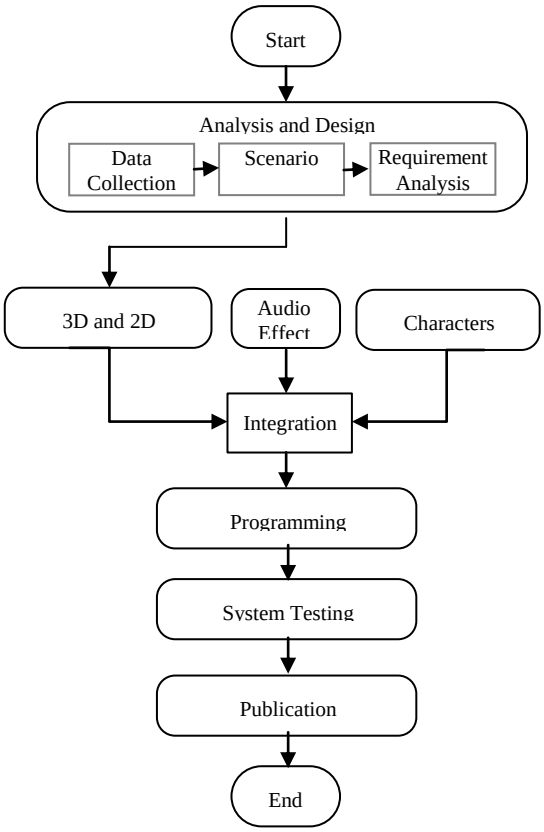


Fig. 1. General pipeline of 3D game development.

A. Game Scenario

Game Scenario made based on National disaster Management Authority (*Badan Nasional Penanggulangan Bencana*/BNPB*)* Indonesia's concept [12]. The scenario designed by considering elements of a game to be effective as a learning tool. Those elements are competitive, engagement, immediate rewards, and immediate reinforcement and feedback [5].

The game concept is about what people should do when volcanic eruption happened. The simulation game consist of two kinds of game. They are tutorial and simulation game. This paper discusses the tutorial part that supposedly gives knowledge about steps that must be done for cope with volcanic eruption disaster to the player. The player must follow all instruction. The game based tutorial must be done to get a hint in the simulation game. Table I shows the simulation tutorial points.

TABLE I: Simulation Tutorial Points, Player as Object

Components	Condition
Perspective	Player has 2 perspectives which can be change.
	3rd Person character: All player bodies show.
	1st Person character: Only hands of player show.
Pick Item	Player can pick items appropriate with quest.
Inventory	Player has inventory slot which have a function about item information that had been taken by player.
Walk and Run	Player can move around with walking or running. The standard movement of player is walking. Player can running when press left shift.
Communication with NPC	Player can communicate to NPC. A few of NPC can dialog with interaction with player.
Interaction with Object	Player can interact to objects like open the door and cupboard.

1) Story of the game

Game "Volcanic Eruption Mitigation Tutorial Game" tells the story of a 22-year-old man (player character) trying to resolve the volcano eruption disaster mitigation missions. The story about the man's efforts outlined by the following summary:

- Chapter 1, the opening of the game begins with a cutscene that tells the circumstances in the home player. His father, mother, and sister were in the living room are watching the news on television. Then player character comes out of his room to go to the family room. When a player has just stepped on to the living room, suddenly the earthquake magnitude 6-8 on the Richter scale. The player immediately rushed to his family in the living room and turned off the television. Not long after the shaking stops, family player get together and discuss the earthquake that had occurred. Then there is the extension to gather information at the village office. Players and their families go to the village office. The village head providing information on disaster-prone area maps. Hazard maps are shown to determine the direction of eruption will occur and anywhere direction evacuation shelters. Then, player should immediately seek, find, and collect items needed in volcanic disaster preparedness.
- Chapter 2, after the players managed to collect items needed, the player should look after the animal farm (cattle), herding her to place designated, but player should pick the feed first.
- Chapter 3, when the animals have been at the shelter, the sirens go off. Neighbors began to trickle out of the house. The circumstances surrounding starting to look chaotic. Then a voice command "displaced quick!" Players then towards the village head's office to meet the head of the village and follow the village head to a place of refuge.

2) Objective

Players are required to complete a given mission. If the

first mission has been fulfilled, then the next mission will appear. If all missions given in the first chapter have been successfully compeleted by the player, the next chapter then can be played.

Missions given in the game are to accomplish competitiveness element requirements of an effective game based learning. Competitiveness element is needed to provide engagement and willingness to finish the activity [5]. Chaptering the game is to provide immediate reinforcement and feedback, this also one of requirements to be an effective game [5]. Immediate rewarding is offered by allowing player able to play the next chapter.

3) Character

Player character is as a man aged 22 years, with straight black hair and brown skin.

4) Mission

The player will be faced with several missions in each chapter. The simulation area setting begins in the game players house, where players will be given a mission to find 12 items needed. In the next chapter mission is the player should walk cattle to a place suggested. Then in the next chapter mission is focused to the player evacuation as directed by the village leader. Here are missions given to each chapter along with the solution:

1. Mission Chapter 1

TABLE II: MISSION CHAPTER 1 - COLLECTING GOODS

No.	Mission	Details	Completion
1.	Talking to Dad to start your search for the goods and can proceed to the next chapter.	Speaking to father.	Having managed to speak to his father, the player has a quest to do a search of refuge goods.
2.	Looking for a bag to be able to take the next item.	Finding items: Bag	After successfully finding it, players can take the next 4 items.
3.	Looking for the next 4 items for evacuation.	Finding items: Clothing, Dried Food, Drinking Water, Drugs	After successfully finding, players can take the next 4 items.
4.	Looking for the next 4 items to evacuate.	Finding items: Nose cover (mask), Protective Glasses, Precious documents, Copy of Identification	After successfully finding, players can take another 4 items.
5.	Looking for 4 last items to evacuate.	Finding items: Flashlight, Battery of Flashlight Lighter, Note of important Phone Numbers	After successfully finding the last 4 items, then the player must speak to his father.
6.	Speaking to the Father to complete the quest.	Talk back to Dad after taking the last item.	After speaking, players are required to get to the exit door of the house.
7.	Moving toward the exit of the house.	Player goes to the door house.	After contact with the door, then chapter 1 is completed and will appear cut scene of Chapter 2.

2. Mission Chapter 2

TABLE III: MISSION CHAPTER 2 - ANIMAL RESCUE.

No.	Mission	Details	Completion
1.	Collecting fodder around the yard.	Collecting fodder available around the yard.	After collecting fodder, the next mission given.
2.	Bring cattle to the animal refuge truck.	Make animal can follow player to the truck evacuation.	After successfully bringing cattle into truck, the mission was completed and then Chapter 3 cut scene appears.

3. Mission Chapter 3.

TABLE IV: MISSION CHAPTER 3 -THE RESCUE MISSION HEADED EVACUATION

No.	Mission	Details	Completion
1.	Make the whole family follows the player to the office of the village and follow the instructions village head.	Walk from the house to the village office. Then the players met the head of the village and follow the instructions for evacuation guidance.	After arriving at the village office, a cut scene will appear.
2.	Walk village heads who were near the evacuation truck.	Players walk towards the village head that was near the evacuation truck.	After talking with the village head, cut scene appeared and 3 missions completed.

B. 3D Modeling Design

3D models that need in the game are houses and characters of main player and his family modelled by [13]. The houses modeled using SketchUp 2014. 3D models characters of main player and his family modeled using MakeHuman 1.0.2.

1) House design

Houses of the villagers are the properties required in this simulation game. It is made to describe the atmosphere in the simulation game. Houses model is to give a feel a reality of village near a mountains.

2) Main player character and his family, headman and people design

Main player character in the game is a young man has the characteristics of straight black hair and brown skin color, he looks young and simple. 3D model character of main player (Fig. 2) created using MakeHuman 1.0.2. format as seen below.

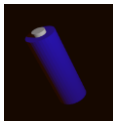
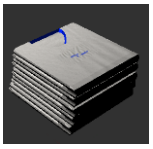
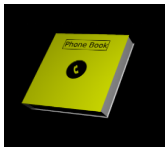
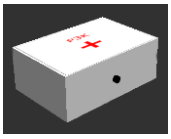
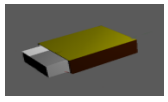
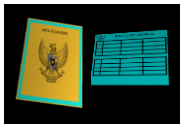
Fig. 2. Main player model.

3) Items and properties

There are 12 items required in performing evacuation designed by [14], those are: Backpack, Clothes, Snacks,

Water, Medicine, Mask, Protective Glasses, Important Documents, Copy of Identity card, Flashlights, batteries, Matches, Important Phone Numbers Notes. In this game, we add items to complete mission, those are fodder, and unnecessary items for evacuation. See Table IV, items models

TABLE V: ITEM LIST

Items	Model	Items	Model
Backpack		Batteries	
Clothes		ID	
Snack		Phone book	
Water		Fodder	
Medicine		Mask	
Protective glasses		Matches	
Important documents		Flashlight	

4) GUI design

GUI in the game is a notification that popping up as shown in Fig. 3.

Fig. 3. GUI notification.

5) NPC analysis and system design

Based on literature about bot, and dialogue system, NPC in this game is bot who can interact with player [15]. NPC interact through dialogue appear on the game screen. NPC System in this game is designed by [16]. Dialogue system use finite states based for NPC quest system, NPC talk system, and NPC waypoint system. NPC System design is behavior steps designed use finite-state based dialogue system. NPC designs are NPC quest system, NPC Talk system, and NPC waypoint system.

6) NPC quest system behavior

Fig. 4 shows the state of NPC quest system. There are 3 states of NPC quest; they are wander state, talk state, and quest state. Wander state is move slowly based on waypoints places. Talk state is animate talk direct to the player. Quest state is activating quest mode to the player. Design of NPC quest system behavior: Spend time wandering in village, When Player collision with NPC, Talk animation play, When Player accept quest, NPC give quest to Player, When Player quest reject, NPC wander in village, and When Player faraway, NPC wander in village.

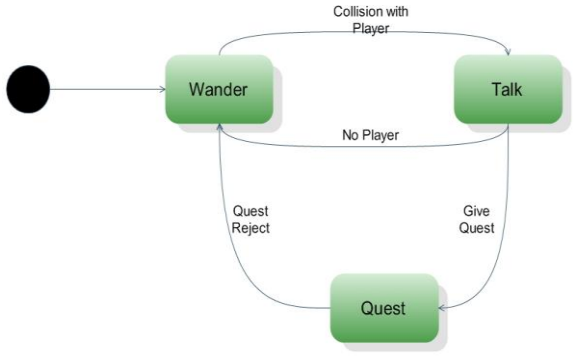


Fig. 4. Finite state based of NPC quest system behavior.

7) NPC talk system behavior

Fig. 5 shows NPC talk system state. There are 3 states, they are idle state, talk state, and question state. Idle state is idle animation when player away. Talk state is animate talk direct to the player. Question state shows questions direct to the player and must be answered. Design of NPC talk system behavior : Spend time with idle in the village or home, When Player collision with NPC, NPC's talk animation play, When NPC play talk animation, NPC give a question to Player, When Player answer NPC's question, NPC's idle animation play, and When no Player near NPC, NPC's idle animation play.

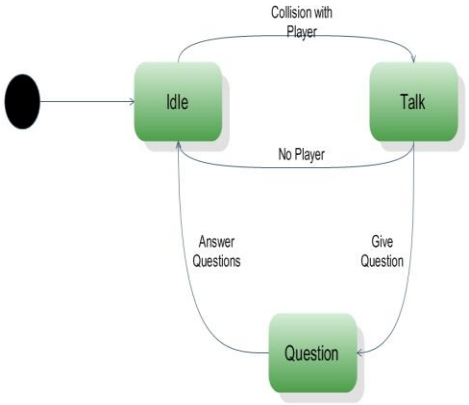


Fig. 5. Finite stated based of NPC talk system behavior.

8) NPC waypoint system behavior

Fig. 6 shows NPC waypoint system. There are 2 states of

NPC waypoint; they are wander state and idle state. Wander state is walk slowly on waypoint GameObject. Idle state is animation play direct to the player. Design of NPC Waypoint System Behavior: Wander all the time based on waypoint GameObject places, When NPC see Player, NPC play idle animation, and When no player near NPC, NPC wander.

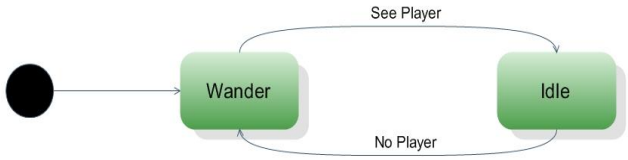


Fig. 6. Finite state based of NPC waypoint system behavior.

IV. Result Analysis

Game based of mitigation tutorial application has been tested starting with putting all elements using Unity game engine. We concluded that all 3D models, terrain, cut scenes, GUI (buttons, notifications, etc) agreed with what we expected.

The NPC Systems used black box testing model. Black box testing used some components for tested the system. There are description, expected results, actual result, and reason. Description is what function will be test in the system. Expected results are the result as designed. Actual result is result after do the test based on expected result to the system. Actual result used valid or not valid explanation. Reason is the reason why the testing results valid or not valid [17].

A. Testing of NPC Quest

There are 7 descriptions tested in NPC Quest system there are NPC Quest wandering, NPC Quest idle, NPC quest talk, NPC quest shows GUI skin of talkskin, activate the quest, GUI skin of talkskin disappear, and GUIskin of talkskin appear after quest completed. The 7 items chosen is to test whether the functions in NPC Quest can work very well or not. NPC quest wandering tested to know whether when player not around, NPC Quest wandering with walk animation. NPC Quest idle tested to know whether when player around range of view with NPC Quest the idle animation play. NPC Quest talk tested to know whether when player collide with collider the talk animation play. NPC Quest shows GUI skin of talkskin tested to know whether the talkskin will appear when player collide with NPC Quest. Activate the quest tested to know whether when player clicked first button of the first question in talkskin the quest will be activate. GUI skin of talkskin disappears tested to know whether when player clicked first button the talkskin will disappear. GUI skin of talkskin appear after quest completed tested to know whether when player have been find or do the quest, the talkskin of NPC Quest will appear again.

B. Testing of NPC Waypoint

There are 3 descriptions tested in NPC Waypoint there are NPC Waypoint wandering, NPC Waypoint walking around with walk animation, and NPC Waypoint idle. The 3 items chosen is to test whether function in NPC Waypoint work well or not. NPC Waypoint wandering tested to know whether NPC Waypoint walking around based on Cube placed, NPC Waypoint walking around with walk animation tested to know whether NPC Waypoint walking around with walk animation of not. NPC Waypoint idle tested to know whether when player collide with NPC Waypoint, the idle animation play and NPC Waypoint stop walking.

The NPC Talk works appropriate with the NPC Talk finite state design. The player can interact with NPC Talk through collider that is placed in it. The player can interact with the NPC through collider. NPC Waypoint works very well as NPC Talk and NPC Quest.

The simulation game tutorial tested in Unity game play. It can work appropriate with the designs and all elements working. But when the Unity Project of Volcanic Eruption Mitigation Simulation Game build into executable(.exe) of Windows Operating System format, the simulation game tutorial would work in the computer which have 8 GB RAM, all elements working. Start from the splash screen, main menu, and the simulation game tutorial. NPC behavior can shows all GUI skin of NPCs, give questions and quest to the player, and wandering around the village.

V. Conclusion

The game based volcanic eruption of mitigation tutorial has in conformity with the design. But of course, it is needed to be tested to the user; people who are potentially would experience a volcanoes eruption. This tutorial is a part of development of simulation game of volcanic eruption disaster mitigation. Therefore user who play the game have learned how to mitigate when eruption emerge The tutorial would be first part of the game.

This game has not involved an uncertainty element that could increase motivation and time spending learning [18]. This work will be continued with the development of the volcano eruption disaster mitigation simulation game that would apply probabilistic volcanic disaster model, and provide more options for player in order to provide user with the experiences of the situation that may encounter in the real situation. Those elements that are built here will be used as supporting equipments in the simulation game.

Acknowledgement

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