Incident and disaster response exercises for Vietnamese firefighters: Situation and solutions

A Thesis for Acquirement of the Degree of Doctor of Engineering

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by
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LIST OF ABBREVIATIONS

AAR	After-Action Report
AHP	Analytic Hierarchy Process
AVG	Average
BCP	Business Continuity Plan
CR	Consistency Ratio
DR	Disaster recovery
E	Expert
EEG	Exercise Evaluation Guides
EIA	Emergency Impact Assessment
EMP	Emergency Medical Plan
EMT	Executive Management Team
EOCs	Emergency Operations Center
FEMA	Federal Emergency Management Agency
FSE	Full-Scale Exercise
FX	Functional exercise
HFA	Hyogo Framework of Action
HSEEP	Homeland Security Exercise and Evaluation Program
IAEA	International Atomic Energy Agency
ICS	Incident Command System
IMT	Incident Management Team
IP	Improvement Plan
IPP	Integrated Preparedness Plan
ISO	International Standard Organization
MCDM	The multi-criteria decision making
MSEL	Master Scenario Events List
NIMS	National Incident Management System
OECD	The Organisation for Economic Co-operation and Development
PCs	People's Committees
SNA	Social Network Analysis
TTX	Table-top exercise
UFPF	The University of Fire Prevention and Fighting

LIST OF APPENDIXS

1. INTRODUCTION

1.1. Background

Emergency management is the managerial function charged with creating the framework within which communities reduce vulnerability to hazards and cope with disasters. [FEMA, 2007; *Principles of emergency management supplement*]. These hazards have an impact on individuals, organizations, and communities. In instances where these hazards exceed a community's capacity to manage independently, they escalate into disasters with distinct consequences. Emergency management encompasses a range of activities, including preparedness, response, mitigation, and recovery. Additionally, terms such as disaster risk reduction and prevention are frequently used. Successful emergency management necessitates a continuous program involving planning, training, equipping, and conducting exercises. The design of training and exercise programs aims to empower emergency responders and supporting organizations to respond effectively and efficiently to emergency situations. (Canton, 2007).

Exercises play a crucial role in preparedness. Engaging in exercises allows organizations, government agencies, communities, and other stakeholders to concentrate on skills enhancement, practical application, evaluation, and enhancement of their emergency management plans. These exercises are essential elements of an effective emergency preparedness program, offering valuable insights into the readiness of emergency response organizations. (International Atomic Energy Agency (IAEA), 2005).

An exercise is an event or activity, delivered through discussion or action, to develop, assess, or validate plans, policies, procedures, and capabilities that jurisdictions/organizations can use to achieve planned objectives. [HSEEP, 2020].

Exercises promote collaboration and interaction among organizations, government agencies, communities, and other stakeholders involved in emergency response. Enhancing communication among responders stands out as a significant advantage of incorporating exercises into an emergency management program (Canton, 2007, p. 119; Phelps, 2011). A thoughtfully crafted exercise offers a low-risk setting for personnel to become acquainted with their roles and responsibilities, encourage meaningful interaction and communication across various jurisdictions and organizations, evaluate and validate plans, policies, procedures, and capabilities, and pinpoint strengths and areas in need of improvement [HSEEP, 2020]. Exercises provide an opportunity for organizations and government agencies

to assess the effectiveness of their emergency management plans and find ways to improve them. In addition, the exercises also help motivate staff, volunteers and other stakeholders to perform and complete their duties in an emergency situation. From the role of exercise, it can be seen that exercise is an important part of emergency management and is considered one of the important tools to improve the ability to respond to emergency situations. Therefore, all emergency management organizations need to work on creating better exercise programs.

Vietnam is a country affected by natural disasters. An estimated 59 percent of Vietnam's total land area and 71 percent of its population were living with the risk of being exposed to extreme storm events and flooding (Chau, Holland, & Cassells, 2014). Vietnam is one of the rapidly developing socio-economic countries in Southeast Asia. Socio-economic development is often accompanied by an increase in the risk of accidents and emergencies. As construction, transportation, manufacturing, and business activities grow, so does the need for energy, resources, and materials. In addition, population growth is also one of the causes leading to an increasing number of accidents and incidents caused by humans. This creates great pressure on the infrastructure system and the environment. If not well managed and controlled, safety risks will increase, leading to accidents, emergency incidents and loss of life and property.

Amid the social and economic changes in Southeast Asia, Vietnamese firefighters' roles are expanded from fire prevention and firefighting to rescue activities in various situations. In Vietnam, fire prevention and fighting force includes 4 forces which are the police force for fire prevention, fighting and rescue (firefighters), specialized fire prevention and fighting force, grassroots fire force and civil defense force [Decree on regulation on Rescue operation by fire departments, 2017]. Fire prevention and fighting have been conducted by Vietnamese firefighters and fire prevention and fighting forces of establishments for many years, and they have obtained many achievements in fire prevention and fighting. Meanwhile, Vietnamese firefighters' roles have expanded from fire prevention and firefighting to rescue activities in various situations since 2017 according to the provisions of Decree 83/2017/ND-CP [Decree on regulation on Rescue operation by fire departments, 2017]. The scope of the rescue of Vietnamese firefighters includes the following: fire incidents and accidents; explosions accidents; incidents, accidents collapsing, falling houses, works, equipment, machines, and trees; incidents and accidents of landslides and rocks; incidents, accidents where people are trapped in houses, construction, overhead, underground, in equipment, in caves, tunnels, and underground works; road, railway, and inland waterway traffic incidents and accidents upon request; accidents of drowning in rivers,

streams, waterfalls, lakes, ponds, wells, deep holes with water, and beaches; and incidents, accidents at tourist areas, and amusement parks.

With the four on-the-spot motto in fire prevention, fighting, and rescue (on-the-spot command, on-site force, on-site equipment, and on-site logistics), Vietnamese firefighters pay great attention to the professional training of fire prevention and fighting for the fire prevention and fighting forces of establishments. Practicing fire fighting plans and practicing rescue plans are two important tasks of Vietnamese firefighters and fire prevention and fighting forces of establishments. They have maintained the practice of fire fighting plans for many years and have gained many benefits in improving their capacity in fire prevention and fighting. However, the practice of rescue plans in Vietnam is facing many difficulties and limitations. According to the provisions of Decree 83/2017/ND-CP, from 2017, firefighters and other fire forces must practice rescue plans. Therefore, not only Vietnamese firefighters but also the fire prevention, fighting, and rescue forces of establishments are facing many limitations in practicing rescue plans, namely, they cannot practice the rescue plan with emergency situations such as construction collapses, landslides, floods, chemical incidents...

This study aims to find out the causes leading to difficulties in practicing rescue plans of Vietnamese firefighters. Since then, research and develop emergency exercises to improve the rescue capacity of firefighters and other fire forces in Vietnam. The research results can be applied in practice and improve the rescue capacity for Vietnamese firefighters as well as fire prevention and fighting forces of more than 1.2 million establishments with safety requirements. In addition, the research results can also be considered and applied to countries with similar conditions to Vietnam such as Laos and Cambodia.

1.2. Problem statement

Emergency management in developing countries is frequently confronted with unique challenges arising from limited resources, skills, and infrastructure. There is a growing need for extensive research on emergency management systems in these nations to enhance their preparedness and response to disasters. It is crucial to take into account local social and cultural factors when investigating emergency management systems in developing countries, as these factors can profoundly impact the development and successful implementation of effective emergency management systems. (Rodríguez, Quarantelli, & Dynes, 2007).

Existing international studies on Vietnam's emergency management (Chau et al., 2014; Garschagen, 2016) focus on specific organizational structures of disaster risk management or flood management. Research by Ngoc Thang To & Takaaki Kato, 2018 has

focused on analyzing the characteristics and development of emergency response policies and institutions in Vietnam. An international study of emergency response exercises in Vietnam (Hoang. L. H. G & Kato. T, 2023) proposed a process to identify the necessary implementation objectives and select the appropriate implementation method to design emergency response exercise manuals and structures. There is a lack of publications that clarify the characteristics of Vietnam's emergency response exercises and the methodology for assessing Vietnam's emergency exercises.

In the field of fire prevention, fighting and rescue in Vietnam, the design and practice of fire fighting plans and rescue plans (emergency response exercises) are specified in the normative documents law [*Law on Fire Prevention and Fighting, 2001; Law on Fire Prevention and Fighting, 2013; Decree 136/2020/ND-CP; Decree 83/2017/ND-CP*]. However, these regulations are still not really complete, specifically the legal documents and the theoretical system on fire prevention, fighting and rescue of Vietnam have not specified specific forms of practice fire fighting plan, practice rescue plan. In other words, there is no clear classification of the types of emergency exercises. This has made it difficult for Vietnamese firefighters to practice fire fighting and rescue plans as well as for establishments. According to the provisions of Vietnamese law, for each establishment under its management of fire prevention, fighting and rescue, firefighters must practice rescue plans at least once a year or anytime upon request. Each establishment owner must develop a rescue plan for their establishment based on available rescue forces and equipment and organize the practice of rescue plan at least once every 2 years or when request [Decree on regulation on Rescue operation by fire departments, 2017].

According to the provisions of Article 31 of the Law on Fire Prevention and Fighting No. 27/2001/QH10 issued on June 29, 2001, Vietnamese firefighters and the fire prevention, fighting, and rescue force of establishments must practice fire fighting plans. They have been doing a good job of practicing fire fighting plans for many years. However, the scope of activities for Vietnamese firefighters was extended to the field of rescue since 2017 with the introduction of Decree 83/2017/ND-CP, which revealed limited issues in terms of training for rescue. Despite the results achieved in practicing fire fighting plans, Vietnamese firefighters cannot apply the same approach to practicing rescue plans.

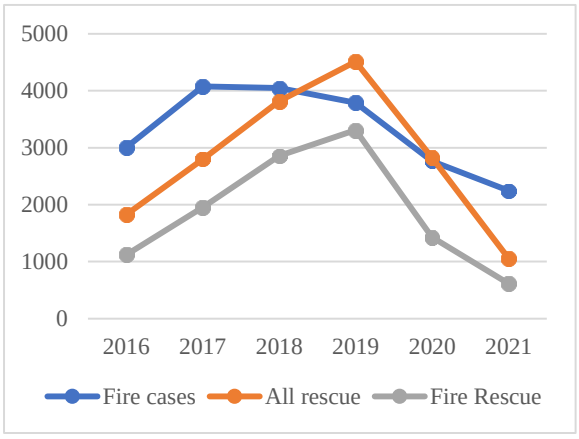
According to statistics from the Vietnam Fire and Rescue Police Department, in 2020, 10 out of 63 provincial fire services did not design a rescue plan, and up to 31 out of the total 63 provincial fire services did not practice rescue plans. In the same year, the total number of designed rescue plans was 6,395, and the total number of practiced rescue plans was 1,653.

Comparing these figures with the practice of firefighting plans, only one provincial fire service had not designed a fire plan, and one provincial fire service had not practiced their fire plan. The total number of designed fire plans was 14,989, and the total number of firefighting plans with implemented practice was 7,240. It is evident that the design and practice of rescue plans are much lower compared to fire plans. The above data indicate limitations in the practice of rescue plans for Vietnamese firefighters.

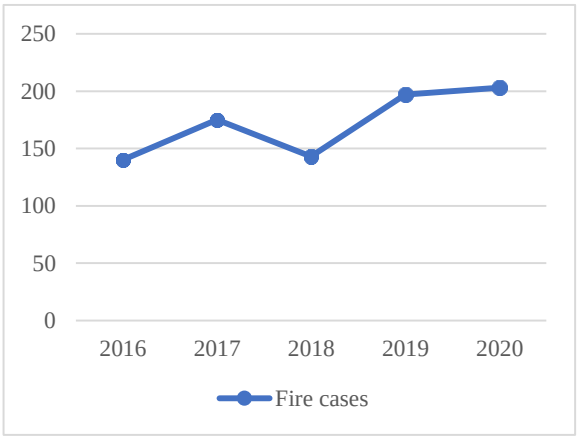
According to the law, there are two types of rescue plans: the rescue plan of the establishment and the rescue plan of the firefighter. Besides, the firefighter force is the force to propagate, guide and disseminate knowledge and laws on fire prevention, fighting and rescue to people, establishment owners and householders. Therefore, in this study, we focus on determining the causes leading to limitations of practicing rescue plans of Vietnamese firefighters. After that, the study provides solutions to help overcome the limitations in practicing rescue plans of firefighters. Once firefighters have been able to work around the limitations, they can organize dissemination and training, and help other fire forces deal with the limitations associated with rescue practice.

According to the statistics of the Fire Prevention, Fighting and Rescue Police Department, as of May 31, 2021, Vietnam has 1,201,227 establishments that need management of fire prevention, fighting and rescue. Among them, 638,409 establishments are directly managed by the Fire Prevention, Fighting and Rescue Police [Summary of work in 2016-2021, Hanoi: Vietnam Fire and Rescue Police Department, 2016-2021]. These establishments can be any factory, factory, office, hospital, school, theatre, hotel, market, shopping mall, garrison and other constructions. The establishments cover many economic, cultural, and social sectors of Vietnam. Vietnamese firefighters have the task of propagating and disseminating legal knowledge on fire prevention and fighting, and training to improve skills on fire prevention, fighting, and rescue for the fire forces of the establishment. Therefore, the difficulties that firefighters are having in designing and practicing rescue plans for the establishments are also a problem. The inability to practice rescue plans has had a significant impact on improving the fire prevention, fighting and rescue capacity of these establishments. It is very important to develop emergency response exercises to improve fire prevention, fighting and rescue capacity for Vietnamese firefighters as well as fire prevention, fighting and rescue forces of establishments. it has great significance in ensuring social security and sustainable economic development of Vietnam. However, there has not been any research to clarify the actual situation and causes leading to limitations in the design and practice of rescue exercises of Vietnamese firefighters.

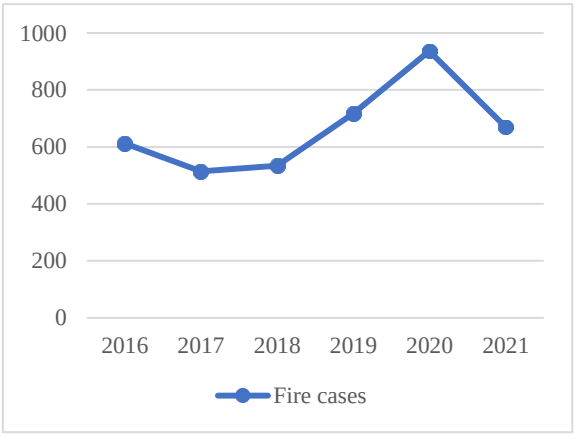
Literature on the design and practice of rescue plans in Southeast Asian countries is scarce. Especially for countries as in Laos and Cambodia that lack university training programs for firefighters The limitations in the design and practice of the current rescue plan for Vietnamese firefighters are also problems faced by Laos, Cambodia, and developing countries.



a. Vietnam



b. Laos



c. Cambodia

Fig. 1.1. Fire and rescue cases in Vietnam, Laos, and Cambodia [Summary of work in 2016-2021, Hanoi: Vietnam Fire and Rescue Police Department, 2016-2021], [Summary of work in 2016-2020, Vientiane: Laos Fire Prevention and Fighting Police Department, 2016-2020], [Summary of work in 2016-2021, Phnom Penh: Cambodia Fire Prevention and Fighting Police Department, 2016-2021].

Fig. 1.1.a. shows the trends in fire and rescue cases in Vietnam. The number of rescue cases rapidly increased before the COVID-19 pandemic period, starting in 2020. There are no rescue statistics available in Laos or Cambodia, but their fire cases show increasing trends, as shown in **Fig. 1.1.b**, suggesting an increased need for rescue activities. According to the Law on Fire Prevention and Fighting of Laos, the Lao Fire Prevention and Fighting Police Force

has not been specified in terms of rescue tasks [Lao People's Democratic Republic, (2007), *Law on Fire Prevention and Fighting*]. However, according to the decision of the Minister of Public Security on the organization and operation of the Fire Prevention and Fighting Police Department, the Laos Fire Prevention and Fighting Police Department has a Rescue Division [The Minister of Peace and Security of Lao People's Democratic Republic, (2009), *Agreement on the organization and activities of the Police Department for Prevention and Fire Prevention*]. In fact, the Lao Fire Prevention and Fighting Police Force has conducted rescue missions when incidents such as fires, motor vehicle accidents, and building collapse occur. They also integrated a rescue plan with the firefighting plan when a fire occurred. Cambodia's fire prevention, fighting, and rescue police forces have clearly defined functions and rescue missions in Cambodia's fire prevention and fighting law [Kingdom of Cambodia Nation Religion King, (2013), *Law on Fire Prevention and Fire Fighting*], [Royal Government of Cambodia, (2015), *Sub Degree on the Organization and Functions of the Ministry of the Interior*]. However, they also have the same limitations as the fire prevention, fighting, and rescue police forces of Vietnam and Laos, which also face difficulties in designing and practicing rescue plans.

For developing countries, the economic, cultural, social, and related conditions are not sufficient to develop complete firefighting and rescue mechanisms and policies. Most of them focus on prevention and response to the most frequent fire incidents. In recent years, the development of the economy, culture, and society has led to the emergence of more diverse economic, cultural, and social establishments. This has led to an increase in the number and diversity of accident and incident types. These types of incidents have different natures, characteristics, and response plans, so having a variety of exercises to suit each type of incident and accident is essential in training rescuers.

In addition, it is also important to develop a method of assessing exercises suitable to the characteristics and institutions of fire prevention, fighting and rescue training. Therefore, in parallel with the development of the exercises, the development of appropriate assessment methods for the exercises should also be focused.

Emergency response exercises are common training activities for emergency responders in developed countries such as the United States and Japan, but there are only a few examples of these exercises being used in developing country. In Vietnam, information, knowledge and publications on emergency response exercises are still limited.

Methods and tools to evaluate the exercises for better disaster preparedness are still under development. In Vietnam, firefighters will have a hot debriefing session right after

practicing fire fighting plans. The organizer of the practice of the fire fighting plan will conduct an assessment of the activities performed by the forces participating in the practice of the fire fighting plan. The comments are made based on the subjective qualitative assessment of the internship organizer. The assessment methods have not been specified in the legal documents on fire prevention, fighting and rescue of Vietnam. This may lead to the fact that the fire fighting plan may not be effective, the activities of the forces participating in the practice of the fire fighting plan may have been underestimated. "lack of detail information on evaluation methods and exercise results. Subjective comments by leaders are normally in Vietnamese emergency exercise program" [To Ngoc Thang, 2019]. In emergency medical operations, an unevaluated or inadequately evaluated plan and exercise may do more harm because it leads to underestimated risk and poor performance in actual emergencies [Gebbie, K.M. et al, 2006]. In addition to researching and providing solutions to improve the practice of rescue plans for Vietnamese firefighters, the development of an effective assessment method suitable for the characteristics of Vietnamese firefighters' training programs is very necessary.

Some methods have recently been developed for evaluating performance during exercises. The Exercise Evaluation Guide (EEG) is a consistent tool to evaluate trainees' performance and rate their achievements in a target rating system [HSEEP, 2020]. Another evaluation instrument for public health emergency preparedness exercises, developed by the Harvard School of Public Health, consists of a combination of action checklists, subjective scoring, and subjective comments. The list common instruments to measure performance during exercises, including checklists, scores, and open-ended questions [Savoia et al, 2014]. A study has developed time-based functional exercise assessment methods. Player feedback actions are recorded, exercise results are evaluated based on the time to complete the response actions [N. T. To et al, 2019], [Kato, T. et al, 2016. *Quantitative evaluation of organized disaster response capacity through functional exercises*]. Increasing knowledge was one of the goals of the emergency exercise participants, but there was a lack of hierarchy in the knowledge levels of the participants.

Exercises are a key component within an emergency management program. The Homeland Security Exercise and Evaluation Program (HSEEP, 2020) provides a set of guiding principles for an exercise program. The HSEEP exercise cycle specifies four elements, which include Exercise Design, Conduct, Evaluation, and Improvement Planning. This cycle is similar to the continuous improvement cycle (PDCA cycle), that emphasizes improvements after evaluating results of any program. Currently, the rescue plans of Vietnamese firefighters also lack continuous improvement programs. More specifically, there

is a lack of methods to identify the content that needs improvement. Therefore, in addition to finding solutions to improve the ability to practice rescue plans and developing assessment methods, Vietnamese firefighters also need a method of selecting the content to be improved for the next exercises.

There are four problems that have been discovered and need to be studied in this thesis:

1. Lack of literature review of the firefighters' emergency response exercise
2. Lack of assessment of the current situation and solutions for rescue exercises of Vietnamese firefighters
3. Limitations in assessing the knowledge level of functional exercise participants
4. Lack of assessment of exercise content that needs improvement to develop the next exercise

1.3. Research questions and objectives

Three main research questions are investigated in this study.

1. How is the practice of the rescue plan conducted in Vietnam?
2. What is the cause of the limitation in the practice of rescue plans?
3. What are the innovative solutions to improve the ability of firefighters to practice rescue plans?

The objectives for this research are as follows:

A. Review the literature of the firefighters' emergency response exercise.

A1. Review the theoretical basis, legal basis and previous studies on rescue plans and practice of rescue plans of Vietnamese firefighters to have an overview of the problem.

A2. Compare an overview of Vietnamese firefighters' exercise with official US exercise documents to uncover issues that need research

Based on this review, the three research questions are specified.

B. To answer the three questions, the current situation, and solutions for rescue exercises of Vietnamese firefighters are investigated.

B1. Determining how to practice the rescue plans of Vietnamese firefighters

B2. Identify the limitations and the causes of these limitations in the practice of rescue plans by Vietnamese firefighters.

B3. Propose the solutions to overcome the limitations in the practice of rescue plans of Vietnamese firefighters.

C. To answer the third question, a new method for evaluating functional exercises is developed.

C1. Apply Bloom's taxonomy to assess the increase in knowledge of the participants in the functional exercise, and shows what is identified by this evaluation methods.

C2. Apply both professional and general sets of evaluation criteria to a firefighter training program, which consists of lectures and an exercise, and shows what is identified by each set of criteria.

C3. Propose ways to effectively use these different criteria to improve firefighter education.

D. To further elaborate answers to the third research question, post-injects response actions for functional exercises are evaluated based on expert assessments.

D1. Use an analytic hierarchical process to determine the content to be improved for the next exercise based on evaluation criteria identified as types of response actions taken in the functional exercise on landslide response at UFPF.

D2. Analyze the similarities and differences in criteria weights of the action types and alternatives across the different disaster types such as landslide, wildfire, and flash flood.

D3. Propose methods to improve functional exercises for Vietnamese rescue professionals.

1.4. Definition of terms

These definitions are according to the International Organization for Standardization, ISO 22300, *Societal Security -Terminology*, 2012.

- Disaster: situation where widespread human, material, economic or environmental losses have occurred which exceeded the ability of the affected organization, community or society to respond and recover using its own resources.

- Hazard: source of potential harm or can be a risk source.

- Incident: situation that might be, or could lead to, a disruption, loss, emergency or crisis.

- Scenario: pre-planned storyline that drives an exercise; the stimuli used to achieve exercise objectives.

- Inject: scripted piece of information inserted into the exercise and designed to elicit a response or decision and facilitate the flow of the exercise.

These definitions are according to the Glossary of FEMA training:

- Communication: A section of the basic plan that refers to the internal and external strategies and tools to communicate with stakeholders in the event of an emergency or incident.

- Coordinate: To advance an analysis and exchange of information systematically among principals who have or may have a need to know certain information to carry out specific incident management responsibilities.

- Exercise: An instrument to train for, assess, practice, and improve performance in prevention, protection, response, and recovery capabilities in a risk-free environment. Exercises can be used for: testing and validating policies, plans, procedures, training, equipment, and inter-agency agreements; clarifying and training personnel in roles and responsibilities; improving interagency coordination and communications; identifying gaps in resources; improving individual performance; and identifying opportunities for improvement.

- Tabletop Exercise (TTX): A discussion-based exercise in response to a scenario, intended to generate a dialogue of various issues to facilitate a conceptual understanding, identify strengths and areas for improvement, and/or achieve changes in perceptions about plans, policies, or procedures

- Drill: An operations-based exercise often employed to validate a single operation or function.

- Functional Exercise (FE): An operations-based exercise is designed to test and evaluate capabilities and functions while in a realistic, real-time environment; however, movement of resources is usually simulated.

- Full-Scale Exercise (FSE): An operations-based exercise that is typically the most complex and resource-intensive of the exercise types and often involves multiple agencies, jurisdictions/organizations, and real-time movement of resources.

These definitions are according to the provisions of Decree 83/2017/ND-CP:

- Rescue" refers to an act of saving victims, vehicles and properties from any danger caused by emergencies or emergency situations, including: Detect, locate, open ways to access to the victims, vehicles and properties in danger, arrange vehicles, tools and rescue forces; identify, prevent and eliminate factors threatening the safety of vehicles, properties, lives and health of the victims and the relief and rescue forces; remove the victims, vehicles and properties from a dangerous location and other measures to bring the victims, vehicles and properties to a safe location

- "Emergency" of "emergency situation" refers to any event caused by the nature, human beings or animals which may violate or threaten life and health of people and destroy, damage or threaten safety of vehicles and properties.

- “Emergency prevention” refers to activities that eliminate causes and conditions that lead to emergencies or emergency situations, including: Propagate, disseminate and educate law and skills to prevent and escape; evaluate, appraise and inspect the requirements for ensuring the safety of people, vehicles, equipment and properties of houses, works, vehicles and equipment; monitor, supervise, test, inspect and handle violations related to assurance of safety, prevent and respond to emergencies; establish schemes, plans and organize rescue drills; provide training and professional training on rescue.

- “Establishment” refers to any factory, plants, working office, hospital, school, theater, hotel, market, shopping mall, garrison and other construction works.

- A rescue plan is a professional document used by a rescue commander in training, standing ready to rescue and organizing activities to save people and property from dangerous factors at the scene of an accident. The plan clearly shows the characteristics of the establishment and area related to the rescue work, anticipates possible incident and accident situations, thereby proposes methods, measures, techniques, tactics and rescue sequence appropriate to each situation [Thuy, V.V & Tien, P.V, (2017). *Textbook of Basics of Rescue*].

- Practicing rescue plans is a form of comprehensive training of officers and soldiers at the highest level, synthesizing basic movements, individual techniques, coordinated formations, tactical skills, ability to guide Command and control all combat activities of rescue officers and soldiers in a specific situation of incident or accident [Thuy, V.V & Tien, P.V, 2017].

1.5. Chapter plan

This dissertation is divided into 6 chapters:

Chapter 1 contains a description of the background research topic and issues. The main content of this chapter: the research problems and research objectives.

Chapter 2. Literature review of firefighters' emergency response exercises. Chapter 2 aims to address the objectives (A1), and (A2).

Chapter 3. Limitations and solutions of the current rescue exercise of Vietnamese firefighters. Chapter 3 aims to address the objectives (B1), (B2) and (B3)

Chapter 4. Developing a method of evaluating functional exercises applying Bloom's taxonomy. Chapter 4 addresses objectives (C1), (C2) and (C3).

Chapter 5 Developing the functional exercises based on expert assessments of the types of post-injects response actions. Chapter 5 addresses objectives (D1), (D2), and (D3).

And Chapter 6 contains conclusion and recommendation for future studies and policy makers.

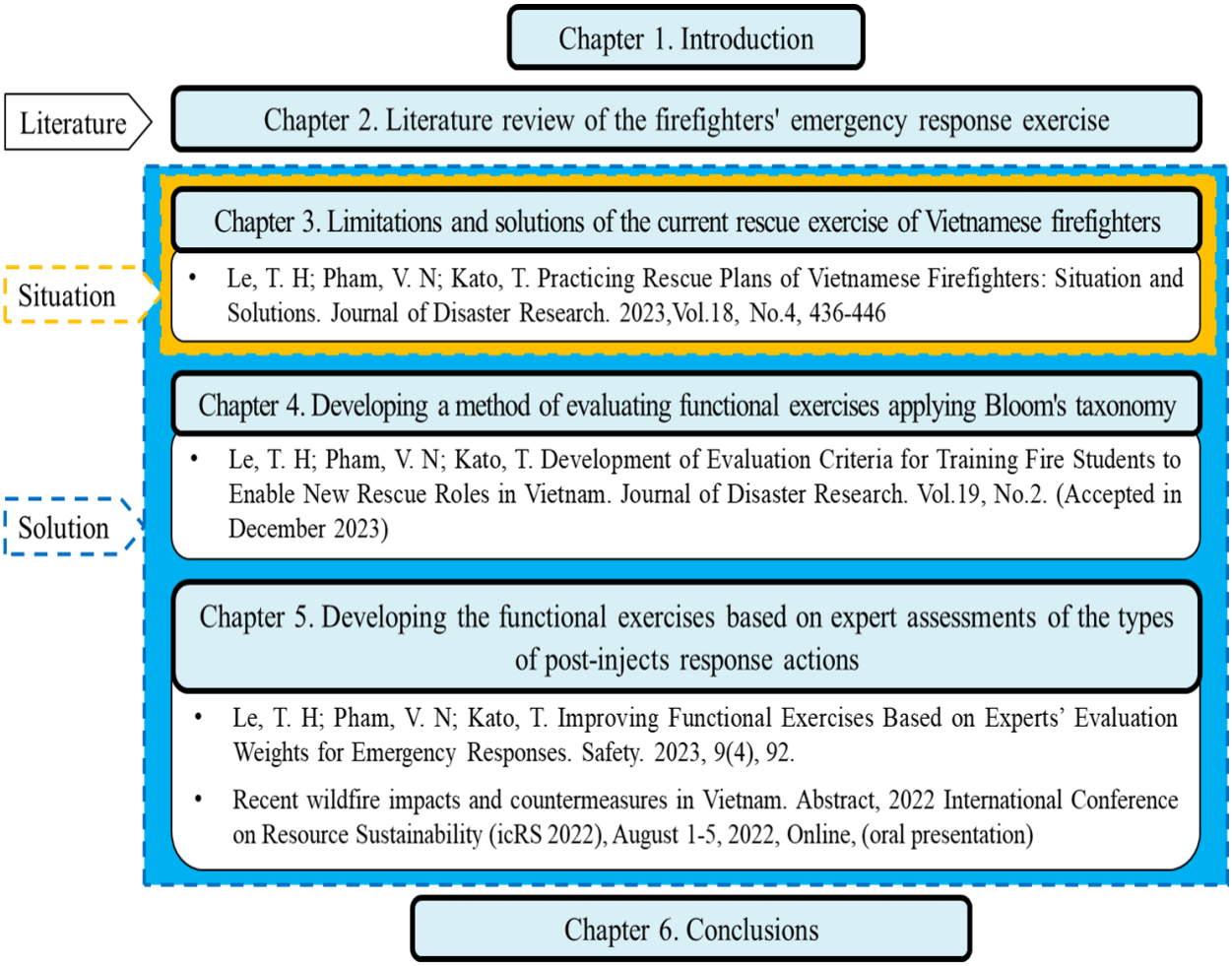


Fig. 1.2. Outline of Dissertation

The outline diagram of the dissertation is shown in Figure 1-2.

2. Literature review of the firefighters' emergency response exercise

2.1. Introduction

Chapter 2 will provide an overview of the exercises of Vietnamese firefighters. First, to understand the overview of the exercises of Vietnamese firefighters, it is necessary to clarify the legal and theoretical basis related to the exercises of Vietnamese firefighters. The content related to the legal basis is the content that firefighters and other subjects are required by Vietnamese law to do. It can be seen that the legal basis plays a very important role in the implementation of exercises by Vietnamese firefighters as well as other subjects in accordance with the law.

Theoretical foundations related to the exercises of Vietnamese firefighters also provide important contents such as clarification of concepts, explanation of terms, overview of training programs, scientific theoretical system, etc. Current Vietnamese studies on the exercises of Vietnamese firefighters. As explained in Chapter 1 regarding the terms "exercise" and "rescue plan" used by the Vietnamese firefighters, Chapter 2 contains numerous contents that we have quoted from textbooks, materials, and legal documents of Vietnam. Therefore, to ensure the accuracy of the quoted content, we will still use the term "rescue plan" for these contents.

Besides, chapter 2 also provides the theoretical basis related to the exercises of the United States. The author also reviews previous studies related to the exercise of Vietnamese firefighters. It is necessary to compare the theoretical basis of Vietnam's exercises with those of other countries in terms of problem identification and solutions to address the limitations of Vietnam's exercises.

Determining the relationship between limitations in the design and practice of firefighters' exercises today and the legal and theoretical foundations is a key issue to find the approach and solution research problem.

2.2 Method

2.2.1. Research Approach

To conduct a systematic study on the exercises of Vietnamese firefighters, we applied the method of document research. Specifically, we approached the system of textbooks, documents, and training programs of the University of Fire Prevention and Fighting, Vietnam, to clarify the theoretical basis of Vietnamese firefighters' exercises. The University of Fire Prevention and Fighting is the only educational institution in Vietnam that provides

professional training and retraining in fire prevention, fighting, and rescue for Vietnamese firefighters. It is also the sole scientific research center in the field of fire prevention, fighting, and rescue in Vietnam. We examined Vietnamese legal documents related to firefighters' exercises to determine the legal basis for such exercises. In addition, we also review previous studies on Vietnamese exercises such as the doctoral thesis "Enhancing communication among emergency responders by developing exercise programs in Vietnam" by To Ngoc Thang (2019); research "Use of analytic hierarchy process and four-component instructional design for improving emergency response exercises" by Hoang, Le Hong Giang and Kato, Takaaki was published in the International Journal of Disaster Risk Reduction in 2023. We focus on research on key contents such as: Concepts, classification of exercises; characteristics of the design of exercises and conduct of exercises; purpose and requirements of the exercise. Afterward, we applied methods of analysis, statistics, and theory synthesis. Based on the study of legal documents, textbooks, various documents, and theories concerning the exercises of Vietnamese firefighters, we analyzed them in sections to gain a deeper understanding. We synthesized the analyzed information to create a comprehensive and profound new theoretical system regarding the exercises of Vietnamese firefighters.

To identify problems in the system of legal and theoretical bases related to the exercises of Vietnamese firefighters, we needed a reference frame for comparison. Therefore, we reviewed several official documents on emergency management exercises from the US to establish a frame of reference. We employed the literature review method to clarify the rationale for emergency management exercises in the US. Subsequently, we used the comparative method to compare the theoretical system of Vietnamese firefighters' exercises with the reference frame in order to identify issues in the theoretical and legal basis related to the training exercises of Vietnamese firefighters.

2.2.2. Data collection

I am a teacher in the Faculty of Rescue at the University of Fire Prevention and Fighting, Vietnam. Therefore, it is very convenient for me to access the system of textbooks, teaching materials, and training programs related to the exercises of Vietnamese firefighters. Firefighter exercises are part of the curriculum in the Faculty of Rescue. Textbooks and instructional materials on firefighter exercises have been compiled by several teachers from the Faculty of Rescue. Hence, I can directly review and synthesize the theoretical basis of Vietnamese firefighters' exercises in a complete and accurate manner. The legal basis for the exercises was reviewed by us online and accessed from the Vietnamese government portal.

Since some Vietnamese legal documents are not available in English, we conducted searches in both Vietnamese and English.

We directly contacted the authors To Ngoc Thang and Hoang Le Hoang Giang to request permission to access and collect their doctoral theses and research.

To gather the rationale for emergency management exercises in the United States, we accessed the official portal of the Federal Emergency Management Agency (FEMA). Here, we conducted a search using the keyword "exercises" and learned that FEMA supports the nation's exercise activities through two programs administered by the National Exercise Division: the National Exercise Program (NEP) and the Homeland Security Exercise and Evaluation Program (HSEEP). NEP consists of a two-year cycle of exercises across the nation that examine and validate capabilities in all preparedness mission areas, guided by strategic priorities set by the National Security Council's Principals Committee. Provides design, development, conduct, and evaluation support for individual exercises to state, local, tribal, territorial, and other whole community partners. Coordinates exercise activities among federal interagency partners. HSEEP provides a set of guidance that any organization can use to structure an effective exercise and evaluation program with a common approach to program management, design and development, conduct, evaluation, and improvement planning. We collected the HSEEP and thoroughly reviewed this set of guidance. In addition, we also reviewed two books on emergency management exercises: Emergency Management Exercises: From response to recovery everything you need to know to design a great exercise by Regina Phelps; Exercise Alternative for Training Emergency Management Command Center Staffs by Walter G. Green III, Ph.D., CEM.

2.3. Results and Discussion

2.3.1. Theoretical basis of exercises of Vietnamese firefighters

2.3.1.1. Concepts and classifications of exercises of Vietnamese firefighters

a) Concepts

According to Textbook of Basic Rescue, the concept of a rescue plan is understood as follows:

"A rescue plan is a professional document used by a rescue commander in training, standing ready to rescue and organizing activities to save people and property from dangerous factors at the scene of an accident. The plan clearly shows the characteristics of the establishment and area related to the rescue work, anticipates possible incident and accident situations, thereby proposes methods, measures, techniques, tactics and rescue sequence appropriate to each situation." [Thuy, V.V & Tien, P.V, (2017). *Textbook of Basics of Rescue*]

b) Classification of exercises

- Classification by subject of management:

+ The firefighter's rescue plan.

+ The establishment's rescue plan.

According to the classification, there will be 2 types of exercises. Exercises designed and conducted by firefighters and exercises designed and conducted by the owner of the establishment. In this study, the author focuses on research related to the exercises of Vietnamese firefighters.

"- Classification according to incident and accident situations:

Depending on the accident situation, there will be rescue plans corresponding to those situations:

+ Plans for rescue of traffic accidents;

+ Rescue plan in case of fire and explosion incidents;

+ Rescue plan in case of underwater incidents or accidents;

+ Rescue plan when the work collapses;

+ Rescue plan for chemical incidents and chemical facilities etc." [Thuy, V.V & Tien, P.V, (2017). *Textbook of Basics of Rescue*]

The above incident situations are determined from Clause 1, Article 5 of Decree 83/2017/ND-CP.

"Article 5. Scope of operation of rescue by fire departments

1. The fire department shall perform rescue operations on the following emergencies and emergency situations:

a) Conflagration;

b) Explosion;

c) Collapse of houses, construction works, equipment, machines and trees;

d) Land slide;

dd) People entrapped in houses; construction works; on a high place, in the depth; in equipment; caves, tunnels; underground construction works;

e) Traffic emergency situations and emergencies on roads, railways and inland waterways if requested;

g) Drowning in rivers, streams, waterfalls, lakes, ponds, wells, water holes, beaches;

h) Emergency situations and emergencies at tourist areas and recreation parks;

i) Other emergency situations and emergencies according to law provisions." [Decree on regulation on Rescue operation by fire departments, 2017]

According to this classification, there will be 9 types of exercises corresponding to 9 types of incident and accident situations.

2.3.1.2. Purpose and requirements of exercises of Vietnamese firefighters

a) Purpose of exercises of Vietnamese firefighter

"- The rescue plan is a legal document that demonstrates the sense of responsibility of the firefighting force in rescue operations in general and in organizing standby rescue operations in particular.

- The rescue plan helps officers and soldiers of the firefighting force understand the relevant characteristics of rescue operations, assess and anticipate potential incident scenarios and accidents that may occur at the establishments, thereby proactively implementing appropriate rescue measures and methods.

- Through studying and practicing the rescue plan, officers, soldiers, and rescue commanders can enhance their professional competence in rescue operations, including techniques, tactics, methods, and rescue measures." [Thuy, V.V & Tien, P.V, (2017). *Textbook of Basics of Rescue*]

b) Requirements of exercises of Vietnamese firefighter

According to Clause 1, Article 9 of Decree 83/2017/ND-CP, the requirements of the exercise of Vietnamese firefighter are specified as follows:

"1. The rescue plans must ensure the following basic requirements and contents:

a) Specify the nature and characteristics of danger when emergencies, emergency situations occur and requirements related to rescue operations;

b) Construct the worst-case scenario and some typical scenarios of emergency situations, emergencies and their development rates;

c) Formulate a plan for mobilizing forces, vehicles, cooperation, technical measures, rescue tactics and rescue tasks suitable for each stage of the emergency situation or emergency." [Decree on regulation on Rescue operation by fire departments, 2017]

In addition to the above requirements, according to Textbook of Basics of Rescue, the exercises of Vietnamese firefighters also need to ensure the following requirements:

"- The rescue plan must be developed in accordance with the prescribed template for each type of plan.

- The rescue plan must be promptly supplemented and revised when there are changes in the nature, characteristics of potential incidents or accidents, and conditions related to rescue operations.

- Agencies and organizations with personnel and equipment involved in the rescue plan must disseminate relevant information about their responsibilities.

- The rescue plan must be approved by competent authorities.

* The rescue plan must ensure the following characteristics:

- Legal compliance:

The rescue plan must meet the requirements and provisions stipulated in Article 9 of Decree No. 83/2017/ND-CP dated July 18, 2017. Additionally, the rescue plan must be developed according to the prescribed templates in Appendices 04 and 05 accompanying Decree No. 83/2017/ND-CP. Furthermore, the rescue plan must undergo the proper approval procedures as defined by the law. Hence, the rescue plan has legal significance.

- Scientific nature:

The rescue plan must demonstrate scientific rigor and adherence to the proper process. It should include calculations and anticipations of the necessary personnel and equipment to effectively rescue individuals and safeguard property in accordance with specific incident scenarios and accidents that may occur at the establishments. Moreover, it should provide appropriate rescue methods, measures, techniques, and tactics.

- Practicality:

The rescue plan should reflect the characteristics of the relevant establishment concerning rescue operations. It should address incident scenarios and accidents closely aligned with the actual conditions of the establishment, particularly through evaluating the hazardous nature and relevant characteristics related to rescue operations. Based on this, the plan should define and develop the most complex incident scenarios and accidents, as well as propose appropriate rescue measures, techniques, and tactics.

In practice, during rescue operations for incidents and accidents at facilities within the firefighting jurisdiction, the rescue commander can study the rescue plan to gain a better understanding of the establishment's characteristics. This allows for better anticipation of the incident's further development and the application of proposed rescue measures, techniques, and tactics at the incident site effectively.

- Combat readiness:

The rescue plan specifies the necessary personnel and equipment to handle potential incident scenarios and accidents at the establishment. It also outlines appropriate rescue methods and measures. Consequently, it empowers firefighters to proactively engage in rescue operations when incidents and accidents occur at establishments within their jurisdiction.” [Thuy, V.V & Tien, P.V, (2017). *Textbook of Basics of Rescue*]

2.3.1.3. Legal basis of the exercise of Vietnamese firefighters.

The legal basis for the exercises of Vietnamese firefighters is stipulated in Article 9 of Decree No. 83/2017/ND-CP. Specifically:

"Article 9. Rescue drills by fire departments

1. The rescue plans must ensure the following basic requirements and contents:

a) Specify the nature and characteristics of danger when emergencies, emergency situations occur and requirements related to rescue operations;

b) Construct the worst-case scenario and some typical scenarios of emergency situations, emergencies and their development rates;

c) Formulate a plan for mobilizing forces, vehicles, cooperation, technical measures, rescue tactics and rescue tasks suitable for each stage of the emergency situation or emergency.

2. Formulation of rescue plans

Rescue plan shall include the following basic contents:

a) Prepare human forces for rescue operations;

b) Prepare vehicles and equipment for rescue in accordance with the characteristics of agencies, organizations, establishments and localities;

c) Assign tasks and cooperating mechanism to cope with emergencies and emergency situations likely to occur;

d) Funding for rescue operations;

dd) Inspect and urge the organization of implementation.

3. Responsibilities for formulating rescue plans

a) Chairperson of People's Committees of communes, heads of establishments shall organize and monitor the formulation of rescue plans under their management in cases specified in Clause 1 Article 13 hereof (establishment's rescue plans);

b) The Fire and Rescue Police Agency shall organize and monitor the formulation of rescue plans in cases specified in Clause 2 Article 13 hereof (rescue plans of the Fire and Rescue Police Agency).

4. The plans for rescue shall be supplemented and amended in a timely manner when there are changes in the characteristics and nature of the emergency situations, emergencies likely to occur and the requirements related to rescue operations.

5. The plans for rescue formulated in accordance with Point a Clause 3 this Article shall be stored and made a copy to send to the Fire and Rescue Police Agency; the plans for

rescue formulated in accordance with Point b Clause 3 this Article shall be managed at the Fire and Rescue Police Agency.

6. The order and responsibilities for organizing the rescue drills

a) The rescue plan formulated in accordance with Point a Clause 3 this Article shall be practiced at least once every two years and irregular rescue drills shall be conducted on request;

b) The rescue plan formulated in accordance with Point b Clause 3 this Article shall be practiced at least once per year and irregular rescue drills shall be conducted on request;

c) Heads of agencies, organizations, establishments, Chairpersons of the People's Committees of communes shall organize the rescue drills under their management;

d) The Head of the Fire and Rescue Police Agency shall organize the rescue drills under his/her management.

7. The Fire and Rescue Police Agency shall provide instructions, inspect and urge the formulation and performance of rescue drills.

8. Authority to approve the plan for rescue

a) Heads of establishments and Chairpersons of the People's Committees of communes shall approve the establishment's rescue plans;

b) Regarding the plan for rescue of the Fire and Rescue Police agency:

- Head of Division of Fire safety and Rescue Police affiliated to the Public Security of provinces shall approve the plans for rescue using human forces, vehicles and equipment of the Fire and Rescue Police within their competence; in the event of mobilization of human forces, vehicles and equipment from other police forces, the rescue plans shall be granted approval by directors of the Public Security of provinces; in the event of mobilization of human forces, vehicles and equipment from organizations and agencies in the administrative division, the rescue plans shall be granted approval by Chairpersons of the People's Committees of the same level;

- Heads of Divisions of Fire safety and Rescue Police affiliated to the Public Security of provinces shall approve the plans for rescue using human forces, vehicles and equipment of the Fire and Rescue Polices within their competence; in the event of mobilization of human forces, vehicles and equipment from other police forces, from organizations and agencies in administrative divisions under district-level management, the rescue plans shall be granted approval by Chairpersons of the People's Committees of district-level;

- Directors of Divisions of Fire safety and Rescue Police of provinces shall approve the plans for rescue using human forces, vehicles and equipment of affiliated units of Fire

safety and Rescue Polices; in the event of mobilization of human forces, vehicles and equipment from other police forces, from organizations and agencies in administrative divisions under provincial-level management, the rescue plans shall be granted approval by Chairpersons of the People's Committees at the provinces or authorized persons;

- Directors of the Fire and Rescue Police Departments shall approve the plans for rescue using human forces, vehicles and equipment from fire departments, public security forces of central-affiliated cities and provinces." [Decree on regulation on Rescue operation by fire departments, 2017]

2.3.1.4. Contents of the exercise of Vietnamese firefighters.

"The rescue plans of the fire and rescue police is made according to form No. 05, issued together with Decree 83/2017/ND-CP dated July 18, 2017. The content of the plan includes 05 main parts, including:

- Content A: Characteristics related to rescue operations

For the part of characteristics related to rescue work in the plan, it is necessary to clearly state: characteristics of geographical location; traffic characteristics inside and outside the facility; essence and characteristics related to rescue work; organize the rescue force and the means and equipment for rescue are equipped at the establishment.

- Content B: Plan for a worst-case scenario that requires the mobilization of forces and means of many participating units, agencies, and organizations to resolve it.

In this content, it is necessary to build the most complicated incident and accident situations; come up with rescue tactics and techniques; calculation of rescue forces, means and equipment; At the same time, it is expected that the forces and means to be mobilized and the organization of rescue operations.

- Content C: Plan for other typical scenarios

In the part of the plan to handle typical emergency situations, it is necessary to assume that the incident or accident situation occurs in each area or work item at risk of incidents or accidents. The situations of incidents and accidents are different, so the organization of rescue is also different; situations are arranged in the order of "Scenario 1, 2, 3…"; the content of each situation is summarized in the order and number of forces, vehicles and equipment to be mobilized and deployed to do what, at what position; The content summarizes the basic tasks of the forces mobilized for rescue.

- Content D: Revision to rescue plan

According to regulations, rescue plans must be promptly supplemented and amended when there are changes in the nature, characteristics of hazards that can lead to incidents or accidents, and conditions related to rescue operations at the establishment.

Specify the case where the change is related to the organization of the rescue but not to the extent that the contents of the rescue plan are changed fundamentally. In case there is a major change that affects the contents of the plan, the rescue plan must be remake as prescribed.

A rescue plan that changes the most complicated incident or accident situation or changes from two or more typical incident or accident situations must be re-approved by a competent person. In case the rescue plan changes only one typical incident or accident situation, it shall be approved by the head of the unit or facility developing the plan.

Content E: Monitor training and practice of rescue plan

The content of this section must clearly state the organization of learning and practicing rescue plans for incident and accident situations. There must be a diagram of the arrangement of forces, means and equipment participating in the practice of the rescue plan and attached to the rescue plan." [Thuy, V.V & Tien, P.V, 2017]

2.3.1.5. Procedure for making and practicing the exercise of Vietnamese firefighters

a) Procedure for making rescue plan

- Presenting the issue to the establishment and local leadership

When engaging with establishment leadership, the officer responsible for developing the rescue plan should state the purpose and necessity of establishing a rescue plan, particularly emphasizing the legal requirements for creating a rescue plan. They should also agree on the time for conducting on-site research and surveys at the establishment and the local area. The establishment owner/manager should be requested to provide necessary information, data, and relevant documents for the rescue plan development.

- Surveying the establishment for rescue plan development

The assigned officer should visit the establishment and the research area in person to gather specific information, utilizing existing records and documentation stored at the unit. Subsequently, a comprehensive survey should be conducted, ensuring the collection of all necessary data for the rescue plan formulation.

- Conducting rescue plan development

Based on the collected information and data, assigned personnel are responsible for filling in the content of the rescue plan according to the provided template. The information must be processed to ensure accuracy, compliance with legal and scientific foundations. The

language used should be appropriate, precise, concise, and easily understandable. The writing style in the rescue plan should be legal and administrative; sentences should be concise, usually in the active voice, and use easily understandable language.

When filling in the content, the following points should be noted: The printed pages of the plan template are limited, and there may not be enough space to fill in all the content. Therefore, typing or handwriting in a new volume may be allowed, but it must still adhere to the prescribed template. The pages should be stamped with overlapping stamps and attached diagram stamps.

- Checking the rescue plan

After the completion of the rescue plan, the personnel responsible for developing the plan need to carefully check each content before preparing for approval at the unit. The checking process includes verifying if the rescue plan follows the prescribed template in terms of format, consistent font usage, layout, spelling errors, and whether the content filled in each section is complete and accurate.

- Discuss the rescue plan

The rescue plan, after being made, should be discussed and organized for officers and soldiers in the unit to learn the plan. The officer prepares the rescue plan, presents all the basic contents of the plan, and is expected to assign tasks to the forces participating in the practice of the rescue plan. Answer questions arising during the workshop, absorb and edit and add correct and reasonable comments to the rescue plan.

- Sign and approve the rescue plan

After the rescue plan has been revised, it must be submitted to the competent authority for approval. The rescue plan is only effective when it has been approved in accordance with regulations.

b) Procedure for practicing rescue plan

Practicing rescue plans is a form of comprehensive training of officers and soldiers at the highest level, synthesizing basic movements, individual techniques, coordinated formations, tactical skills, ability to guide Command and control all combat activities of rescue officers and soldiers in a specific situation of incident or accident. To practice a rescue plan, follow these steps:

- Preparation for practice of rescue plans:

Choose an establishment to practice rescue plans.

Develop a schedule to practice rescue plans. The schedule must clearly state the purpose, requirements, scale, location, time, content of the incident situation, the practice

process, the budget for practicing the rescue plan and the method of implementation. Especially in the schedule, there must be a list of the participating forces and the tasks of these forces when practicing the rescue plan.

Agree on time and plan to coordinate with the establishment.

Organize for officers and soldiers to practice the rescue plan on the diagram of the rescue plan.

Set up a steering committee to practice rescue plans (if necessary), and a steering committee to practice rescue plans.

- Practice the rescue plan:

The rescue commander assumes an accident or incident scenario as planned in the rescue plan, monitors the progress of the rescue operations by the grassroots forces, monitors the deployment of personnel, vehicles, and equipment of the firefighter, and ensures the implementation of safety measures during practicing rescue plans.

When there is an alarm command, the grassroots force shall carry out the tasks as stated in the rescue plan.

Firefighters mobilized rescue forces, vehicles and equipment to the rescue plan practice site, carried out tasks according to the rescue procedures and the content assumed in the rescue plan.

- Conduct experience in practicing rescue plans:

Conduct experience in practicing rescue plans is necessary and very useful. Lesson learned can be done right after the training session at the establishment. Participants to learn from experience include firefighters, grassroots forces and other forces mobilized to practice rescue plans.

The experience of practicing rescue plans aims to: Evaluate and analyze the performance of assigned tasks of the forces, the rescue staff, the logistics department, and the role of the rescue commander, the coordination between the forces participating in the practice of rescue plans. An overview of the results of practicing rescue plans on the advantages and limitations that need to be overcome, lessons learned for the next practicing rescue plans and experience in preparing for rescue if an accident or incident occurs in each work item of the establishment.

2.3.2. Review of previous studies on the exercise of Vietnamese firefighters.

- The doctoral thesis "Enhancing communication among emergency responders by developing exercise programs in Vietnam" of To Ngoc Thang, 2019 has studied an overview of emergency management institutions and policies in Vietnam. The thesis also clarifies the

importance of communication in emergency response and the great effects of the above exercises and functional exercises in training and capacity building for the involved parties. The thesis also provides a quantitative assessment method by time factor for functional exercise. Some important points that the thesis mentioned are as follows:

Table-top and functional exercises are two types of emergency exercise for addressing communication issues. More benefits from these exercises should be used for exercise participants and managers in countries, including Vietnam. [To Ngoc Thang, 2019]

Improving common understanding and enhancing communication among stakeholders become core issues. Although many information can learn for improving communication from exercise events, lack of mention in Vietnamese legal documents on conducting table-top and functional exercise program. [To Ngoc Thang, 2019]

In exercise evaluation, there are different objectives for table-top and functional exercise. Since table-top exercise encourage discussion among groups, organizations, the evaluation program is better to contribute share knowledge and information on communication structures among participants. By understanding more details on relationship among stakeholders, it supports to prevent communication failures by human factors in real emergencies. [To Ngoc Thang, 2019]

Functional exercise is more complicated exercise type than table-top exercise, that is useful to evaluate and test communication among stakeholders. Observing and analysing time-element in evaluation programs are advantages to find out quantitative evidence about player's performance in functional exercise. The approach has been proposed by using serval methods of process mapping technique, and task performance analysis in timestudy for analysing data. Relationship among time, groups, and tasks has been analysed. [To Ngoc Thang, 2019]

The thesis has also pointed out some further implications such as:

From reviewing situation on exercise program in Vietnam, drills are popular events for emergency responders. Meanwhile lack of experiences on table-top exercise and functional exercise. My suggestion is doing some table top exercise then improving to functional exercise. After exercises, communication structures should be clearly defined for sharing common understanding among participants. This issue is very important in emergency to quick and appreciate actions and ensure safety for responders.

For evaluation program on functional exercise, the observed data in case studies were mainly focused on measuring time element to find quantitative evidences in the exercise. However, how well tasks are performed, and the speed of execution are both important in

emergency response. To comprehensively describe the quality of an action, it needs to consider both quality metric and time metric. By considering the time element in addition to the qualitative information obtained by doing checklists, score sheets, and open ended questions, we can be more accurate at answering four questions regarding exercise evaluation: what happened, why and when it happened, and how it should be improved. Exercise managers can decide objective of exercise program, then select appropriate evaluation methods.

- Research "Use of analytic hierarchy process and four-component instructional design for improving emergency response exercises" by Hoang, Le Hong Giang and Kato, Takaaki (2023) introduced a model based on the Analytic Hierarchy Process to optimize instructional designs for emergency response exercises. This study aimed to propose a procedure to identify the necessary exercise targets and select suitable implementation methods by objectively summarizing the knowledge of emergency management professionals.

- Some functional exercises of Vietnamese firefighters:

Functional exercise to respond to fire incidents at Hai Phong International General Hospital, Vietnam, 2019. This is a functional exercise with the participation of forces such as Hai Phong city firefighters, Viet-Tiep friendship hospitals, the grassroots force of Hai Phong International General Hospital and Hai Phong City Police. The time factor was included for the quantitative evaluation of the exercise results. The participating forces have completed and handled the all of inject well. After the exercise, the participants all said that they had improved their knowledge and skills on fire response through the exercise. In addition, all forces believe that functional exercises have outstanding advantages in terms of cost savings compared to previous types of exercises in Vietnam.

Functional exercise to respond to fire incidents at Bac Son apartment building, Hai Phong, Vietnam, 2022. This is an exercise with the participation of many forces including Hai Phong City firefighters, Viet-Tiep friendship hospitals, Hai Phong International General Hospital, base force of Bac Son apartment building, Hai Phong City Police. The time factor was included for the quantitative evaluation of the exercise results. The exercise was conducted in the context that Vietnam has policies to respond to the Covid-19 pandemic. However, the successful implementation of exercises has revealed more advantages of functional exercises compared to the previous type of exercises in Vietnam. The participating forces all said that their coping capacity was enhanced through the exercise.

2.3.3. Review documents on emergency management exercises from the United States

2.3.3.1. Concepts and classifications of exercises

a) Concepts of exercises

"An exercise is an event or activity, delivered through discussion or action, to develop, assess, or validate plans, policies, procedures, and capabilities that jurisdictions/organizations can use to achieve planned objectives." [HSEEP, 2020]

"An exercise is the performance of duties, tasks, and operations in a way very similar to the way they would be performed in a real emergency. Very simply put, an exercise is an activity that is designed to promote emergency and business preparedness." [Regina Phelps, 2010].

b) Classifications of exercises

According to HSEEP, there are two types of exercises: discussion-based exercises and operations-based exercises.

Discussion-based exercises include seminars, workshops, tabletop exercises (TTXs), and games. These types of exercises familiarize players with or develop new plans, policies, procedures, and agreements. Discussion-based exercises focus on strategic, policy-oriented issues, and facilitators or presenters lead the discussion, keeping participants moving towards meeting the exercise objectives.

Operations-based exercises include drills, functional exercises (FE), and full-scale exercises (FSE). These exercises validate plans, policies, procedures, and agreements; clarify roles and responsibilities; and identify resource gaps. Operations-based exercises include a real-time response such as initiating communications or mobilizing personnel and resources.

According to Regina Phelps there are six types of exercises to consider: Orientation (including workshops and training); Drill; Tabletop (including Basic and Advance); Functional; Full-scale; Multi-site.

An existing system of five exercise types has developed over the past thirty years to provide a continuum of options for exercise training. The types of exercises that are Orientation, Tabletop, Drill, Functional, and Full Scale Exercises [Walter G. Green III, 2000].

2.3.3.2. Purpose and role of exercises

a) Purpose of exercises

The Homeland Security Exercise and Evaluation Program (HSEEP) provides a set of fundamental principles for exercise programs, as well as a common approach to program management, design and development, conduct, evaluation, and improvement planning. Exercises are an important component of preparedness, by providing the whole community

with the opportunity to shape planning, assess and validate capabilities, and address areas for improvement.

The National Preparedness Goal, strategy documents, Threat and Hazard Identification and Risk Assessment (THIRA) processes, capability assessments, and results from previous exercises and real-world incidents impact the priorities. These priorities guide the overall direction of an exercise program where individual exercises anchor to a common set of priorities or objectives, which increase in complexity over time. These priorities guide the design and development of individual exercises and allow planners to identify and align objectives to the capabilities being evaluated. Exercise evaluation assesses the ability to meet the objectives and capabilities by documenting strengths, areas for improvement, capability performance, and corrective actions in an After-Action Report (AAR)/Improvement Plan (IP).

b) Role of exercises

Exercises play a vital role in preparedness. A well-designed exercise provides a low-risk environment to familiarize personnel with roles and responsibilities; foster meaningful interaction and communication across jurisdictions/organizations; assess and validate plans, policies, procedures, and capabilities; and identify strengths and areas for improvement. Exercises bring together and strengthen the whole community to prevent, protect against, mitigate, respond to, and recover from all hazards. Overall, exercises help the whole community address the priorities established by a jurisdiction's/organization's leaders; and evaluate progress towards meeting preparedness goals.

2.3.3.3. Content of exercises

The following tables (Table 2.1, Table 2.2, Table 2.3, and Table 2.4) provide the important information for each type of discussion-based exercise:

Table 2.1. Discussion-Based Exercise Types: Seminar [HSEEP, 2020]

Seminar: A discussion-based exercise that orients participants to or provides an overview of authorities, strategies, plans, policies, procedures, protocols, resources, concepts, and ideas.	
Element	Considerations and Activities
Purpose	- Provide a common framework of understanding - Provide a good starting point for developing or making major changes to existing plans, policies, or procedures
Structure	- Usually in the form of multiple presentations, subject-matter expert (SME) panels, or case study discussions

	- Lecture-based - Led by a seminar facilitator/presenter - Limited feedback or interaction from participants
Participant goals	- Gain awareness of or assess interagency capabilities or inter jurisdictional operations - Set objectives for future capabilities
Conduct features	- Minimal time constraints - Effective for small or large groups
Outcomes	- A report that captures the discussion, issues raised, and (if appropriate) action items that will address these issues - An After-Action Report (AAR)/Improvement Plan (IP)

Table 2.2. Discussion-Based Exercise Types: Workshop [HSEEP, 2020]

Workshop: A discussion-based exercise often employed to develop policy, plans, or procedures.	
Element	Considerations and Activities
Purpose	- Increased participant interaction with a focus on achieving or building a product - Should have clearly defined objectives, products, or goals and focus on a specific issue
Structure	- A group of individuals in a venue conducive to discussion - Lectures, presentations, panel or case-study discussions, or decision support tools - Facilitated working breakout sessions - Led by a workshop facilitator/presenter
Participant goals	- Develop a product as a group - Obtain consensus - Collect or share information
Conduct features	- Effective for small and large groups - Broad attendance by relevant stakeholders - Conducted based on clear objectives/goals - More participant discussion than lecture-based - Frequently uses breakout sessions to explore parts of an issue with similar groups
Outcomes	- Emergency Operations Plans - Mutual Aid Agreements - Standard Operating Procedures - Continuity of operations plans - Workshop Summary Report - An After-Action Report (AAR)/Improvement Plan (IP)

Table 2.3. Discussion-Based Exercise Types: Tabletop Exercise [HSEEP, 2020]

Tabletop Exercise (TTX): A discussion-based exercise in response to a scenario, intended to generate a dialogue of various issues to facilitate a conceptual understanding, identify strengths and areas for improvement, and/or achieve changes in perceptions about plans, policies, or procedures.	
Element	Considerations and Activities
Purpose	- Generate discussion of various issues regarding an exercise scenario - Facilitate conceptual understanding, identify strengths and areas for improvement, and/or achieve changes in perceptions
Structure	- Scenario is presented to describe an event at a simulated time - Players apply their knowledge and skills to a list of problems presented by the facilitator - Problems are discussed as a group, and resolution may be reached and documented for later analysis - Plenary or breakout session(s) - Discussion led by a facilitator(s) - Presentation
Participant goals	- Enhance general awareness - Enhance roles and responsibility understanding - Validate plans and procedures - Discuss concepts and/or assess types of systems in a defined incident
Conduct features	- Requires an experienced facilitator - In-depth discussion - Problem-solving environment - All participants should be encouraged to contribute to the discussion and be reminded that they are making decisions in a no-fault environment
Outcomes	- Recommended revisions to current plans, policies, and procedures - An After-Action Report (AAR)/Improvement Plan (IP)

Table 2.4. Discussion-Based Exercise Types: Game [HSEEP, 2020]

Game: A discussion-based exercise that is a structured form of play designed for individuals or teams in a competitive or noncompetitive environment. It is an event players take part in and are guided by clear rules, data, and procedures for its execution. Games are designed to depict an actual or hypothetical situation to ensure that the participants make decisions and take actions that would be plausible. Games can be used to reinforce training, stimulate team building, or enhance operational and tactical capabilities.	
Element	Considerations and Activities

Purpose	- Simulation of operations that explore the consequences of player decisions and actions - Identification of critical decision-making points is a major factor in the success of evaluating a game
Structure	- Usually in an environment that can involve two or more teams, using rules, data, and procedures designed to depict an actual or hypothetical situation - Decision-making may be either slow and deliberate or rapid and more stressful, depending on the exercise design and objectives - The open, decision-based format of a game can incorporate "what if" questions that expand exercise benefits - Depending on the game's design, the consequences of player actions can be either pre-scripted or decided dynamically
Participant goals	- Explore decision-making processes and consequences - Conduct "what-if" analyses of existing plans - Evaluate existing and potential strategies
Conduct features	- No actual resources used - Often involves two or more teams - May include models and simulations of increasing complexity as the game progresses - May or may not include pre-scripted activities
Outcomes	- Validate plans, policies, and procedures or evaluating resource requirements - An After-Action Report (AAR)/Improvement Plan (IP)

The following tables (Table 2.5, Table 2.6, and Table 2.7) provide the important information for each type of operations-based exercise:

Table 2.5. Operations-Based Exercise Types: Drill [HSEEP, 2020]

Drill: An operations-based exercise often employed to validate a single operation or function.	
Element	Considerations and Activities
Purpose	- Coordinated, supervised activity to validate a specific function or capability in a single agency/organization, often employed to validate a single operation or function - Provide training on new equipment, validate procedures, or practice and maintain current skills
Structure	- Can be standalone or used as a series of drills - Clearly defined plans, procedures, and protocols need to be in place
Participant goals	- Evaluate new procedures, policies, and/or equipment - Practice and maintain skills - Prepare for future exercises

Conduct features	- Immediate feedback - Realistic environment - Narrow focus - Performance in isolation - Results are measured against established standards
Outcomes	- Determine if plans can be executed as designed - Assess whether more training is required - Reinforce best practices - An After-Action Report (AAR)/Improvement Plan (IP)

Table 2.6. Operations-Based Exercise Types: Functional Exercise [HSEEP, 2020]

Functional Exercise (FE): An operations-based exercise is designed to test and evaluate capabilities and functions while in a realistic, real-time environment; however, movement of resources is usually simulated.	
Element	Considerations and Activities
Purpose	- Validate and evaluate capabilities, multiple functions and/or sub-functions, or interdependent groups of activities - Exercise plans, policies, procedures, and staffs involved in management, direction command, and control functions - Apply established plans, policies, and procedures under crisis conditions
Structure	- Events are projected through a realistic exercise scenario with event updates that drive activity typically at the management level - Controllers typically use a Master Scenario Events List (MSEL) to ensure participant activity remains within predefined boundaries - Evaluators observe behaviors and compare them against established plans, policies, procedures, and standard practices (if applicable)
Participant goals	- Validate and evaluate capabilities - Focused on plans, policies, and procedures
Conduct features	- Conducted in a realistic environment - Usually, a simulated deployment of resources and personnel - Use of Simulation Cell and Master Scenario Events List (MSEL) - Simulators can inject scenario elements - Include controller and evaluators
Outcomes	- Management evaluation of Emergency Operations Center (EOCs), command post, headquarters, and staffs - Performance analysis - Cooperative relationships are strengthened - An After-Action Report (AAR)/Improvement Plan (IP)

Table 2.7. Operations-Based Exercise Types: Full-Scale Exercise [HSEEP, 2020]

Full-Scale Exercise (FSE): An operations-based exercise that is typically the most complex and resource-intensive of the exercise types and often involves multiple agencies, jurisdictions/organizations, and real-time movement of resources.	
Element	Considerations and Activities
Purpose	- Often includes many players operating under cooperative systems such as the Incident Command System (ICS) Unified Command - Focus on implementing and analyzing the plans, policies, and procedures that may have been developed in discussion-based exercises and honed during previous, smaller exercises
Structure	- Events are projected through an exercise scenario with event updates that drive activity at the operational level - Involves multiple agencies, organizations, and jurisdictions - Use of a MSEL drives player actions - SimCell controllers inject scenario elements - Level of support needed may be greater than that needed for other types of exercises - Conducted in a realistic environment to mirror a real incident by presenting complex problems
Participant goals	- Demonstrate roles and responsibilities as addressed in plans and procedures - Coordinate between multiple agencies, organizations, and jurisdictions
Conduct features	- Rapid problem solving; critical thinking ▪ Mobilization of personnel and resources - Exercise site is usually large with many activities occurring simultaneously - Site logistics require close monitoring - Safety issues, particularly regarding the use of props and special effects, must be monitored - Demonstrate roles and responsibilities as addressed in plans and procedures
Outcomes	- Validate plans, policies, and procedures - Evaluate resource requirements - An After-Action Report (AAR)/Improvement Plan (IP)

"- Orientation exercise

Orientation exercises are great ways to introduce a new team to a plan or a new plan to a team. It uses a simple narrative and is delivered in a PowerPoint or other visual slide format in a conversational, non-threatening manner. This style exercise is useful in the following situations to orient:

- A new Incident Management Team (IMT) to their role.

- An Executive Management Team (EMT) to their role.

- A business unit or a recovery team to their new Business Continuity Plan (BCP).

- A facilities and security team to their company responder role.

- A disaster recovery (DR) team (technology team) to their plan in preparation for a full-scale DR exercise.

Orientation exercises are known for their simplicity and ease of time in preparation.

Orientation exercise characteristics:

- Introduces the participants to plans and procedures

- Introduces a new plan or a revised old one

- Requires no previous experience

- Helps orient new staff or leadership

Planning cycle: About one month Exercise time: From 1 to 2 hours" [Regina Phelps, 2010]

"Multi-site exercise

Multi-site exercises are a great way to exercise regional disaster response plans or to practice how one team would support another. If you have an Incident Management Team located at headquarters and part of their mandate is to support the recovery of mission-critical locations, one way to exercise this responsibility is to have an "affected site" reach out to the headquarters team during an exercise, and then both teams work together to practice their roles and communication linkages.

These exercises are expensive to plan and facilitate, and are very time-con- suming. Those organizations likely to do a multi-site exercise are those with major regional risks (such as hurricanes and earthquakes), multiple locations, and/or companies whose recovery strategy is to transfer processing to another site. The best way to know if this will work is to do it. Due to the highly spe- cialized and complex nature of the multi-site exercise, this style will not have its own chapter.

Multi-site exercise characteristics

- Involves one or more locations.

- seither a Functional or Full-scale style exercise

- Assesses communication, hand-offs between teams, and a team's ability to support another team

- Is complex in design, administration, and facilitation

Planning cycle: About six months Exercise time: Half-day to full-day" [Regina Phelps, 2010]

2.3.4. Discussion

From the concept of Vietnam's rescue plan, we see that Vietnam's rescue plan is practiced with a lot of participating forces, has the movement and real operation of vehicles and equipment, time real and according to pre-designed scenarios. It is easy to see that Vietnam's rescue plan has many similarities with Drill and Full-scale exercises of HSEEP. However, we see that the rescue plan of Vietnamese firefighters has many forces involved, therefore it is not Drill. Besides, we see that the rescue plan of Vietnamese firefighters does not undergo small exercises such as tabletop exercise or functional exercise before conducting the practice, so it is not completely full-scale exercise.

From the classification of exercises, we can see that the theoretical system of exercises in Vietnam is still very sketchy. Vietnam's classification is classified by incident and accident situations, not by the form and method of conducting exercises. This is probably a major flaw in the reasoning system of the Vietnamese firefighter's exercise.

"Through these legal documents, drill is main type of emergency exercise for forces in Vietnam." [To Ngoc Thang, 2019]. This view is not true when considered in the field of fire fighting and rescue. As I explained above, the type of exercise of Vietnamese firefighters is not Drill.

One problem that we need to do is determine the exercises of Vietnamese firefighters. To do this, we need to answer research question 1: How is the practice of the rescue plan conducted?

Vietnamese firefighters have started to prepare and practice fire fighting plans since 2001 according to the provisions of Article 31 of the Law on fire prevention and fighting No. 27/2001/QH10. Over the years they have achieved many achievements. The duties of Vietnamese firefighters were extended to the field of rescue from 2017 when Decree 83/2017/ND-CP was issued. However, they are having difficulty in practicing rescue plans. Finding the cause of the limitations is the key to effective solutions.

Research question 2: What is the cause of the limitation in the practice of rescue plans?

There have been a few functional exercises performed by Vietnamese firefighters such as Functional exercise to respond to fire incidents at Hai Phong International General Hospital, Vietnam, 2019; Functional exercise to respond to fire incidents at Bac Son apartment building, Hai Phong, Vietnam, 2022. However, these two exercises are performed in the event of a fire incident. This shows that there still needs to be exercises for other incidents and accidents than fire incidents. Specifically, the rescue situations of Vietnamese firefighters are specified in Article 5 of Decree 83/2017/ND-CP.

Finding solutions to overcome the limitations of practicing rescue plans of Vietnamese firefighters is very important. In addition to improving the response capacity, making the rescue highly effective and ensuring the safety of the firefighters, it can also be applied to the grassroots forces to practice well the establishment's rescue plan. As mentioned in Chapter 1, Vietnam now has more than 1.2 million establishments. It is very necessary to improve the incident response capacity for grassroots forces through practicing rescue plans. This has great significance to the stable and sustainable development of Vietnam's economy and society.

Research question 3: What are the innovative solutions to improve the ability of firefighters to practice rescue plans?

2.4. Summary of Chapter 2

Chapter 2 summarizes the theoretical and legal basis of current firefighting exercises in Vietnam, reviews previous studies on emergency exercises, and examines documents on emergency exercises in the United States.

In addition, Chapter 2 identifies certain issues that need to be addressed within the theoretical framework of firefighting and rescue exercises in Vietnam, such as the inclusion of additional exercise types and the development of a classification method based on the exercise's form and content.

Furthermore, Chapter 2 presents three research questions that must be answered to fulfill the original research objective.

3. Limitations and solutions of the current rescue exercise of Vietnamese firefighters

3.1. Introduction

Based on a theoretical overview of the exercises of Vietnamese firefighters and the problems discovered in Chapter 2. In Chapter 3, the author will conduct a study on the actual situation of the design and practice of exercises of Vietnamese firefighters. It is very important to determine the current status of the design and practice exercises of Vietnamese firefighters. It will provide the necessary information on how the design work and exercises are being done? In addition, the study of how the practice of firefighters' exercises is happening also helps the author to analyze and synthesize the characteristics of the exercises of Vietnamese firefighters. This will help the author identify the type of exercises of Vietnamese firefighters.

From the reality of the design and practice of the exercise, the author will analyze and synthesize the data to show the limitations of the design and practice of the exercise. Finding out the causes leading to limitations in the design and practice of Vietnamese firefighters is considered a key issue to be able to provide solutions to overcome the limitations correctly and effectively. Then, propose solutions to overcome limitations in the design and practice of exercises of Vietnamese firefighters.

In order to achieve the above objectives, in Chapter 3, the author needs to answer the following three research questions:

1. How is the practice of the rescue plan conducted?

2. What is the cause of the limitation in the practice of rescue plans?

3. What are the innovative solutions to improve the ability of firefighters to practice rescue plans?

The results of Chapter 3 will be a new theoretical basis for Vietnamese firefighters to design and practice exercises. Vietnamese firefighters can guide the forces of many establishments in the design and selection of appropriate forms of practicing so that they can practice their exercises effectively. This chapter is an expansion of Le et al. [Le, T. H., Pham, V. N., and Kato, T. (2023). *Practicing Rescue Plans of Vietnamese Firefighters: Situation and Solutions.*].

3.2. Methods

3.2.1. Strategy for analysis

To answer Research Question 1, the author has collected plans and practice videos of Vietnamese firefighters. Government documents were also used. The author will then review and evaluate the plans and videos to answer research question 1. To answer Research Question 2, the authors conducted a survey of staff in charge of designing and practicing exercises of Vietnamese firefighters, identifying limitations and causes leading to limitations in practice exercises of Vietnamese firefighters. To answer Research Question 3, the authors compared the method of practicing rescue plans of Vietnamese firefighters with the exercises of HSEEP, conducted discussions to determine the issues that need to be improved, and proposed solutions.

3.2.2. Data collection methods

3.2.2.1. Target provinces

We referred to government statistics and created two groups of targeted provinces. Based on a report on the actual firefighting and rescue practices of the Vietnam Fire and Rescue Police Department in 2020. The author found that eight provincial fire services were unable to design and practice of rescue plans in 2020. Therefore, the author included these provincial fire services as a research group to conduct a survey to discover the limitations and causes leading to those limitations in the design and practice of Vietnamese firefighters. Besides, the author also wants to receive opinions from many different angles of the subjects. Therefore, the author has selected another research group, which are the 8 best performing provincial fire services according to the 2020 report of the Fire Prevention, Fighting and Rescue Police Department.

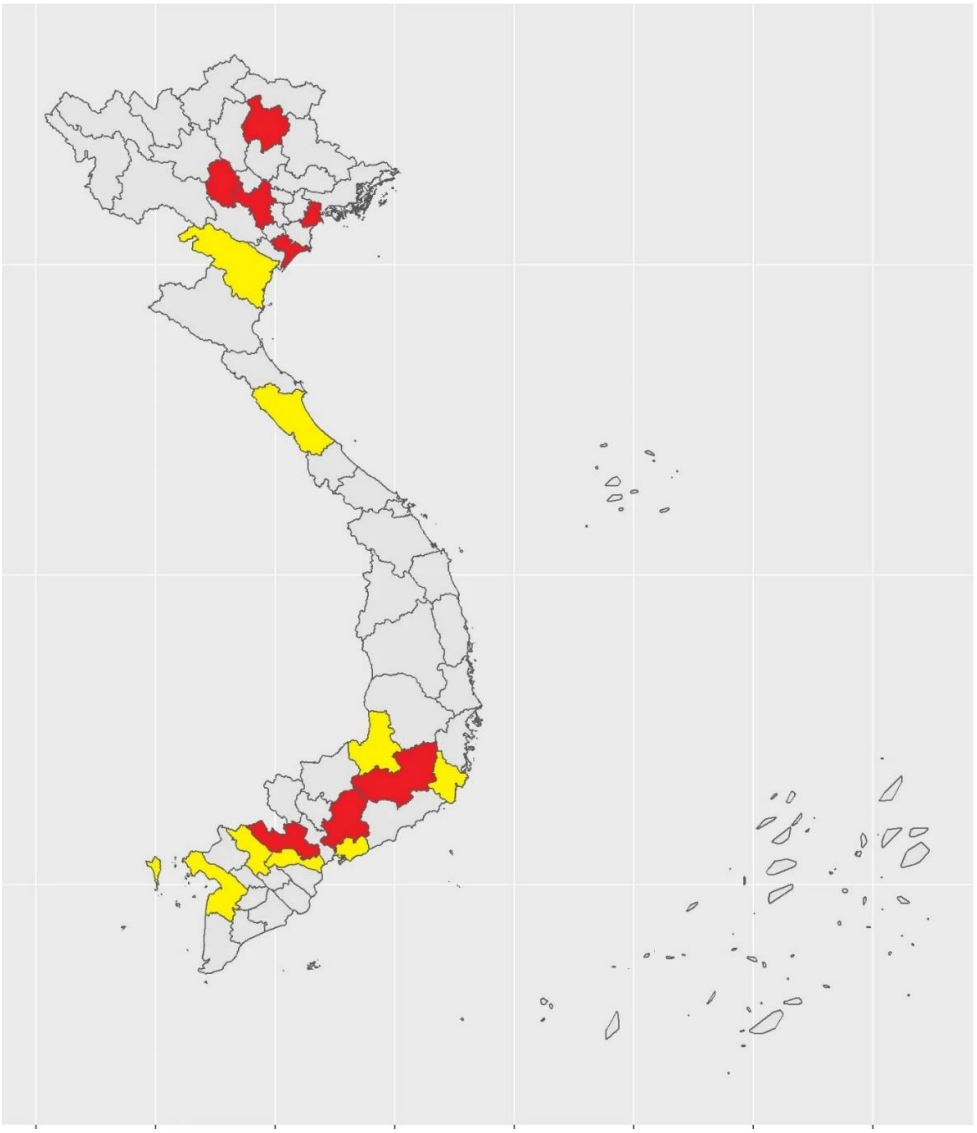
Table 3.1. Design and practice of rescue plans of Group A and Group B in 2020

Group	Province	Population (1000 persons)	Area size (km^2)	Number of exercises designed	Number of exercises practiced
A	Bac Kan	323,71	4.859,96	150	86
	Dong Nai	3.169,10	5.863,62	393	132
	Ha Noi	8.330,83	3.359,82	475	395
	Hai Phong	2.072,39	1.526,52	84	179
	Lam Dong	1.321,84	9.781,20	121	66
	Long An	1.725,75	4.494,79	120	60
	Nam Dinh	1.836,27	1.668,83	128	128
	Phu Tho	1.507,54	3.534,56	180	133
B	BRVT	1.176,08	1.982,56	0	0
	Dak Nong	664,42	6.509,27	0	0
	Dong Thap	1.601,31	3.382,28	0	0
	Kien Giang	1.752,32	6.352,02	0	0

	Ninh Thuan	596,05	3.355,34	0	0
	Quang Binh	910,66	7.998,76	0	0
	Thanh Hoa	3.716,43	11.114,71	0	0
	Tien Giang	1.779,42	2.556,36	0	0

[General Statistics Office of Vietnam, 2022], [Vietnam Fire and Rescue Police Department, 2020].

The authors selected 16 provincial fire services including Bac Kan, Dong Nai, Ha Noi, Hai Phong, Lam Dong, Long An, Nam Dinh, Phu Tho, Ba Ria - Vung Tau (BRVT), Dak Nong, Dong Thap, Kien Giang, Ninh Thuan, Quang Binh, Thanh Hoa, Tien Giang to advance survey practice.



Note:

The 8 Provincial Fire Services of Group A

The 8 Provincial Fire Services of Group B

Fig. 3.1. Selected provinces on the map of Vietnam

There are eight provincial fire services with the best performance (Group A) and eight provincial fire services with the worst performance (Group B) in 2020, according to statistics from the Vietnam Fire and Rescue Police Department [Vietnam Fire and Rescue Police Department, 2020].

Table 3.1 shows the results of the 2020 work report of the Vietnam Fire and Rescue Police Department [Vietnam Fire and Rescue Police Department, 2020] illustrating the number of times of designing and practicing of eight provincial fire services in Groups A and B.

3.2.2.2. Collecting Rescue plans and exercise videos

The author collected 200 rescue plans and 100 videos of the rescue plans of 16 provincial fire service units. To collect rescue plans and exercise videos, the authors asked the Faculty of Rescue of the University of Fire Prevention and Fighting, Vietnam, for rescue plans and exercise videos. Every year, the Faculty of Rescue of the University of Fire Prevention and Fighting has an annual professional activity that involves collecting documents and data on the rescue activities of provincial fire services. This serves the work of editing and supplementing textbooks and teaching materials on rescue subjects of the Faculty of Rescue. The lead author of this study was a lecturer in the Faculty of Rescue and was thus able to access and consult these data.

3.2.2.3. Survey of provincial fire services

The survey was conducted from September 15, 2021, to November 15, 2021. The author planned to survey up to 15 officers in charge of designing and implementing rescue plans for each selected provincial fire service unit. The officials participating in the survey need to ensure the criteria of the survey subjects so that the survey results have high reliability.

Criteria for survey subjects:

- Working position: Officer of the fire prevention team or the fire and rescue team of the provincial fire services.

- Qualification: university degree

- Experience: At least 1 year working experience

The survey used a questionnaire answer sheet [Appendix 2]. Owing to the COVID-19 pandemic, the authors could not conduct a survey in person and used online Google forms. First, the author has directly contacted the commander of the fire prevention team, the commander of the fire and rescue teams of the provincial fire services by phone. The author presented the purpose, requirements and content of the survey program and received enthusiastic help from the

provincial fire services. Then the author introduced and instructed how to participate in surveys and answer questions on the online Google form. All survey participants were re-confirmed that they understood and were able to use the online Google form.

The survey questionnaire consisted of 19 questions designed to collect the following data [Appendix 2]: the number of staff unable to design and practice firefighting and rescue plans in both teams A and B and the cause of the problem, the factors that influence the design and practice of firefighting and rescue plans, and their influence. The responses from employees who designed and practiced a firefighting and rescue plan, as well as those who were unable to design and practice a firefighting and rescue plan, were included. These questions were based on the HSEEP document exercise evaluation program [HSEEP, 2020].

The organizational structure of provincial fire services depends on the characteristics of the fire situation and incidents of each locality, so there is a difference in the number of officers of the provincial fire services. Because some provincial fire services have a limited number of officers in charge of designing and practicing rescue plans, the author received 196 of the 240 expected participants. Of these, 78 survey participants were from Group A (the team with good results in 2020), and 118 were from Group B (the team with poor results in 2020). The survey results showed that there were eight non-fire officers, since these eight people did not meet the standards of the survey subjects as the study originally had set out; the total number of survey participants meeting the standards of the study was 188.

3.2.3. Analytical method

The author used a comparative method to analyze the data on the rescue plan collected by our group. The authors used Form No. 05 stipulating the rescue plan of the Fire Prevention, Fighting, and Rescue Police [Appendix 1] to determine the contents to be evaluated for the rescue plans. The author built this content into a checklist to facilitate comparison. The checklist for the rescue plan includes 19 items. Through this method, the authors answered two sub-questions for the first research question. There are:

1. Are the rescue plans of the provincial fire services different in terms of form and content from the model of rescue plan prescribed by Vietnamese law?

2. Are the rescue plans of the provincial fire services different from each other?

The author synthesized and reviewed government documents on the design and practice of fire and rescue plans, research on the theoretical basis of firefighting and rescue plans for Vietnamese firefighters, and compare the contents of the firefighting and rescue plans with the regulations of government documents.

The collected videos were visually analyzed to determine the characteristics of the current method of practicing firefighting and rescue plans for Vietnamese firefighters. The authors used checklists to evaluate the characteristics of rescue practices recorded in the videos.

There are several possible approaches to the development of a scheme for the classification of exercises. The two approaches that the author has applied to this study are functional and content taxonomies.

The most basic way of classifying an exercise is by the function that the exercise performs. The broad classes of needs of agencies and individuals create a functional taxonomy of what an exercise is designed to do, including the following purposes: training, testing and validation, system development, and research [Walter G. Green III, 2000]. Vietnamese firefighters' exercises are for testing and validation. Items to be drawn from this approach include scenario, coordination, cost, and safety.

Currently, Vietnam does not have a theoretical basis or legal documents on exercise characteristics. However, the requirements for the content of the exercise are specified by the law in Article 9 of Decree 83/2017/ND-CP [Decree on regulation on Rescue operation by fire deparments, 2017]. Therefore, the authors also used the second approach, which is content taxonomies. Items to be drawn from this approach include forces, facility, equipment, time frame, building block. Using these two approaches, the authors extracted the items for characterizing exercises. From these items, specific questions were developed as shown in Table 3.4. Then the characteristics of the exercises were further identified in Table 3.5 according to the HSEEP exercise categories: element, purpose, structure, participant goals, conduct characteristics, and outcomes. The authors also relate the items in Table 3.4 and the categories in Table 3.5 as shown later. This method helped the authors answer the first research question: How is the practice of the rescue plan conducted?

Qualitative analytical methods were used to analyze the data obtained from the survey to answer the second research question. To consider the problem from two perspectives, namely, the team with good performance and the team with poor performance, the authors compared the results of Groups A and B. Specifically, the author's team used a general statistical method to determine the following contents of Groups A and B:

1- The number of people who have never designed a rescue plan.

2- The reason people who have never designed a rescue plan do not design a rescue plan

3- The number of people who have never practiced rescue plan.

4- The reason people who have never practiced a rescue plan do not practice.

5- The factors that affect the practice of rescue plans and their influence.

In addition, to assess the relationship between limitations in the design and practice of rescue plans and work experience, the authors divided the survey participants into four groups according to the number of years of work experience, including Group I who had 1–5 years of work experience; Group II, people with 6–10 years of work experience; Group III, people with 11–15 years of work experience; and Group IV, people with 16 years of work experience. Comparing the survey results of the four groups can help to identify specific problems that the four groups of subjects are facing. These issues may differ because these four groups of subjects have different years of work experience, and the training process changes over time.

Owing to the different organizational structures of the provincial fire departments, the total number of response plans of Groups A and B is not the same, similar to the number of survey participants in the four groups according to work experience. Therefore, we compared the data based on percentages. The authors determined the influencing factors and degree of influence based on the descending order of the selected answers.

To answer the third research question, after identifying six characteristics of the rescue-plan practice, the authors compared the characteristics of the rescue-plan practice of Vietnamese firefighters with other types of exercises shown in HSEEP of the United States Department of Homeland Security [HSEEP, 2020] and other documents.

3.3. Results

3.3.1. Analysis of the rescue plans and videos

We collected 200 rescue plans and 100 rescue practice videos from 16 provincial fire services. Table 3.2 shows 125 rescue plans when a fire occurred, 37 rescue plans when a construction collapse occurred, 20 rescue plans when a motorized traffic accident occurred, 11 rescue plans when someone was injured by drowning, and seven rescue plans when landslides occurred. In addition, there are 100 videos of practicing the plan, 92 videos of practicing the rescue plan in the case of a fire, five of practicing the rescue plan when a construction collapse occurred, two of practicing the rescue plan when a motorized traffic accident occurred, and a video of practicing rescue plans in the case of a ship fire at a seaport.

Table 3.2. Number and type of rescue plans and rescue practice videos collected

Group	Province	Number of rescue plans collected					Number of rescue videos collected				
		Hazard type					Hazard type				
		Fire	Construction collapse	Traffic accident	Injury/ drowning	Landslide	Fire	Construction collapse	Traffic accident	Injury/ drowning	Landslide
A	Bac Kan	9	1	0	0	3	7	0	0	0	0
	Dong Nai	13	4	1	1	0	9	0	0	0	0
	Ha Noi	30	16	4	0	1	19	5	1	0	0
	Hai Phong	21	8	6	2	0	12	0	1	0	0
	Lam Dong	6	0	1	0	1	6	0	0	0	0
	Long An	6	0	0	0	0	4	0	0	0	0
	Nam Dinh	10	2	1	0	0	8	0	0	0	0
	Phu Tho	4	0	0	0	0	2	0	0	0	0
B	BRVT	3	1	0	2	0	3	0	0	0	0
	Dak Nong	2	0	0	0	0	2	0	0	0	0
	Dong Thap	2	0	0	1	0	2	0	0	0	0
	Kien Giang	4	1	0	2	0	4	0	0	0	0
	Ninh Thuan	3	1	1	0	0	3	0	0	0	0
	Quang Binh	4	1	2	0	1	4	0	0	0	0
	Thanh Hoa	6	2	4	0	1	6	0	0	0	0
	Tien Giang	2	0	0	3	0	2	0	0	0	0

The design of the rescue plan of Vietnamese firefighters shows the nature and characteristics of danger in the event of an incident or accident and the conditions related to the rescue operation. The most complicated incident and accident situations and other typical incidents and accidents may occur. The possibility of the occurrence of subsequent dangers of incidents and accidents according to different levels are present. The plan for mobilization and use of forces, means, organization of command, technical measures, rescue tactics, and work in service of the rescue is appropriate for each stage of the incident situation.

Table 3.3. Comparison of collected rescue plans with a sample of rescue plans prescribed by the law of Vietnam

The rescue plans prescribed by the law			Number of collected rescue plans	
			Similar	Difference
A. Characteristics related to rescue operations	I. Geographic location		200	0
	II. Internal and external traffic system		200	0
	III. Nature and characteristics related to rescue operation		200	0
	IV. Standing force for rescue operation	1. Organization of rescue force	200	0
		2. Standing force for rescue operation	200	0
	V. Internal rescue equipment		200	0
B. Plan for a worst-case scenario that requires the mobilization of forces and means of many participating units, agencies, and organizations to resolve it.	I. Presumptive scenario		200	0
	II. Tactics, rescue skills		200	0
	III. Calculating the necessary forces and means for rescue		179	21
	IV. Expected forces and means to be mobilized		200	0
	V. Organization of rescue operation	1. Tasks of the standing force for rescue	200	0
		2. Specific tasks of the fire prevention fighting and rescue police force	200	0
		3. Tasks of other forces	200	0
	VI. Diagram of rescue forces and equipment for the worst-case scenario		200	0
C. Plan for other typical scenarios	I. Scenario 1		38	162
	II. Scenario 2		5	195
	III. Scenario…		0	200
D. Revision to rescue plan			200	0
E. Monitor training and practice of rescue plan			200	0

Table 3.3 shows all 200 rescue plans that were guaranteed to comply with the provisions of the law. However, most of the options only show the plan for the worst-case scenario, whereas plans for other typical scenarios are not focused. Thirty-eight rescue plans are presented for typical scenario 1 and five a typical Scenario 2. It is worth noting the rescue plans that include plans for typical scenarios are all rescue plans when a fire occurs. Rescue plans for incidents other than fire incidents do not include plans for other typical scenarios.

Table 3.4. Visual assessment of exercise videos

No	Items	Contents	Yes	No
1	Cost	Are human and equipment operations complex and resource intensive?	100	0
2	Equipment	Is there real-time operation and movement of specialized rescue equipment?	100	0
3	Forces	Is there real-time human movement and activity?	100	0
4	Scenario	Are events projected through an exercise scenario with event updates that drive activity at the operational level?	100	0
5	Forces	Are there many forces involved in practicing rescue plans? (two or more participating forces)	100	0
6	Coordination	Is there coordination between the many forces involved in the practice of the rescue plan?	100	0
7	Time frame	Are information, decisions, requests immediately responded to and enforced?	100	0
8	Facility	Do you need a location or scene to practice the rescue plan?	100	0
9	Safety	Is there a danger to people and equipment when participating in the practice?	63	37
10	Scenario	Are the hazard factors for an incident created as the real thing?	58	42
11	Building block	Are other formal or smaller-scale exercises conducted before the practice of the rescue plan?	2	98

Table 3.5. Characteristics of rescue-plan practice

Items	Rescue-plan practice of Vietnamese firefighters
Element	- An operations-based exercise that is typically complex and resource-intensive of the exercise types and often involves multiple agencies, jurisdictions/organizations, and real-time movement of resources, real-time device activity
Purpose	- Often includes many players operating under cooperative systems - Focus on the implementation and analysis of established plans, policies, and procedures

	- Confirm the use of equipment, task procedures, and practices that maintain current skills by agencies/organizations
Structure	- Events are projected through an exercise scenario with event updates that drive activity at the operational level - Involves multiple agencies, organizations, and jurisdictions - The level of support needed may be greater than that needed for other types of exercises - Conducted in a realistic environment to mirror a real incident by presenting complex problems
Participant goals	- Practice and maintain skills - Demonstrate roles and responsibilities as addressed in plans and procedures - Coordinate between multiple agencies, organizations, and jurisdictions
Conduct features	- Immediate feedback - Realistic environment - Mobilization of personnel and resources - The practice site is usually done with a specific construction with many activities taking place at the same time - Site logistics require close monitoring - Safety issues, particularly regarding the use of props and special effects, must be monitored - Demonstrate roles and responsibilities as addressed in plans and procedures
Outcomes	- Determine if the plans can be conducted as designed - Validate plans, policies, and procedures - Evaluate requirements for resources, workforce, equipment

The questions in Table 3.4 helped the authors answer and identify the contents in Table 3.5. For example: Within the same type of activity-based exercises, the cost for different types of exercises is different. Functional exercises have a much lower cost than Drill and Full-scale exercises because in functional exercises resource movements are simulated. Question 1 in Table 4 helped the author determine that the exercise of Vietnam is similar to Drill and Full-scale exercise in terms of cost.

Drill and Full-scale exercises involve the operation and movement of equipment. However, for Functional exercises, the operation and movement of equipment are simulated. Question 2 in Table 3.4 helped the author to determine that the exercise of Vietnam is similar to Drill and Full-scale exercise in terms of equipment.

Drill has only one force involved while Functional exercises and Full-scale exercises have multiple forces involved. Question 5 in Table 3.4 helped the author to determine that the

exercise of Vietnam is similar to Functional exercise and Full-scale exercise in terms of the number of forces involved in the exercise.

Summarizing the above examples, questions 1-5,7,8 in Table 3.4 helped the authors identify the "element" in Table 5 of the Vietnamese exercise as "An operations-based exercise that is typically complex and resource-intensive of the exercise types and often involves multiple agencies, jurisdictions/organizations, and real-time movement of resources, real-time device activity".

3.3.2. Analyze survey results

3.3.2.1. A comparison between Groups A and B

Group A in Table 1 consisted of 77 people from the Provincial Fire Service. Group B consisted of 111 participants. The results of the data analysis of Groups A and B from the survey are shown in Table 3.6.

Table 3.6. Survey results on the design and practice of rescue plans for Groups A and B.

Content		Group A		Group B	
Design of the rescue plan	Have not ever	10 (13%)		24 (22%)	
		Reason	Number of people	Reason	Number of people
		- Only be able to design part of the exercise	4 (40%)	- Only be able to design part of the exercise	3 (13%)
		- Due to the impact of Covid-19	3 (30%)	- Due to the impact of Covid-19	2 (8%)
		- Combine firefighting and rescue exercises	2 (20%)	- Combine firefighting and rescue exercises	4 (17%)
		- Can’t practice the exercise so the design doesn’t make sense	1 (10%)	- Can’t practice the exercise so the design doesn’t make sense	6 (25%)
				- Don’t know how to design exercises	8 (33%)
				- The cost is too expensive	1 (4%)
	Have ever	67 (87%)		87 (78%)	
Practice of the rescue plan	Have not ever	30 (39%)		56 (50%)	
		Reason	Number of people	Reason	Number of people

		- The practice form is not suitable for the type of incident	9 (30%)	- The practice form is not suitable for the type of incident	15 (27%)
		- The cost of practice is too much	5 (17%)	- The cost of practice is too much	13 (23%)
		- Need much specialized equipment to practice	4 (13%)	- Need much specialized equipment to practice	11 (20%)
		- Cannot create a hypothetical crash scene	6 (20%)	- Cannot create a hypothetical crash scene	6 (11%)
		- Long practice time	3 (10%)	- Long practice time	4 (7%)
		- Need more force to participate in practice	2 (7%)	- Need more force to participate in practice	4 (7%)
		- Another reasons	1 (3%)	- Another reasons	3 (5%)
	Have ever	47 (61%)		55 (50%)	

Group A had a lower percentage of people who had never designed a rescue plan than Group B. Group A was the main reason for not designing a rescue plan because they were only able to design a part of the rescue plan. Group B was the main reason for not designing a rescue plan because they did not know how to design it.

Group A had a lower percentage of people who had never practiced a rescue plan than Group B. Both Groups A and B stated that the main reason they did not practice the rescue plan was that the form of practice was not suitable for the type of incident.

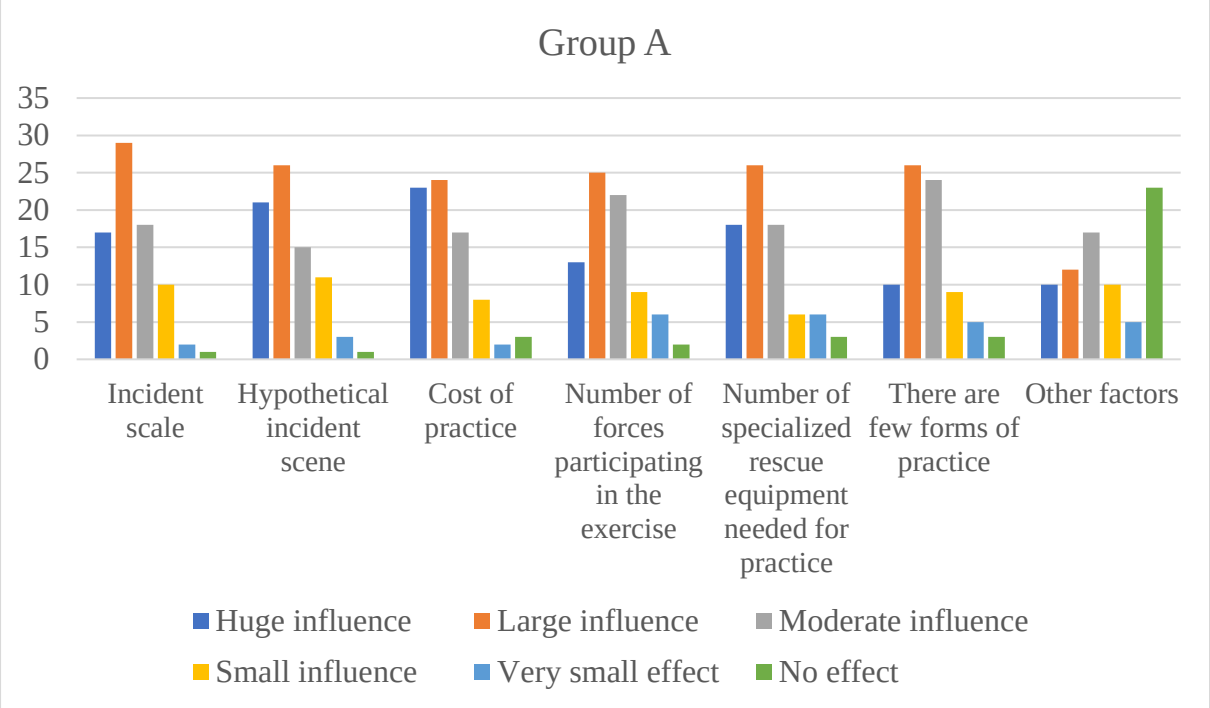


Fig. 3.2. Levels of influence of factors related to the practice of rescue plans of Group A

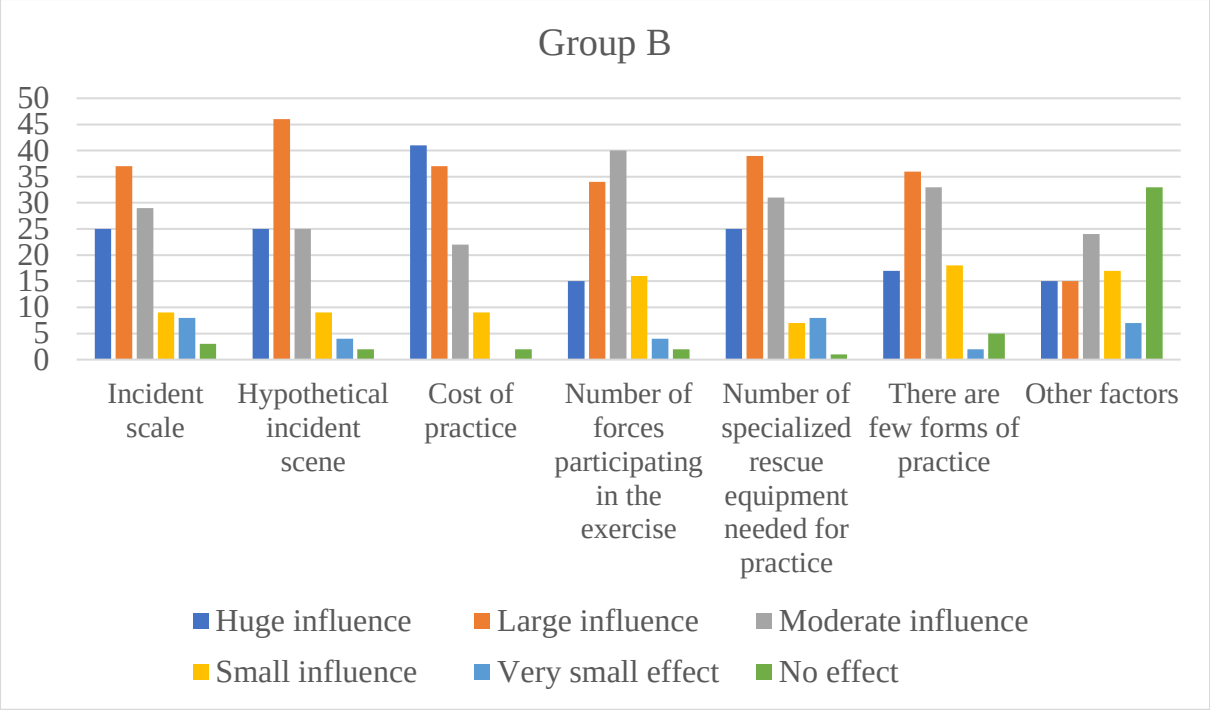


Fig. 3.3. Levels of influence of factors related to the practice of rescue plans of Group B

The factors believed to affect the practice of rescue plans are shown in Figures 3.2 and 3.3. Both Groups A and B believed that the cost of practice was the most influential factor in the practice of rescue plans.

3.3.2.2. Work experience and survey results

Group I had 52 people, Group II 84, Group III 42, and Group IV 10 as shown in Table 3.7. The results of the data analysis in these groups are shown in Tables 3.8–3.9 and Fig. 3.4-3.7. Group II had the highest percentage of people who had not yet designed rescue plans. Group I had the highest percentage of people who had not practice rescue plans. The reasons for not designing and practicing the rescue plan for each group were different. However, the percentage of those who had not designed or practiced rescue plans gradually decreased with the increase of the number of years of work experience.

Table 3.7. Work experience distribution of the groups A and B

Group	No of respondents	Group I (1–5 years of experience)	Group II (6–10 years of experience)	Group III (11–15 years of experience)	Group IV (16 years of experience or more)
A	77	21	35	18	3
B	111	31	49	24	7

Table 3.8. Experience of designing or practicing rescue plans

Category	Experience	Group I	Group II	Group III	Group IV
Designing	Yes	40 (77%)	64 (76%)	40 (95%)	10 (100%)
	No	12 (23%)	20 (24%)	2 (5%)	0 (0%)
	Total	52 (100%)	84 (100%)	42 (100%)	10 (100%)
Practicing	Yes	16 (31%)	50 (60%)	27 (64%)	9 (90%)
	No	36 (69%)	34 (40%)	15 (36%)	1 (10%)
	Total	52 (100%)	84 (100%)	42 (100%)	10 (100%)

Table 3.9. Reasons for not having experienced designing or practicing rescue plans for four groups

Category	Reason	Group			
		I	II	III	IV
Designing	Don't know how to design exercise	6 (50%)	2 (10%)	0	0
	Only be able to design part of the exercise	3 (25%)	3 (15%)	1 (50%)	0
	Combine firefighting and rescue exercises	2 (17%)	4 (20%)	0	0
	Can't practice the exercise so the design doesn't make sense	0	7 (35%)	0	0
	Due to the impact of Covid-19	0	4 (20%)	1 (50%)	0
	The cost is too expensive	1 (8%)	0	0	0
	Total number of people	12	20	2	0
Practicing	Cannot create a hypothetical crash scene	10 (28%)	1 (3%)	1 (7%)	
	Cost of practice is too high	4 (11%)	10 (29%)	3 (20%)	1 (100%)
	Form of the practice is not suitable for the type of incident	6 (17%)	9 (26%)	9 (59%)	
	Need a lot of specialized equipment to practice	7 (19%)	7 (21%)	1 (7%)	
	Need more force to participate in practice	4 (11%)	2 (6%)		
	Long practice time	3 (8%)	4 (12%)		
	Another reason	2 (6%)	1 (3%)	1 (7%)	
	Total number of people	36	34	15	1

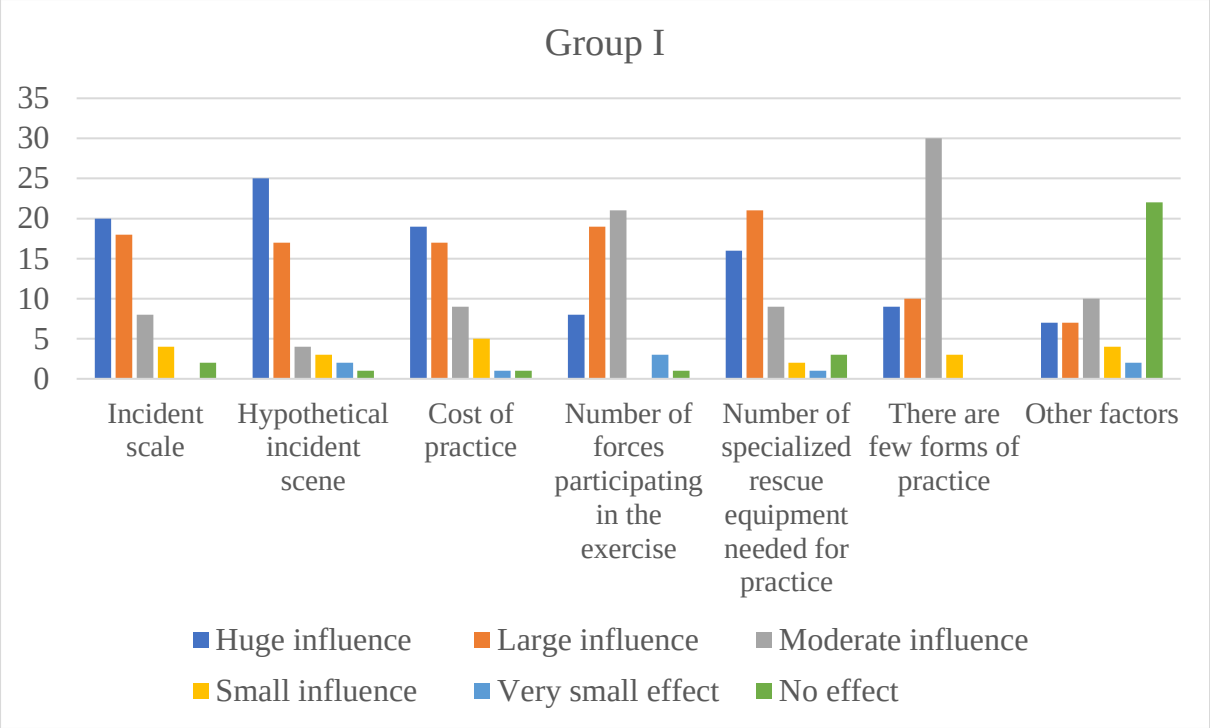


Fig. 3.4. Levels of influence of factors related to the practice of rescue plans of Group I

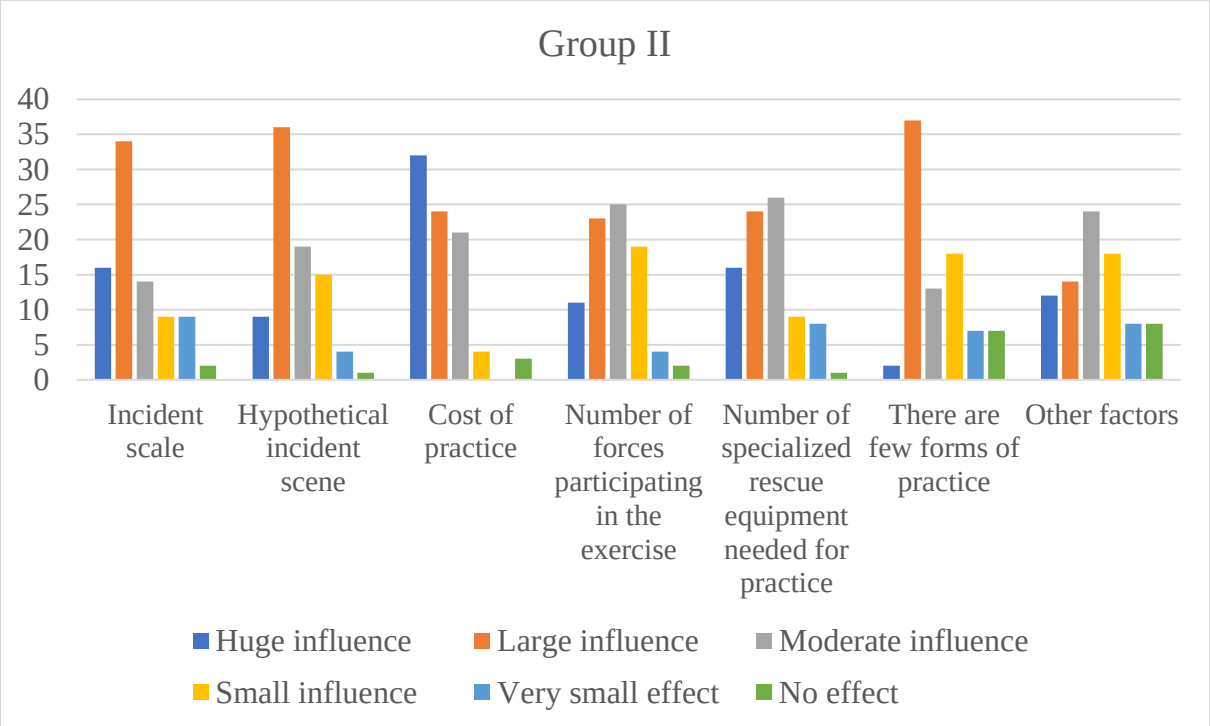


Fig. 3.5. Levels of influence of factors related to the practice of rescue plans of Group II

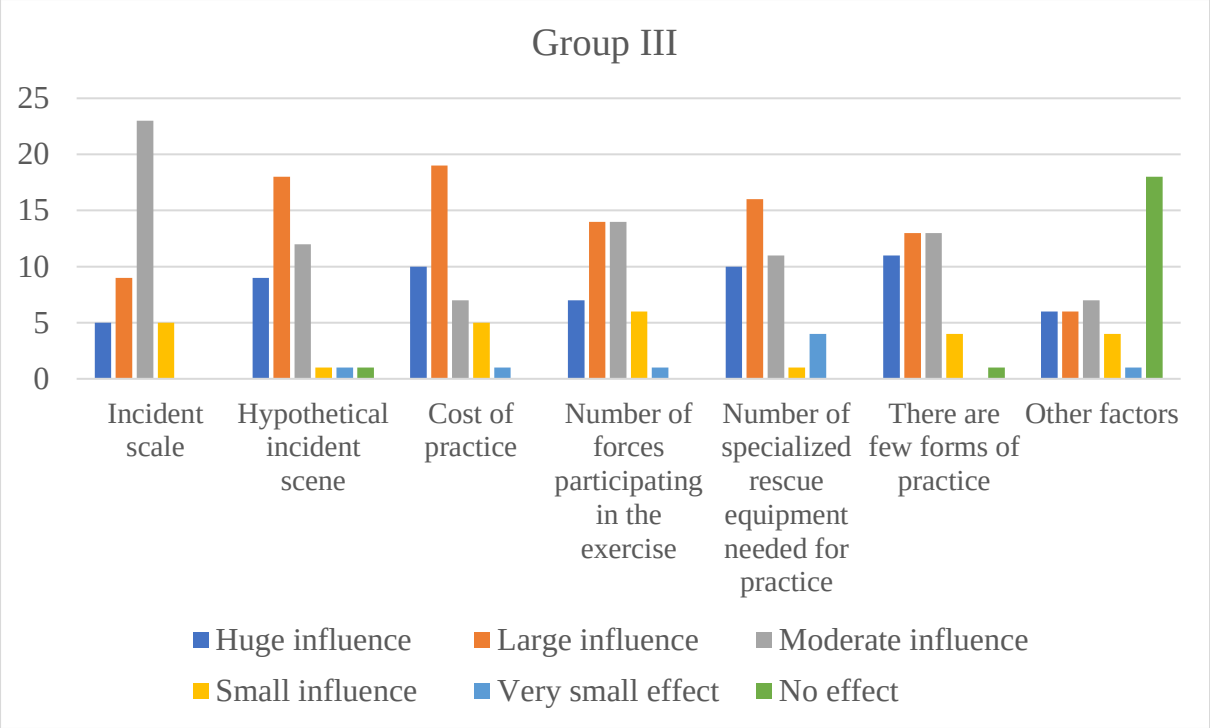


Fig. 3.6. Levels of influence of factors related to the practice of rescue plans of Group III

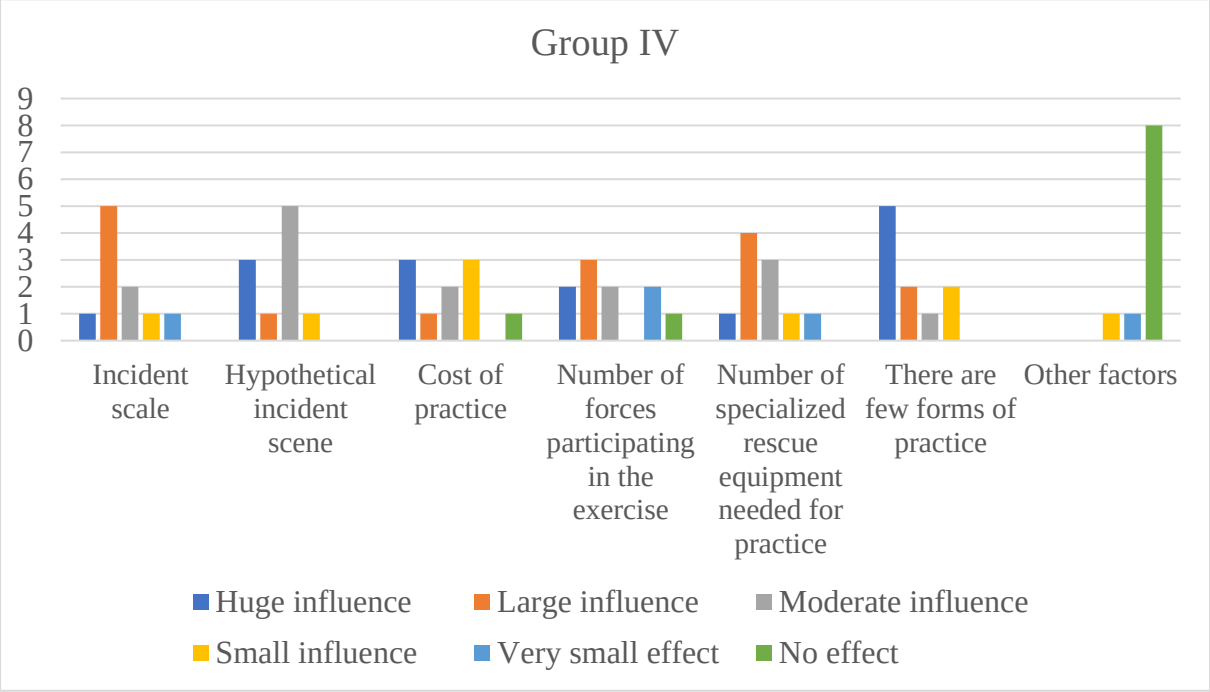


Fig. 3.7. Levels of influence of factors related to the practice of rescue plans of Group IV

Factors that are believed to affect the practice of rescue plans are shown in Figs. 3.4-3.7. Group I considered that the hypothetical incident scene factor had the greatest influence on the practice of rescue plans. Group II said that the cost factor to practice is the factor that has the

greatest influence on the practice of rescue plans. Groups III and IV considered that few forms of practice were the factors that had the greatest influence on the practice of rescue plans.

3.3.3. A comparison of Vietnamese firefighters' practice method with HSEEP

Vietnamese firefighters' rescue-plan practice is an operations-based exercise. The authors compared the exercises characteristics of Vietnamese firefighters in Table 3.5 with operations-based exercises based on the HSEEP (drill, functional exercise, and full-scale exercise) [HSEEP, 2020].

Table 3.10. The differences in the characteristics of the exercises of Vietnamese firefighters with drill, functional exercises, and full-scale exercises

Items	Rescue-plan practice of Vietnamese firefighters	HSEEP		
		Drill	Functional Exercises	Full-scale exercises
Element	(Same as Full-scale exercise)	It is often employed to validate a single operation or function of a force	The movement of resources is usually simulated.	(Same as the rescue-plan practice of Vietnamese firefighters)
Purpose	Similar to Full-scale exercise. However, the plans, policies, and procedures are not developed in discussion-based exercises and honed during previous, smaller exercises.	It is often employed to validate a single operation or function a force.	Focus on performing management, direction command, and control functions. Do not endorse the use of equipment, facilities, and skill retention practices.	The plans, policies, and procedures that may have been developed in discussion-based exercises and honed during previous, smaller exercises
Structure	Similar to Full-scale exercise. However, do not use Master Scenario Events List (MSEL) and Simulation Cell (SimCell).	Unrelated to multiple agencies, organizations and jurisdictions	Events are projected through a realistic exercise scenario with event updates that drive activity typically at the management level	- MSEL drives player actions - SimCell controls inject scenario elements
Participant goals	Similar to Full-scale exercise. Besides, it also has the goal of practicing and maintaining skills (Same as Drill).	There is no coordination between multiple agencies, organizations and jurisdictions	There is no practice and maintenance of skills.	(Same as the rescue-plan practice of Vietnamese firefighters)

Conduct features	(Same as Full-scale exercise)	- Narrow focus. - Performance in isolation	- A simulated deployment of resources and personnel - Use of MSEL and SimCell - Simulators can inject scenario elements	(Same as the rescue-plan practice of Vietnamese firefighters)
Outcomes	Similar to Full-scale exercise. However, there is no After-Action Report (AAR) /Improvement Plan (IP)	There is AAR /IP	- Management evaluation of Emergency Operations Center (EOCs), command post, headquarters, and staffs - Performance analysis - There is AAR/IP	There is AAR/IP

Table 3.10 shows that the Vietnamese exercises have many similarities with the Full-scale exercises of HSEEP. However, it does not undergo discussion-based exercises (TTX) or Functional Exercises. Vietnam's exercises are different from Drills because they deploy many forces. The Vietnam exercise can be considered as a partial version of the Full-scale exercise.

3.3.4. Discussion

Another interesting contradiction may be observed in this study. According to the 2020 work report of the Vietnam Fire and Rescue Police Department, eight provincial fire services belonging to Team B indicated that the number of times to design and practice the rescue plan and practice is zero (0). However, according to the survey, 78% designed the rescue plan of Team B, and 50% had practiced the plan. The explanation for the 2020 figures of the Vietnam Fire and Rescue Police Department is that the provincial fire services of Team B have combined the two types of firefighting and rescue plans. Rescue together into a type of plan: firefighting and rescue when a fire occurs. However, this type of plan is only applicable to fire incidents. This indicates that for incidents other than fire, rescue training exercises cannot be organized.

First, Section 3.3.1 helped the authors to answer Research Question 1. The rescue plan in Vietnam must be designed according to form No. 05 promulgated with the

Government's Decree 83/2017/ND-CP, stipulating the guidelines for rescue work on fire of the Fire Prevention and Fighting Police force. In fact, the 200 options collected in the study were guaranteed to follow the prescribed form. The training of Vietnamese firefighters was conducted by the University of Fire Prevention and Fighting. This textbook has specific instructions on how to design a rescue plan according to the prescribed form. However, in the system of legal documents of Vietnam as well as the system of theoretical basis at the University of Fire Prevention and Fighting, there are no regulations referring to the form of practice in rescue plans. In addition, there is no specific definition or concept to describe what is and how to classify it. By directly observing the rescue exercises and watching 100 videos of Vietnam's rescue exercises, the rescue practice in Vietnam is an activity-based exercise, incidents are constructed as closely as possible to the actual incidents, resources are mobilized according to the plan, all human and equipment activities are actual real-time activities. This is the only form of practice applied by Vietnamese firefighters for firefighting and rescue plans.

Second, Section 3.3.2 helped the authors to answer Research Question 2. According to the survey results of Groups A and B, Group A had a lower percentage of officers who had never designed a rescue plan than Group B (Table 3.6). Looking at four groups from I to IV, the percentage of officers who have never designed a rescue plan is as follows: Group II (24%), Group I (23%), and Group III (5%). All people in Group IV have designed a rescue plan (Table 3.8). According to the analysis results, the main reason leading to the failure to design is not knowing how to design the plan or only partially being able to design a rescue plan (Table 3.9). This highlights the limitations in training and guiding the design of rescue plans. In addition, the difficulty in practicing the rescue plan has reduced the design motivation. It also tends to integrate the rescue plan into the same rescue plan as that for fire. However, this solution can only be applied to fires. The survey also shows that the people with one to ten years of work experience faces the most design problems.

The analysis shows that the percentage of people who have never practiced a rescue plan was 39% in Group A and 50% in Group B (Table 3.6). These two ratios are quite large, indicating that the practice of rescue plans for Vietnamese firefighters experiences great difficulties. The analysis results according to four groups of subjects according to work experience showed that the rate of not practicing the rescue plan of Groups I to IV was 69%, 40%, 36%, and 10%, respectively (Table 3.8). All four groups have difficulties in practicing rescue plans. The main reasons for this are that the form of the practice is not suitable, too high costs, and not creating a hypothetical incident scene (Table 3.9). The results also show

that the specific problems faced by each group are different. According to the survey results, Groups A and B had different opinions about the influence of factors on the practice of rescue plans. In addition, four groups of subjects, according to years of working experience, also had different opinions about the influence of factors on the practice of rescue plans (Figs. 3.4-3.7). However, the factors that frequently appear in the very large, large and medium influence groups are the cost of practice and ineffective forms of practice.

Table 3.11 summarizes the answers to Research Question 3. Section 3.3.3 helped the authors answer this question. Vietnam firefighters' rescue-plan practice is an operations-based exercise. Table 11 show that the Vietnamese way of practicing the rescue plan is similar to a full-scale exercise. However, Vietnam's rescue practice does not undergo drill and functional exercises, and once implemented, it is not specifically evaluated by the After-Action Report (AAR) or Improvement Plan (IP). Practicing the rescue plan in Vietnam is not the same as in drills because the rescue plan in Vietnam involves many forces. The type of exercise performed by Vietnamese firefighters did not have an effective method of evaluating results. The addition of AAR/IP is necessary for the evaluation of the results of training in rescue plans for Vietnamese firefighters.

Table 3.11. Identified problems and recommendations

Problems found in this study	Recommendations
Practicing the rescue plan of Vietnamese firefighters is a form of exercise similar to a full-scale exercise. The difference is that it doesn't develop plans, policies, and scenarios through honing in previous smaller exercises. In addition, the evaluation method of Vietnamese exercise is not clear and effective.	Evaluation methods for the exercise of Vietnamese firefighters need to be developed. Developing plans, policies, and scenarios through small drills is essential when practicing with large-scale incidents.
There is only one type of exercise; It is not possible to create a hypothetical incident scene and it is too expensive to practice exercises with major incidents such as landslides, building collapses, etc.	Vietnam needs to build a system of theoretical foundations on the types of exercises and their applications. For large-scale incidents such as building collapses, landslides, Vietnamese firefighters can apply functional exercise and table-top exercise as a solution to overcome limitations such as cost, incident scene.

In addition, the fact that only one type of operation-based exercise exists makes it difficult for Vietnamese firefighters to apply it to emergencies that require space, time, and cost. The development of some types of exercises similar to drills and functional exercises is necessary for Vietnamese firefighters to practice rescue plans. Therefore, the solution to improve the practice of rescue plans in Vietnam is to have more forms of rescue practice; thus, more types of exercises are suitable for each type of incident pattern, as well as the size of the incident. Thus, reducing the dependence of rescue-plan practice on creating a hypothetical incident scene or the cost of practice is too great.

3.4. Summary of Chapter 3

Chapter 3 has shown the characteristics of the rescue plan exercises in Vietnam. Regarding the first research question of this chapter, it closely resembles the full-scale exercise of HSEEP. However, it is not honed and developed through the previous smaller exercises.

The chapter also pointed out that the reason leading to the limitation in the design and practice of rescue plans for Vietnamese firefighters (the second research question) is the lack of types of exercises; it is too expensive to practice exercises with large-scale incidents and it is not possible to create a hypothetical incident scene.

Finally, the research suggests that the solution to improve the practice of rescue plans in Vietnam (the third research question) is to improve the current type of exercise by developing effective assessment methods. Besides, it is necessary to diversify the form of rescue practice, such as more types of exercises suitable for each type of incident pattern, as well as the scale of the incident. Vietnamese firefighters can apply functional exercise and table-top exercise as a solution to overcome limitations such as cost, and incident scene. Vietnamese firefighters can disseminate these exercise skills to many establishments in the country. These problems are largely shared in Cambodia and Laos; thus, our recommendations are applicable to these countries as well.

4. Developing a method of evaluating functional exercises applying Bloom's taxonomy

4.1. Introduction

The literature on the appropriate education criteria for training young emergency responders in developing countries is scarce. There is a gap between general education and emergency responder education in terms of the criteria used for designing education courses and evaluating students. Chapter 4 reviewed the criteria used at the University of Fire Prevention and Fighting in Vietnam. Although the university had used Bloom's taxonomy, which is one of the well-known evaluation criteria for general education programs, in addition to the professional criteria for emergency management, only the bottom three levels of the taxonomy were considered. The author then designed a new training course for preparing and conducting landslide rescue exercises, and applied all six levels of Bloom's taxonomy to evaluate students' performance and responses. The course consisted of lectures, an exercise, and a hot debriefing session for 52 3rd-year students. Consideration of all levels of Bloom's taxonomy enabled the identification of differences in learning performance between exercise participants and observers among the students. The evaluation results based on the general and professional education criteria differed regarding the performance of students with work experience.

Bloom's taxonomy has been frequently used to design and evaluate general education programs [López-Reyes, L.J. et al, 2022; Maffei, A. et al, 2022; Pikhart, M. et al, 2019; Plack, M.M. et al, 2007]. Bloom's taxonomy was first published in 1956 [Bloom, 1956] and then modified in 2001 [Krathwohl, D. & Anderson, L., 2001]. The 2001 version has six hierarchical levels. They are, from the bottom to the top, "remember," "understand," "apply," "analyze," "evaluate," and "create." Bloom's taxonomy has been applied not only to school student education, but also to the education of practitioners, such as tour guides [Wang, 2012]. Some scholars have applied Bloom's taxonomy to the education of emergency responders [Lamb, K. et al, 2021; Dobrovic, Z. & Jovicic, N., 2022; Neal, 2004], but the merits of applying the taxonomy to firefighters' education have not been fully identified.

UFPF is the only place that trains Vietnamese firefighters. This university also regularly trains officials and experts in the fields of fire prevention, fighting, and rescue in countries such as Laos and Cambodia. Currently, UFPF offers five regular training programs for firefighters, including an Intermediate training program, a Transition program from

intermediate to university levels, an Undergraduate university program, a Master's program, and a Doctoral program.

Table 4.1. Regular training programs in the University of Fire Prevention and Fighting, Vietnam

Program	Main content
Intermediate training program	The training period is 2 years. Training subjects are high school graduates and conscript soldiers. After graduation, students will become fire prevention, fighting and rescue workers.
Transition program from intermediate to university levels	The training period is 3,5 years. Training subjects are firefighting workers who have intermediate degrees. After graduation, the students will become fire prevention, fighting and rescue officers.
Undergraduate university program	The training period is 4 years. Training subjects are high school graduates and conscript soldiers. After graduation, the students will become fire prevention, fighting and rescue officers.
Master's program	The training period is 2 years. Training subjects are team-level leaders of the firefighting force who have university degrees, trainee teachers, teaching assistants of the University of Fire Prevention and Fighting.
Doctoral program	The training period is 3 years. Training subjects are departmental leaders of the firefighting force who have master's degrees, and lecturers at the University of Fire Prevention and Fighting who have master's degrees.

In this Chapter, the author chose the undergraduate university program at UFPF as the subject for evaluation. UFPF trains firefighting leaders in a 4-year higher education program. They learn general science, industry foundation, and specialized subjects. Two teaching methods were applied to these students: theoretical teaching and practical teaching. A university degree is a must-have criterion for becoming a leader at all levels of the Vietnamese firefighting force. In addition to the criteria for degrees, leaders are selected and promoted through their professional lives.

Some countries have now implemented professional training programs for firefighters, which are often short and focus on providing specialized knowledge, practicing skills in using equipment, and improving coordination when performing tasks for firefighters. There is a large difference in firefighters' education in Vietnam and in other countries, such as Japan and the US. For example, Japan does not have a 4-year university program that

specializes in firefighter education. Instead, students who graduate from regular high schools or universities are employed in fire departments. These new firefighters received basic training in a fire academy for approximately six months. They are then trained on a job basis, and leaders are selected and promoted through their professional life [Kadokura, 2013] In addition to training methods, evaluation methods differ across countries.

This Chapter has three objectives. First, it reviews the methods for designing and evaluating criteria for firefighter education subjects at UFPF, and compares them with existing general and professional education criteria. Second, it applies both professional and general sets of evaluation criteria to a firefighter training program, which consists of lectures and an exercise, and shows what is identified by each set of criteria. The differences between exercise participants and observers and the effects of previous work experience as a firefighter are also discussed. Third, it proposes ways to effectively use these different criteria to improve firefighter education. The evaluation framework for firefighters' education in developing countries has rarely been documented in the literature, and this paper provides comprehensive information about Vietnam as a case study. This chapter is an expansion of Le et al. [*Development of Evaluation Criteria for Training Fire Students to Enable New Rescue Roles in Vietnam*. (Accepted in December 2023)].

4.2. Student evaluation criteria of the University of Fire Prevention and Fighting, Vietnam, and our extension

The method of evaluating students at the University of Fire Prevention and Fighting depends on the objectives of the training program. Based on the training objectives of the program, faculty members develop detailed objectives for each subject that the faculty is in charge of teaching. The detailed objectives of the subjects were built in three domains: knowledge, skill, and attitude. Achievement of the knowledge goal was assessed based on Bloom's taxonomy. However, only three lower levels were used: remembering, understanding, and applying. To assess students' knowledge levels, the university created a bank of exam questions and answers for each subject. The testing format typically includes three questions corresponding to three taxonomic levels. The tests for the theoretical subjects used constructed-response or selected-response questions. The tests for practical subjects used oral and practical questions. The examinations for practical subjects included three questions, including one remembering level theory question, one understanding level theory question, and one applying level practice question. The answers to the practice questions were graded based on the time taken to perform the skill and the precision of the skill. Skill

goals were specified based on Dave's taxonomy [Dave, 1970]. However, the university has not yet built its own question-and-answer bank to assess students' skills in practical subjects. Achievement of the attitude goal was evaluated based on each teacher's view and experience.

The target of this chapter was a practical subject that teaches emergency management exercise methods for landslide rescue scenes. The rescue responsibility of Vietnamese firefighters was expanded in 2017 to include various incidents and accident cases according to the provisions of Decree 83/2017/ND-CP in response to national policy to expand preparedness for incidents and accidents. Therefore, this is a new training program. The training course consisted of lectures, an exercise, and a hot debriefing session. Due to time and equipment limitations, some of the students did not join the exercise as players, but observed the exercise.

In this chapter, knowledge, skills, and attitude goals were considered. A full set of six levels of Bloom's taxonomy were considered. Thus, the upper levels of analyzing, evaluating, and creating capabilities were assessed in addition to the three previously assessed lower levels. Achievements in the upper three levels require not only knowledge but also skills. In job-skill education, productive diversity" has been pursued since the end of Fordism and post-Fordism [Kalantzis, M. & Cope, B., 2012]. Firefighters' jobs are not a repetition of a simple procedure because of the diverse situations to which they deal. However, analyzing and evaluating situations and the effectiveness of their interventions and creating new countermeasures are becoming increasingly important as the intensity of natural disasters increases. Therefore, we evaluated these three levels. Students' attitudes toward the lecture and exercise were also considered because the players and observers of the exercise might differ in this regard. Kirkpatrick's criteria [Kirkpatrick, D.L. & Kirkpatrick, J.D., 2006], which are often used in job-oriented education, were used to measure students' attitudes.

In addition to general education criteria, emergency management-specific criteria were used to evaluate students' performance in the exercise. Details of the evaluation criteria used in this study are explained in the next section.

4.3. Methods

4.3.1. Training course and participants

The author designed and conducted a new training course on emergency management exercises at the University of Fire Prevention and Fighting. This training course is considered an extracurricular activity for students. The training course took place from July 25, 2022, to July 27, 2022. The venue for the training course was Classroom 403 at the University of Fire

Prevention and Fighting. The training course consisted of two main parts. The first part was theoretical training with lessons that provided knowledge of emergency management exercises. The second part was practicing a functional exercise and hot discussion after the exercise. In functional exercises, students created groups to simulate firefighting functions, such as a field rescue force. They communicated and made decisions to respond to the exercise injects provided by teachers according to a disaster timeline hidden from the students. This is a typical procedure of functional exercises for emergency responders [Phelps, R., 2010; Walter G. Green III, 2000].

The students targeted by the author were third-year undergraduate university students. The reason the authors chose third-year students is because, at the time of the training, the fourth-year university students were doing graduate internships at the provincial fire services and the third-year students were the most senior students. A total of 52 students participated in this course.

One challenge in conducting this study was that the participants had not learned about the concept of an emergency management exercise. However, a good point was that they had been equipped with fairly complete knowledge of the rescue work of the firefighting force. Therefore, the content of the training course focused on providing participants with knowledge about emergency management exercises. It was expected that from there, they could prepare, plan, design, and conduct the exercises.

The duration of the theoretical training was nine hours. The content of the theoretical training was divided into four major topics, as shown in Table 4.2. (I) Introduction to emergency management exercises; (II) Design of emergency management exercises; (III) Practice emergency management exercises; (IV) Report on post-exercise management of emergency management exercises. When designing the course content, the authors and lecturers referred to documents written by emergency management researchers [Phelps, 2010; Walter G. Green III, 2000; Thuy, V.V. & Tien, P.V., 2017] and organizations [HSEEP, 2020]. The course was taught by lecturers in the Faculty of Rescue at UFPF.

Table 4.2. Topics of theoretical training

Topic	**Sub-topic**	**Duration** (minute)
I. Introduction to emergency management exercises	1. Purpose, concept of emergency management exercises	45
	2. Classification of emergency management exercises	
II. Design emergency	1. Requirements for the selection of the design team	225

management exercises	2. Develop an exercise design plan	
	3. Developing the exercise scenario	
	4. The drivers – exercise injects	
	5. Discussion to defend the exercise	
	6. Support tools and exercise support documents	
III. Practice emergency management exercises	1. Requirements for the selection of the exercise team	180
	2. The preparation work before practicing exercises	
	3. How to conduct an orientation exercise	
	4. How to conduct a tabletop exercise	
	5. How to conduct a functional exercise	
IV. Report, post-exercise management of emergency management exercises	1. Preparing the after-action report and exercise follow-up	90
	2. Developing an annual or multi-year exercise and training calendar	
	3. Exercise design resource list	

Among the course students, 25 participated in the functional exercise as players (Group A), and 27 observed the exercise (Group B). The members of Groups A and B were randomly selected. They participated in the same theoretical training and hot debriefing sessions. Table 4.3 lists their personal attributes. The job experience column shows the number of students who had previously worked as firefighters.

Table 4.3. Personal attributes of program participants

	Sex (persons)		**Job experience** (persons)	**Age** (years)			
				Without job experience		With job experience	
	Male	Female		Range	Average	Range	Average
Group A	22	3	5	21-23	21.4	22-24	23.2
Group B	26	1	4	21-23	21.5	22-25	23.3
Total	48	4	9	21-23	21.4	22-25	23.2

A functional landslide response exercise was designed and practiced by the participants. Group A was divided into four implementation teams: grassroots firefighting force (team I), command information center 114 (team II), rescue force (team III), and medical force (team IV). A teacher at the Rescue Faculty of the university sent exercise injects, which indicated problems to be solved, to the teams according to the disaster timeline. There were five types of tasks to be completed: reporting, decision-making, suggestions,

discussion, and maneuvering. Each team was evaluated by a teacher from the university's Rescue Faculty. There were 21 exercise injects, and 71 tasks were expected to be completed in response to these injects. Table 4.4 lists the number of students on each team.

Table 4.4. Student groups for functional landslide response exercise

	Job experience (persons)		**Exercise intensity**		
	Not experienced	Experienced	Number of injects	Number of tasks done	Number of tasks skipped
Team I	4	2	3	10	1
Team II	5	1	2	9	0
Team III	6	1	11	45	1
Team IV	5	1	5	5	0

4.3.2. Evaluation by self-administered questionnaires

The questionnaire used for this chapter consisted of three parts: Part 1 is about demographic data. Part 2 askes the knowledge of landslide rescue operations. Part 3 concerns participants' attitudes toward the course [Appendix 3-5].

Students' knowledge levels were evaluated using the questions listed in Table 4.5. The descriptions of the questions included both the question texts shown in the questionnaire and information orally supplemented by the teachers. These questions correspond to each level of Bloom's taxonomy. The table shows the taxonomy levels in the opposite order. The questions for the first three levels were referenced to the examination question set of the university, and the remaining questions were created by the author. The students answered these questions in an open-ended format and the teachers determined the correctness of their answers.

Table 4.5. Questions for evaluating Bloom's taxonomy levels

Question number	**Bloom's taxonomy**	**Question**
1	Remember	Please name the rescue activities at the scene of the landslide incident
2	Understand	Please explain why safety management is an extremely important activity at the site of a landslide incident.
3	Apply	Suppose at 22:15 on May 25, 2022, there was a landslide of 1200m3 of soil that buried a house in province B. At the time of the incident, there were 3 people inside the house. If you are a rescue

		commander, what activities do you need to do? Explain why you do those activities.
4	Analyze	Please analyze the difference between landslide rescue and firefighting work
5	Evaluate	In your opinion, what are the points that need to be improved in the current landslide rescue work in Vietnam? Why?
6	Create	Please present your idea for a new landslide response procedure that you think is more suitable for the conditions in Vietnam. What are the new features and advantages of the new process you propose?

Attitudes toward this training course were measured using the questions listed in Table 4.6. These questions were presented in the questionnaire. Kirkpatrick's four levels, which are frequently used to design job-related education programs, were used to create these questions [Kirkpatrick, D.L. & Kirkpatrick, J.D., 2006]. The four levels are reaction, learning, behavior, and results. The reaction level is mostly relevant to students' attitudes toward the course in question, and we focused on this level. The students answered these questions on a five-point scale: (very good, good, normal, poor, and very poor).

Table 4.6. Attitude questions

Question number	Question
1	Are you satisfied with the course?
2	Was the course useful?
3	Is the content relevant to your future work?
4	Would you recommend the course to others?

The questionnaire surveys were administered three times to the same students. The first survey was conducted immediately before the lectures. This survey questionnaire did not have the attitude questions. The second survey was done after the functional exercise and before the hot debriefing session. The last survey was completed immediately after the hot debriefing session.

4.3.3. Evaluation by teachers' observations and exercise records

Two types of professional evaluation criteria closely related to emergency management practices were used in this Chapter. First, the authors created a checklist for use by the exercise teachers. The checklist included the following items: ability to convey

information, ability to receive information, ability to analyze situations and make decisions, and positive attitudes of each team member. During the functional exercise, four teachers evaluated the performance of each student in Group A using this checklist on a five-point scale: very good, good, average, poor, and very poor. Video and audio recordings were used for evaluation. Second, the number of tasks completed and time spent completing each task were recorded. These are objective indices of achievement in functional exercise [To, N.T. et al, 2019; Kato, T. et al, 2016].

4.4. Results

4.4.1. Knowledge and skills

Figure 1 shows the percentage of correct answers for Groups A and B regarding landslide rescue, evaluated at each level of Bloom's taxonomy. The first level of remembering had been cleared by all the students before this training course started. This performance was maintained until completion of the training course. The understanding capability was significantly improved by listening to lectures. Then, through functional exercises, every student understood the required ideas. There was no difference in this pattern between the participation and observation groups. Students' performance on the application and analysis levels improved significantly after participating in the exercise. The performance gain of the analysis level occurred mainly because of the hot debriefing session. Group A's performance outstripped that of Group B, indicating the importance of participation in both the exercise and the hot debriefing session to develop these capabilities. The development of the evaluation capability was limited to a small number of students, even in Group A. Regarding the top-level taxonomy of creating, no correct answers were elicited throughout the three surveys, and its graph was omitted from the figure. Among the results shown in Fig. 1, the following pairs produced statistically significant differences between the groups by means of exact chi-square tests: Survey 2 ($x2(1)=22.2$, $p=0.000$) and Survey 3 ($x2(1)=6.61$, $p=0.013$) in panel c and Survey 3 ($x2(1)=7.77$, $p=0.008$) in panel d.

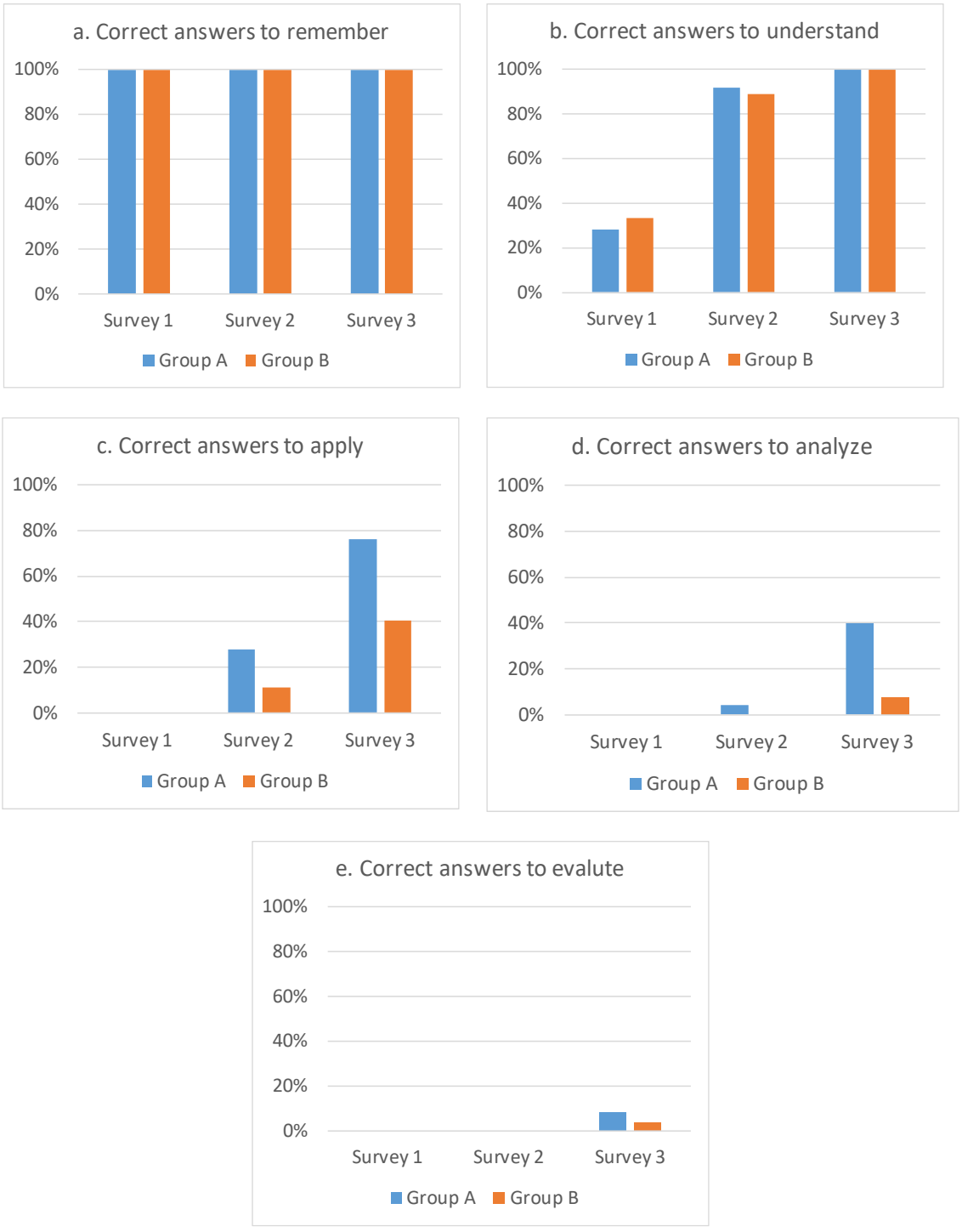


Fig. 4.1. Percentage of correct answers to knowledge and skill questions

Table 4.7 shows the average of the highest levels reached by the students in Bloom's taxonomy. Numbers 1–6 were assigned to the levels of Bloom's taxonomy from bottom to top and then averaged. In all six cases in terms of groups and survey waves, students with firefighting job experience were outperformed by those without job experience. The probability of obtaining this result when there is no performance difference due to job

experience is 0.5^6 = 0.0156 or 1.56%. Thus, job experience is related to the difficulty of reaching higher levels in terms of Bloom's taxonomy at the 5% statistical significance level.

Table 4.7. Average scores for the knowledge and skill questions

		Participants (Group A)			Observers (Group B)		
		All	Without job experience	With job experience	All	Without job experience	With job experience
Survey 1		1.28	1.35	1.00	1.33	1.35	1.25
Survey 2		2.24	2.35	1.80	2.00	2.04	1.75
Survey 3		3.24	3.35	2.80	2.52	2.57	2.25
Difference	1 and 2	0.96	1.00	0.80	0.67	0.69	0.50
	2 and 3	1.00	1.00	1.00	0.52	0.53	0.50

Table 4.8 shows the average scores for Group A exercise teams. All teams improved their knowledge scores during the training. Team III had the highest average score from the beginning and continued to lead the other groups until the end of the program.

Table 4.8. Average knowledge and skill scores by exercise teams

		Team I (Grassroots force)	**Team II** (Information and Command Center)	**Team III** (Rescue force)	**Team IV** (Medical force)
Survey 1		1.17	1.00	1.86	1.00
Survey 2		2.17	2.00	3.00	1.67
Survey 3		3.33	3.00	4.14	2.33
Difference	1 and 2	1.10	1.00	1.14	0.67
	2 and 3	1.16	1.00	1.14	0.66

4.4.2. Attitudes

Figure 4.2 summarizes the distribution of the answers to the attitude questions. There were distinctive differences between the exercise participants (Group A) and observers (Group B). The answers to all four questions by the observation group shifted toward the students valuing the training more highly in Survey 3 than in Survey 2. Thus, after the hot debriefing session, Group B students changed their attitudes toward the training course and perceived the course as beneficial to them. The directions of the answer changes in Group A differ across the four questions. Thus, the exercise players did not clearly change their attitudes toward the training course.

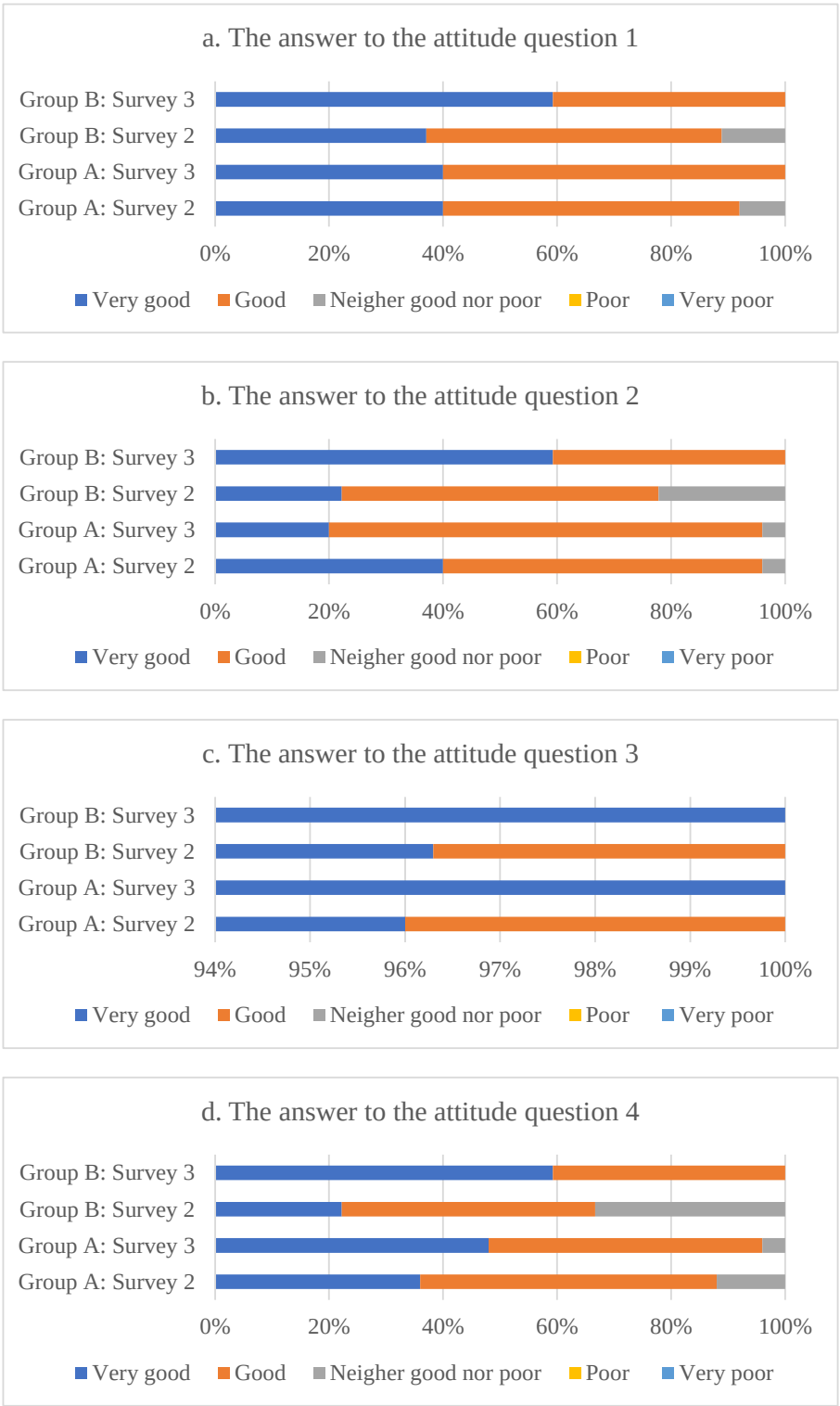


Fig. 4.2. Answer distributions for attitude questions

Table 4.9 shows the average scores for the four attitude questions across the students. The author assigned a score from 5 to 1 to answers very good, good, normal, poor, and very poor, and then averaged the scores. Students with firefighting job experience obtained higher scores than those without job experience in all comparable cases. However, this seemingly different result is not statistically significant ($p = 0.5^4 = 0.0652$).

Table 4.9. Average scores for the attitude questions

	Participants (Group A)			Observer (Group B)		
	All	Without job experience	With job experience	All	Without job experience	With job experience
Survey 2	4.47	4.39	4.80	4.28	4.27	4.31
Survey 3	4.50	4.43	4.80	4.69	4.67	4.81
Difference	0.03	0.04	0.00	0.41	0.40	0.50

4.4.3. Teachers' observations and exercise records

Table 4.10 shows the average scores obtained from the teachers' evaluation for Group A. Interestingly, students with work experience performed better than students without it.

Table 4.10. Exercise performance evaluation by teachers

Content	All	Without job experience	With job experience
Ability to convey information	3.96	3.57	4.80
Ability to receive information	4.08	3.67	5.00
Ability to analyze situations and make decisions	3.72	3.33	4.60
Positive attitude	4.28	4.05	4.40
Average	4.01	3.66	4.70

Figure 4.3 summarizes the objective records of the functional exercises involving all teams. The tasks are sorted into five types. The bar chart shows that almost all tasks were completed by Group A students; indicating, they responded to the exercise injects appropriately. Decision-making took more time than other types of tasks.

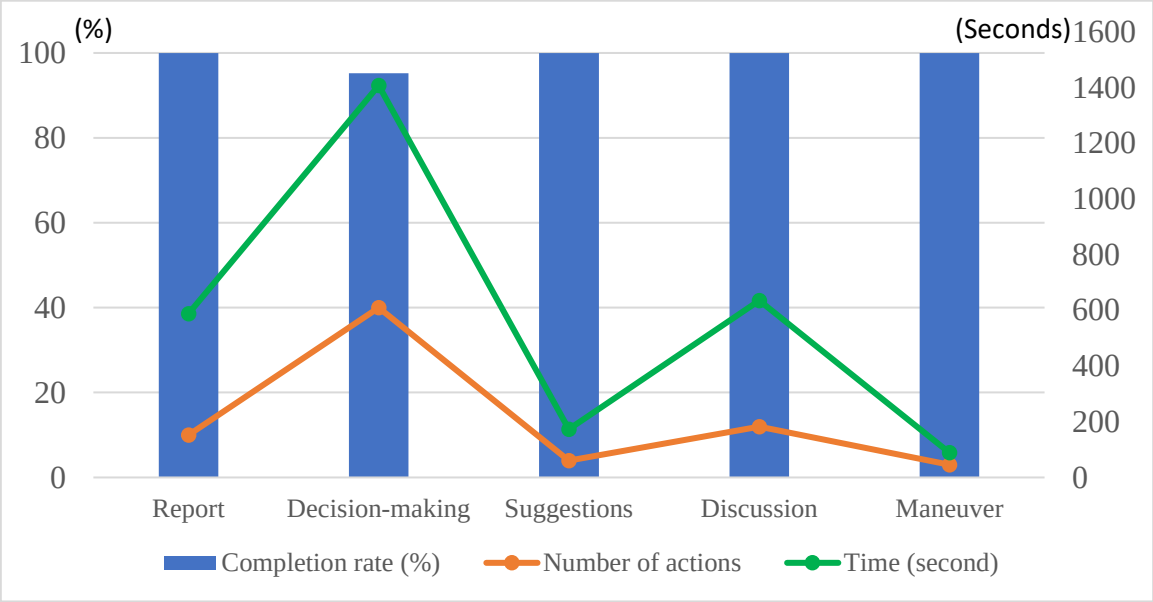


Fig. 4.3. Task completion rate and total task completion time for each task type

4.5. Discussion

4.5.1. Application of general and professional evaluation criteria to the training course

4.5.1.1. Knowledge and skills

All participants in the course increased levels of knowledge during the course activities. Table 4.7 shows that before taking the course, Group A had a slightly lower average knowledge/skill score than Group B. After the exercise, Group A showed a higher average score in the knowledge/skill domain than group B. This shows that participating in the functional exercise had a positive effect on increasing the knowledge and skills of the participants. Figure 4.3 shows that the Group A students performed well in the exercise. Participating in the exercise helped players better understand the emergency response process, preparation and support activities, activities at the incident scene, and how to coordinate the mutual support of agencies and organizations participating in emergency responses. Indeed, a student in group A noted in the questionnaire that "Before taking the course, we learned about the emergency response when a landslide occurs. We know and understand the activities, functions, the roles of agencies and organizations, however, it is difficult for us to imagine how they coordinate, how to solve problems arising in reality. I have felt like we were on a real emergency response, which provided us with more knowledge and experience." Figure 4.1 shows that this improvement by Group A occurred at the application and analysis levels of Bloom's taxonomy. Application capability improved during the exercise, but the analysis capability improved during the hot debriefing session after the exercise. Although not as effective as Group A, Group B students who observed the exercise did show some improvement in their application capability, but they failed to improve their analysis capability through this training course. These results demonstrate the importance of considering all six levels of Bloom's taxonomy for evaluating student performance and designing better training courses for firefighters. This result is consistent with the findings of a previous study on educating emergency responders [Lamb, K. et al, 2021].

Before taking the course, students who had no work experience in Groups A and B had the same level of knowledge and skills (see Table 4.7). Group A students with work experience had slightly lower levels of knowledge and skills than Group B students with work experience. After taking the course, the students with and without work experience in Group A achieved higher knowledge/skill levels than the corresponding student portions in Group B. Students with no work experience in Group A showed the highest improvement during the course (score of 1.00), and the students with work experience in Group B showed the lowest improvement (score of 0.50).

Before entering the University of Fire Prevention and Fighting, the group of students with work experience received only three months of short-term training in using personal equipment skills and knowledge of fire prevention and fighting. They were not provided with in-depth knowledge of rescue, and landslide rescue, in particular. None of the five students with work experience in Group A had ever participated in landslide rescue and were mainly involved in firefighting. Therefore, their work experience did not provide good scores for knowledge/skill questions regarding landslide rescue exercises.

Among the student groups of the functional exercise, before joining the course, Team III had the highest knowledge/skill scores (S=1.86); Team II and Team IV were the two teams with the lowest scores (S=1.00). After participating in the exercise, team IV had the lowest knowledge and skill scores, and team III had the highest levels. Table 4.4 shows that the number of injects that each team received and the number of tasks that each team performed were not the same, which could cause differences in the levels of improvement across the teams. Tables 4.4 and 4.8 show that the increase in knowledge and skill scores tended to be proportional to the total number of injects received and the number of tasks performed by the teams. Receiving many injects and performing many tasks may increase a player's ability to think, evaluate, and apply knowledge. This is a point worth noting, so that we can adjust the structure of the exercise so that groups of players achieve the same effect.

4.5.1.2. Attitudes

Table 4.9 shows the attitudes of the students, measured in terms of the reaction level among Kirkpatrick's four levels. Groups A and B both achieved good levels in surveys 2 and 3. This shows that the course content and assignments were relevant to the student's needs. The average attitude score of Group A after participating in the exercise was higher than that of Group B. However, Group A's score after finishing the course was lower than that of Group B. Group B had a desire to participate in more assignments because they did not participate in the exercises. For example, a Group B student noted "Watching people take on tasks and handle situations is interesting. I and everyone is looking forward to participating in the exercise."

4.5.1.3. General and professional evaluation criteria

Table 4.10 shows that teachers' performance evaluation during the exercise was preferable to students with work experience than those without work experience. The ability to receive and communicate information in particular, showed a distinctive difference between the two types of students. The students with working experience seem to have become familiar with receiving and communicating information during their active firefighting roles. They know how to convey information in a concise, clear, and complete manner. A calm attitude also

helps them grasp information more accurately and quickly. In contrast, the students without work experience often conveyed information in a non-fluent manner. They used many redundant words, making the conversation longer. It is notable that the knowledge/skill evaluation due to the questionnaires and this work skill evaluation by teachers created opposite results regarding the impacts of work experience even though some of the evaluation items were similar between these two methods. Thus, evaluating students from different angles using different evaluation media is important to know their diverse capabilities.

4.5.2. Recommendations for education improvement

The bottom three levels of Bloom's taxonomy will help learners effectively apply the knowledge and skills learned. In particular, it has a significant effect on firefighters when applied to responding to incidents that occur frequently. However, for incidents of new or unusual nature, those that have never happened in the past, or problems arising when responding, firefighters need the following three upper levels of Bloom's taxonomy: analyze, evaluate, and create. Incidents and accidents are highly diverse phenomena. Therefore, full use of Bloom's taxonomy for firefighter evaluation is necessary.

Designing a uniform number of injects and response actions for exercise groups can contribute to a more uniform increase in player knowledge. However, further research is required to support this view. Functional exercise has been shown to have a positive effect on participants' ability to increase knowledge. Therefore, it is recommended that everyone participates in the exercise. However, sometimes the conditions are insufficient for everyone to participate in the exercise. Therefore, methods for increasing observer knowledge need to be studied and developed further. One possible method is to have a group of observers sit in small groups and discuss it in parallel with exercise practice. This idea was suggested by the authors' finding that observers commented enthusiastically when observing the exercise practice. Having observations and small-group discussions about specific goals can help observers improve their analytical and evaluation abilities.

Trainees with work experience produced mixed results depending on the evaluation method. Thus, evaluation methods need to be designed from multiple angles to accurately address the capabilities of students with different backgrounds. Through the answers to the attitude questions, students with work experience can contribute to evaluating the effectiveness of the training course. They were able to evaluate the practicality of the training courses. In this Chapter's case, their positive attitudes towards the training, especially for functional exercise, show that the training course is relevant to their real-life work and suitable for their future work.

The author believe that this Chapter 4 is a good example of the combined application of general and professional education assessment criteria for training firefighters. This Chapter can serve as a useful reference for other countries to evaluate training courses for firefighters.

The limitations of this Chapter are as follows. More diverse cases, in terms of course topics and student backgrounds, should be studied to generalize the results obtained from this study. To capture the diverse capabilities of students, education criteria other than Bloom's taxonomy may play important roles, depending on the types of training courses [Slick, 2019; Chan, C.C.H. et al, 2014]. For each taxonomy level, there should be at least three evaluation questions. Future studies should apply Kirkpatrick's Four Levels of Training Evaluation to consider the effects of training on real-world activities following education.

4.6. Summary of Chapter 4

There is a gap between general education and emergency responder education in terms of the criteria for designing education courses and evaluating students. The three objectives of this chapter were addressed as follows.

First, this Chapter reviewed the criteria used for designing training programs and evaluating firefighting students at UFPF in Vietnam. The results provide rare insights into firefighter education in developing countries. It was found that the university considered the knowledge, skills, and attitude domains in designing education programs. Although the university had used Bloom's taxonomy, which is one of the well-known evaluation criteria for general education programs, in addition to the professional criteria for emergency management, only the bottom three levels of the taxonomy had been considered.

Second, the author designed a new training course for landslide rescue exercises and applied all six levels of Bloom's taxonomy to evaluate this course. The course consisted of lectures, an exercise, and a hot debriefing session. Both Bloom's taxonomy and professional assessment criteria for firefighting were applied to evaluate the course. This consideration of all levels of Bloom's taxonomy enabled the authors to identify differences in learning performance between exercise participants and observers among the course students. The evaluation results based on the general and professional education criteria differed when measuring the performance of students with work experience. This Chapter shows the importance of using the full set of Bloom's taxonomy in firefighters' education. It also shows that assessing students from different angles using different assessment measures is important for understanding students' diverse abilities.

Third, recommendations for firefighter education using both general and professional educational criteria were provided.

5. Developing the functional exercises based on expert assessments of the types of post-injects response actions

5.1. Introduction

After conducting a functional exercise on landslide response at UFPF, 2022 (in Chapter 4), there were many positive feedbacks from participants and experts. However, there are also many opinions wishing to improve some content for the next exercises. The author identified post-injects response actions that have important role in achieving the goal of the exercise. Therefore, each type of response action has certain different effects on the participants as well as on the results of the exercise. This Chapter will use an Analytic Hierarchy Process (AHP) to select the content to be improved for the next exercise based on evaluation criteria as types of response actions that have been taken in the functional exercises to respond to landslides at UFPF, 2022.

In this chapter I collect the assessment of rescue professionals about the types of post-injects response actions. These experts are the lecturers of Faculty of Rescue of UFPF. They are the ones who participated in teaching, designing exercises, and evaluating the groups of participants in the course and functional exercise on landslide response at UFPF, 2022 (see sections 4.3.3 in Chapter 4). In addition to collecting assessments of the types of post-injects response actions for the functional exercise on landslide response, the author also collected similar assessments for the functional exercises on wildfire response, flash flood.

This Chapter has three objectives. The first objective is to use an analytic hierarchical process to determine the content to be improved for the next exercise based on evaluation criteria identified as types of response actions taken in the functional exercise on landslide response at UFPF, 2022. The second objective is to analyze the similarities and differences in criteria weights of the action types and alternatives across the different disaster types such as landslide, wildfire, and flash flood. The third objective is to propose methods to improve functional exercises for Vietnamese rescue professionals. To achieve the above three objectives, the study needs to answer the following three questions:

Research question 1: What is the content to be improved for the next exercise at UFPF?

Research question 2: What is the similarities and differences in criteria weights of the action types and alternatives across the different disaster types such as landslide, wildfire, and flash flood?

Research question 3: What is the method of improving functional exercises for Vietnamese rescue professionals?

This chapter is an expansion of Le et al. [Le Tien, H.; Pham Van, N.; Kato, T. (2023). *Improving Functional Exercises Based on Experts' Evaluation Weights for Emergency Responses.*]

5.2. The exercise injects - response actions

Inject is scripted piece of information inserted into the exercise and designed to elicit a response or decision and facilitate the flow of the exercise [ISO 22300*, 2012; Societal Security -Terminology*]

Injects are specific scenario events or messages within the scenario that prompt players to implement the plans, policies, and/or procedures that require testing during the exercise. Each inject should be considered its own "event" within the timeline of the scenario. [U.S. Department of Education, 2019; *Master Scenario Event List (MSEL)*]

"Inject is a Master Scenario Events List (MSEL) event introduced to a player by the control staff, representing non-playing entities, to build the exercise environment based on the exercise scenario and to drive operations-based exercise play" [HSEEP, 2020].

MSEL is a document presenting a chronological timeline of anticipated actions and scripted events intended to be introduced into the exercise by controllers to stimulate or guide player engagement. Its purpose is to ensure the occurrence of essential events that contribute to the fulfillment of all objectives. In more extensive and intricate exercises, a procedural flow may also be employed, differing from the MSEL as it exclusively outlines anticipated player actions or events. The MSEL serves to connect simulation with action, enriching the overall exercise experience for players, and represents an incident or activity designed to prompt players into action. [HSEEP, 2020].

"An inject is simply a pre-scripted message that is provided to players during the course of an exercise, with "message" being defined liberally. Injects continue the story that began with the baseline narrative you gave the team at the start of the exercise" [Phelps, 2010].

The injects can be interpreted as events that furnish information to players. Nevertheless, these injects are deliberately crafted and linked to the exercise's objectives. Besides offering additional insights into the exercise's progression, the majority of exercise injects are intended to prompt recipients to react, take action. [Phelps, 2010]

These response actions are referred to by the author as post-injects response actions. The player's response actions are the ultimate objectives of the designer, the response actions help to achieve the objectives of the exercise. However, the player's response actions are

stimulated by the injects, or in other words, the injects will require the player to react, act in the direction of the designer to achieve the objectives of the exercise.

The player's response actions have a great influence on the objectives of the exercise, while the injects are intended to stimulate the player's response actions. Therefore, the author has conducted research on improving the content of the exercise based on the response actions of the players.

5.3. Methods

To answer the research question 1, the author first conducted to identify the contents that need to be improved in the functional exercise on landslide response at UFPF, 2022. After that, the author has applied the analytic hierarchical process to determine the content that needs improvement for the next exercise.

To answer the research question 2, the author determines the criteria weights for the various action types and alternatives within the functional exercise, considering different disaster types such as landslide (case 1), wildfire (case 2), and flash flood (case 3). Subsequently, the author conducts a comparative analysis of the obtained results across these cases to identify both similarities and differences.

To answer research question 3, the author analyzes the relationship between the weights of the criteria according to the pairwise comparison, the weights of the criteria according to the alternatives, the decision weights of the alternatives, and the types of incidents. Based on this analysis, the author proposes methods to improve functional exercises for Vietnamese firefighters.

In many models for multi-criteria decision making (MCDM), the process of assigning weights to criteria is a crucial step that requires careful reconsideration. Identifying the appropriate weights for criteria stands out as a primary challenge within the context of multi-criteria decision making (Dragan et al., 2018). Several weighting methods have been suggested in the literature and employed to address diverse multi-criteria decision-making (MCDM) problems. The classification of these weighting methods varies:

“- Subjective weighting methods: Point allocation; Direct rating; Ranking method; Pairwise comparison; Ratio method; Delphi method; Simple Multi-attribute Ranking Technique...

- Objective weighting methods: Entropy method; Criteria Importance Through Inter-criteria Correlation; Mean weight; Standard deviation; Statistical variance procedure; Ideal point method

- Integrated weighting methods: Multiplication synthesis; Additive synthesis; Optimal weighting based on sum of squares; Optimal weighting based on relational coefficient of graduation" [Delta State University, (2019). *Weighting Methods for Multi-Criteria Decision Making Technique*. Table 1, pp 1451].

In objective weighting methods, the weights assigned to criteria are calculated using mathematical models based on the information obtained for each criterion, without taking into account the intervention of the decision maker (Aldian and Taylor, 2005). The integrated weighting approach is a weighting method based on the combination of subjective weighting and objective weighting methods [Delta State University, (2019). *Weighting Methods for Multi-Criteria Decision Making Technique*]. In these methods, weights are calculated based on available data. However, the application of the weighting method to the criteria that are the response actions of the players in the exercise is a new study. Therefore, no data are available to apply the objective weighting methods and the integrated weighting methods.

From the above reason, the author has chosen the subjective weighting method. With the aim towards determining the correlation weight between the criteria, the author has chosen the weighting method by pairwise comparison. There are two common methods commonly applied for pairwise comparison, which are the ELETRE method (Elimination and Choice Translating Reality) and the AHP method (Analytical Hierarchy Process).

In 1968, Roy introduced ELETRE to solve the problem of ranking alternatives from the best to worst. In the 1970s, Saaty proposed the AHP, which has become one of the most widely used methods in MCDM applications, as it is easy to use [Delta State University, (2019). *Weighting Methods for Multi-Criteria Decision Making Technique*].

ELECTRE focuses on comparing options based on criteria without requiring the determination of priority levels among the criteria. AHP enables the decision-maker to assess the relative correlations between criteria by pairwise comparisons to determine their priority levels. With the objective of determining the priority and importance of each criterion, the author has chosen the AHP method to apply to chapter 5.

The analytic hierarchy process (AHP), also analytical hierarchy process [Forman, Ernest H.; Saul I. Gass, 2001] is one of the most popular and widely employed multicriteria methods. In this technique, the processes of rating alternatives and aggregating to find the most relevant alternatives are integrated. The technique is employed for ranking a set of alternatives or for the selection of the best in a set of alternatives [Ramanathan, 2004]. AHP was developed by Thomas L. Saaty in the 1970s (Saaty, 1970). AHP has particular

application in group decision making [Saaty & Peniwati, 2008], and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, emegency situation. [Saracoglu, 2013; Nivolianitou et al.,2015; Nivolianitou et al., 2015; Gulum et al., 2021]. The Analytic Hierarchy Process (AHP) is most useful where teams of people are working on complex problems, especially those with high stakes, involving human perceptions and judgments, whose resolutions have long-term repercussions [Bhushan, Navneet & Kanwal Rai, 2004]. The applications of AHP to complex decision situations have numbered in the thousands [de Steiguer. et al, 2003], and have produced extensive results in problems involving planning, resource allocation, priority setting, and selection among alternatives [Bhushan, Navneet & Kanwal Rai, 2004]. AHP is one of the most widely adopted multi-criteria methods for solving various decision problems in emergency management [Hoang. L. H. G & Kato. T., 2023].

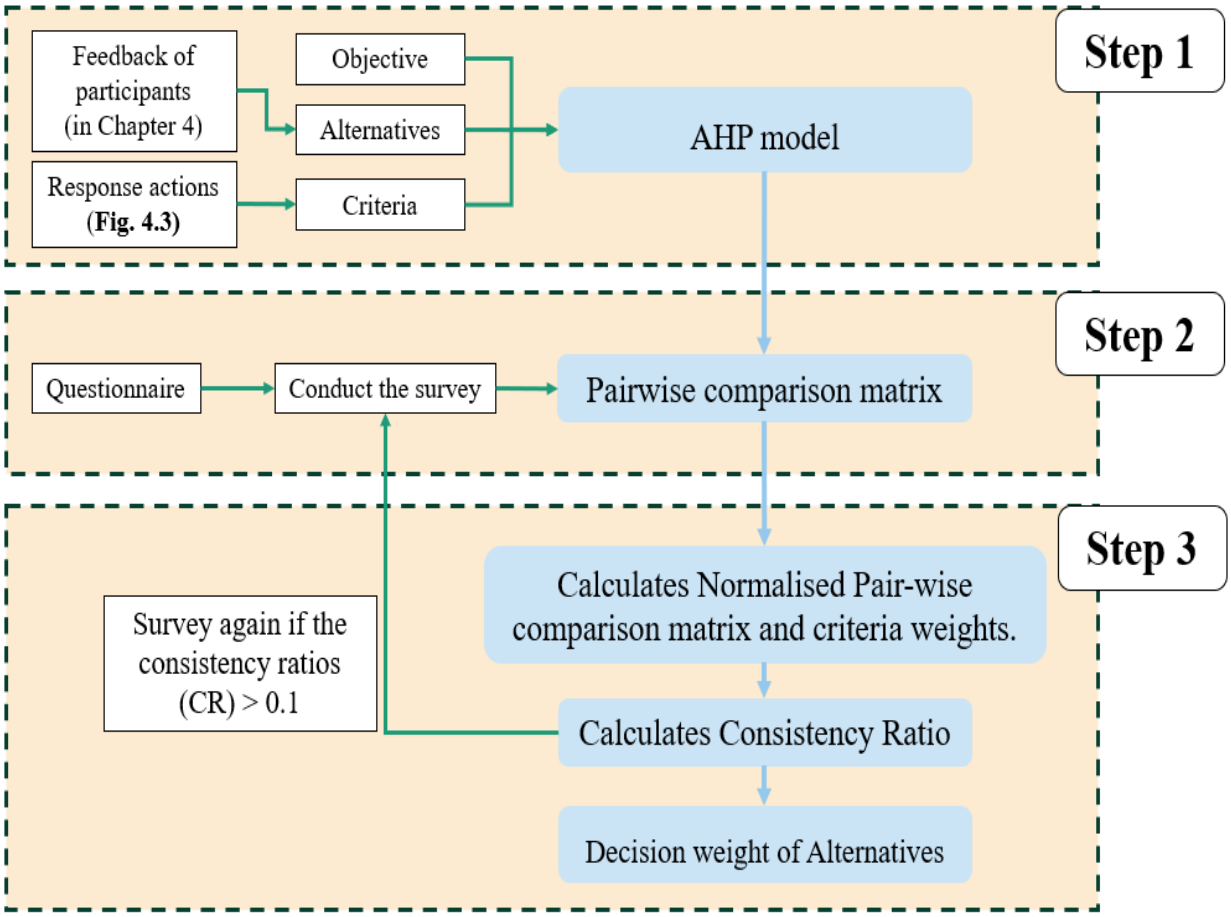


Fig. 5.1. AHP application diagram of chapter 5

To apply the hierarchical analysis process, the author carried out 3 steps as follows:

Step 1: Build the AHP model

Step 2: Establish Pairwise comparison matrix

Step 3: Conducting the AHP analysis

5.3.1 The AHP model

To build an AHP hierarchy model, it is necessary to define three contents: Objectives, criteria and alternatives.

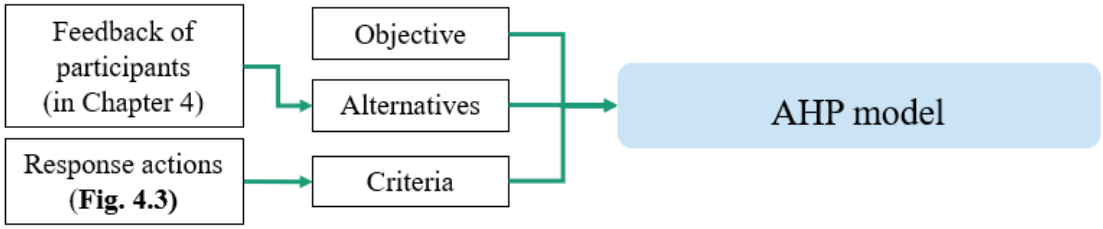


Fig. 5.2. Build the AHP model.

Objective: improvement of exercises

The evaluation criteria were identified as the types of response actions of participants in the exercise at UFPF, 2022 (Fig. 4.3 in Chapter 4).

Criteria: Report, Decision Making, Suggestion, Discussion, and Maneuver.

One of the objectives of the emergency management exercise is to obtain participant feedback and recommendations for program improvement [U.S. Department of Homeland Security, 2021; *Exercies*]. Therefore, the author conducted an analysis of the responses and recommendations of the experts who observed the functional exercise on landslide response at UFPF, 2022. Responses and recommendations were obtained in the third survey after hot discussion. There are 3 contents that experts have recommended to improve: Raise awareness levels; Reduce time of participant response actions; Increase response actions completion percentage.

Alternatives: Raise awareness levels; Reduce time of participant response actions; Increase response actions completion percentage.

The AHP model was built (Fig. 5.3.).

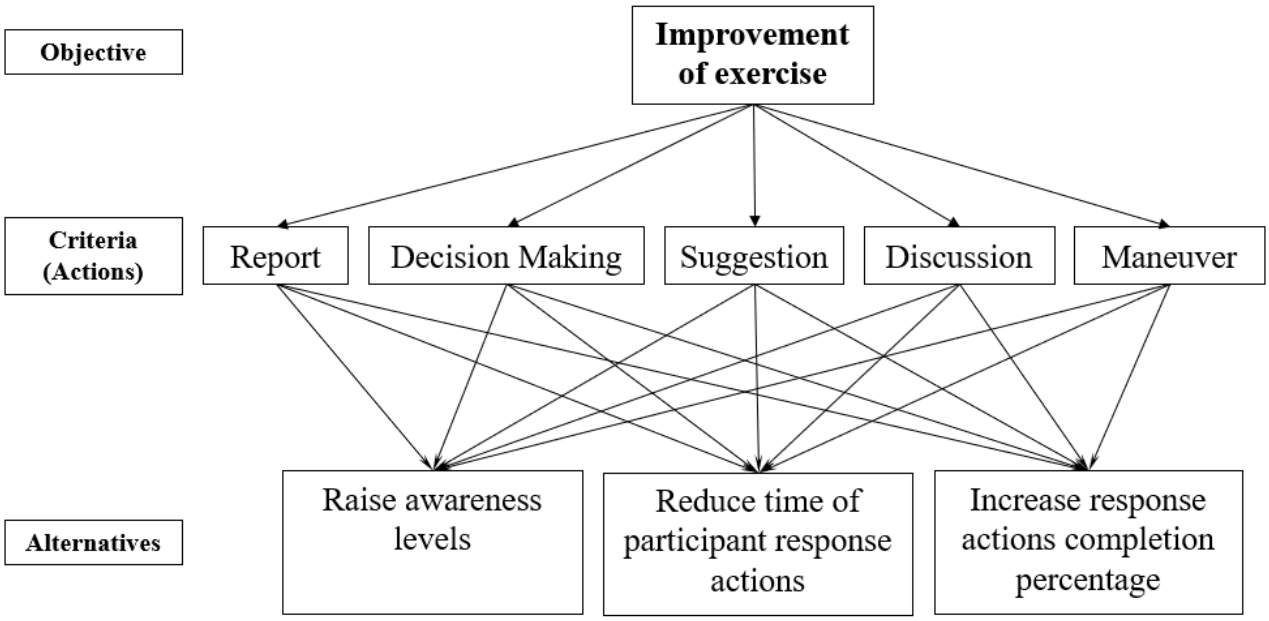


Fig. 5.3. The AHP model

5.3.2. Pairwise comparison matrix

To be able to set up a pairwise comparison table. The author needs to collect expert judgments on the criteria. The author has conducted a survey to collect the reviews of experts.

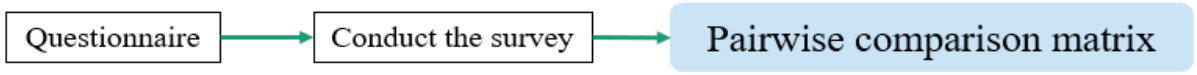


Fig. 5.4. Establish Pairwise comparison matrix

Information about the survey:

- Pre-survey:

+ Date of survey: May 6th – May 10th, 2023

+ The targeted experts of pre-survey: Teachers at UFPF

+ Number of experts: 4 people

+ The types of functional exercises: Landslide, and wildfire

+ How to conduct a survey: Direct survey

- Main survey:

+ Date of survey: September 6th, 2023

+ The targeted experts of the main survey: Teachers at UFPF +

Number of experts: 7 people

+ The types of functional exercises: Landslide, wildfire, and flash flood

+ How to conduct a survey: Direct survey

Experts participating in the survey need to meet the following criteria:

- Job position: Teachers of Rescue of Faculaty
- Workplace: The University of Fire Prevention and Fighting
- Qualification: Master and PhD of fire prevention, fire fighting and rescue
- Work experience: 5 years or more
- Exercise: Participated in the exercise at UFPF, 2022.

The survey questionnaire (Appendix 6) was developed by the author based on the guidance from Saaty (1987). Pairs of comparison criteria are generated from the AHP hierarchy model (Fig. 5.3).

The survey questionnaire is designed to collect expert opinions on pairwise comparisons according to the criteria (Table 5.1) and the priority of criteria according to the alternatives (Table 5.2). These two tables are applied to collect expert opinions on three types of incidents, landslides, wildfire, and flash flood.

Table 5.1. Pairwise comparison of criteria

Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision Making
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Discussion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver

Table 5.2. Priority of criteria according to the alternatives

Report	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
D	Raise awareness	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of

	levels																		participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Suggestion	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Discussion	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Maneuver	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage

- *The explanation in this section is adopted from Saaty (1987).*

The experts were directed to answer the questionnaire. Then the author proceeds to establish Pair-wise comparison matrix. Similarly, the priority matrix of the alternatives according to each criterion has also been establish. The matrix has the form

$$C = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & 1 & \cdots \\ a_{n1} & a_{n2} & \ldots & 1 \end{bmatrix}$$

In there:

Criteria a_{ij} : represents the importance of the indicator row i compared to the indicator column j.

a_1 is more important than a_2, a_3,...a_n how many times

a_2 is more important than a_1, a_3,...a_n how many times

…

a_n is more important than a_1, a_2,… a_{n-1} how many times

The relative importance of indicator i to j is calculated by the ratio k (k from 1 to 9), the opposite of indicator j over i is 1/k. So $a_{ij} > 0$, $a_{ij} = 1/a_{ji}$, $a_{ii} = 1$.

Table 5.3a. The fundamental scale [Saaty 1987]

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal rmportance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one acttvity cwer another
7	Very strong importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals	If activity i has one of the above numbers assigned to It when compared with activity j, then j has the reciprocal value when compared with i	
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

For example:

Expert answer 1 in case 1.

	Extremely		Very strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very strongly		Extremely	
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision Making
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Discussion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver

From the expert answer 1 in case 1, we establish Pair-wise comparison matrix

Pair-wise comparison matrix

	Report	Decision making	Suggestion	Discussion	Maneuver
Report	1	1/5	4	1/3	7
Decision making	5	1	7	2	9
Suggestion	1/4	1/7	1	1/4	3
Discussion	3	1/2	4	1	8
Maneuver	1/7	1/9	1/3	1/8	1
Sum of columns	9.3929	1.9540	16.3333	3.7083	28.0000

5.3.3. Conducting the AHP analysis

Figure 5.5. shows the steps to calculate the criteria weight according to pairwise comparison, the criteria weight according to the alternative, the decision weight of the alternative, and the process of checking the consistency ratio.

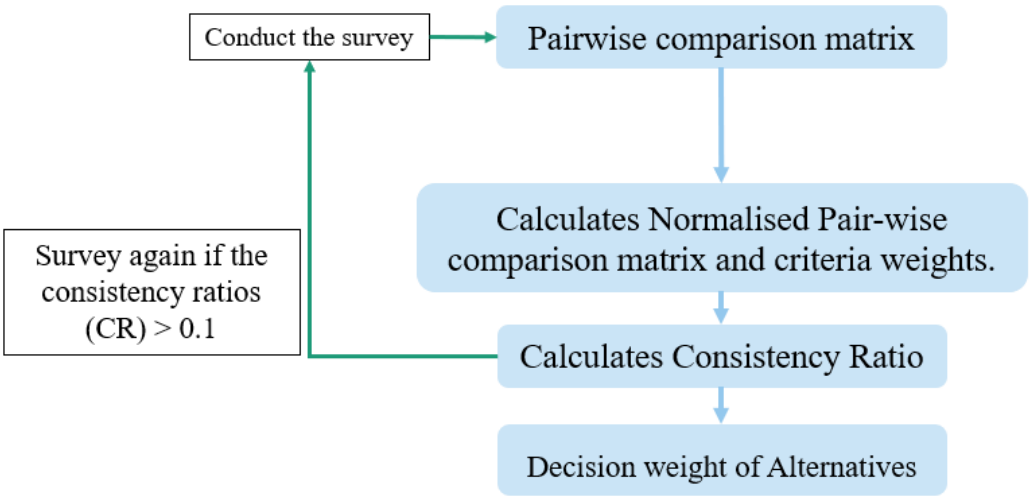


Fig. 5.5. Conducting the AHP analysis

- *The explanation in this section is adopted from Saaty (1987).*

1. Calculates Normalised Pair-wise comparison matrix and criteria weights.

Normalised Pair-wise comparison matrix and criteria weights are calculated according to the following formula:

$$W_{ij} = \frac{S_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} S_{ij}} \qquad W_i = \frac{\sum_{j=1}^{n} W_{ij}}{n}$$

For example:

$$W_{11} = \frac{S_{11}}{\sum_{j=1}^{n} S_{1j}} = \frac{1}{9.3929} = 0.1065$$

$$W_i = \frac{\sum_{j=1}^{n} W_{ij}}{n} = \frac{0.1065+0.1024+0.2449+0.0899+0.2500}{5} = 0.1587$$

Normalised Pair-wise comparison matrix and criteria weights

Criteria (actions)	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1065	0.1024	0.2449	0.0899	0.2500	0.1587
Decision making	0.5323	0.5118	0.4286	0.5393	0.3214	0.4667
Suggestion	0.0266	0.0731	0.0612	0.0674	0.1071	0.0671
Discussion	0.3194	0.2559	0.2449	0.2697	0.2857	0.2751
Maneuver	0.0152	0.0569	0.0204	0.0337	0.0357	0.0324

2. Calculates Consistency Ratio

After calculating the criteria weight, it is necessary to check the consistency ratio. Consistency ratios (CR) value below 0.1 represents a high consistency of response. Consistency ratio values greater than 0.1 then respondents were asked to answer the questions again.

The process of estimating the consistency ratio includes the following steps:

- Determine the total weight vector by multiplying the pair-wise comparison matrix by the criteria weight matrix.

- Determine the consistency vector by dividing the total weight vector by the previously defined criteria weight.

- Calculate the maximum eigenvalue (λ_{max}) by calculating the average of the consistency vector

- Calculates Consistency Ratio

$$\text{CR (Consistency Ratio)} = \frac{\text{CI (Consistency index)}}{\text{RI (Random index)}}$$

$$\text{CI (Consistency index)} = \frac{\lambda_{max} - n}{n - 1}$$

Table 5.3b. RI values for the different values of n (Saaty 2008)

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.24	1.41	1.45	1.49

n is the number of criteria.

For example:

- Determine the total weight vector:

	Report	Decision making	Suggestion	Discussion	Maneuver
Report	1	1/5	4	1/3	7
Decision making	5	1	7	2	9
Suggestion	1/4	1/7	1	1/4	3
Discussion	3	1/2	4	1	8
Maneuver	1/7	1/9	1/3	1/8	1

X

Criteria weight
0.1587
0.4667
0.0671
0.2751
0.0324

=

=

	Total weight vector
Report	0.8388
Decision making	2.5717
Suggestion	0.3394
Discussion	1.5121
Maneuver	0.1637

- Determine the consistency vector

	Total weight vector	**Criteria weight**	**Consistency vector** (Total weight vector/Criteria weight)
Report	0.8388	0.1587	5.284965694
Decision making	2.5717	0.4667	5.51047225
Suggestion	0.3394	0.0671	5.057544295
Discussion	1.5121	0.2751	5.496216892
Maneuver	0.1637	0.0324	5.054401184

- Calculate the maximum eigenvalue (λ_{max})

$$\lambda_{max} = \frac{5.284965694 + 5.51047225 + 5.057544295 + 5.496216892 + 5.054401184}{5} = 5.280720063$$

CI (Consistency index) = $\frac{\lambda_{max} - n}{n-1} = \frac{5.280720063 - 5}{5-1} = 0.070180016$

CR (Consistency Ratio) = $\frac{\text{CI (Consistency index)}}{\text{RI (Random index)}} = \frac{0.070180016}{1.12} \approx 0.0627 < 0.1$ (High consistency)

3. Calculates Decision weight of Alternatives

Expert 1	Weight of criteria according to the alternatives				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0978	0.6232	0.2973	0.7380	0.0869
Reduce time of participant response actions	0.7151	0.2395	0.1638	0.0944	0.6393
Increase response actions completion percentage	0.1871	0.1373	0.5390	0.1676	0.2737

X

Expert 1	Criteria weight
Report	0.1587
Decision making	0.4667
Suggestion	0.0671
Discussion	0.2751
Maneuver	0.0324

=

Alternatives	Decision weight of Alternatives
Raise awareness levels	0.5322
Reduce time of participant response actions	0.2829
Increase response actions completion percentage	0.1849

5.4. Results

5.4.1. The content to be improved for the next exercise at the University of Fire Prevention and Fighting (case 1)

5.4.1.1. The criteria weights according to pairwise comparison (case 1)

We established a pair-wise comparison matrix between the criteria, then calculated the normalized pairwise comparison matrix and the criteria weights. After that, we checked for consistency, and the results are shown in Tables 5.4-5.10.

Table 5.4. Criteria weights according to pairwise comparison of expert 1 (case 1)

Expert 1	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1065	0.1024	0.2449	0.0899	0.2500	0.1587
Decision making	0.5323	0.5118	0.4286	0.5393	0.3214	0.4667
Suggestion	0.0266	0.0731	0.0612	0.0674	0.1071	0.0671
Discussion	0.3194	0.2559	0.2449	0.2697	0.2857	0.2751
Maneuver	0.0152	0.0569	0.0204	0.0337	0.0357	0.0324
CR (consistency ratio) = 0.0627 < 0.1				**High consistency**		

Table 5.5. Criteria weights according to pairwise comparison of expert 2 (case 1)

Expert 2	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0599	0.0367	0.2000	0.0661	0.1290	0.0983
Decision making	0.3593	0.2202	0.3200	0.1983	0.2581	0.2712
Suggestion	0.0120	0.0275	0.0400	0.0661	0.0323	0.0356
Discussion	0.5389	0.6606	0.3600	0.5950	0.5161	0.5341
Maneuver	0.0299	0.0550	0.0800	0.0744	0.0645	0.0608
CR (consistency ratio) = 0.0803 < 0.1				**High consistency**		

Table 5.6. Criteria weights according to pairwise comparison of expert 3 (case 1)

Expert 3	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1746	0.1435	0.3182	0.2759	0.3130	0.2451
Decision making	0.6985	0.5742	0.3636	0.4138	0.5217	0.5144
Suggestion	0.0249	0.0718	0.0455	0.0345	0.0261	0.0405
Discussion	0.0437	0.0957	0.0909	0.0690	0.0348	0.0668
Maneuver	0.0582	0.1148	0.1818	0.2069	0.1043	0.1332
CR (consistency ratio) = 0.0578 < 0.1				**High consistency**		

Table 5.7. Criteria weights according to pairwise comparison of expert 4 (case 1)

Expert 4	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0370	0.0562	0.0270	0.0256	0.0250	0.0342
Decision making	0.3333	0.5056	0.4054	0.6154	0.4500	0.4619

Suggestion	0.1111	0.1011	0.0811	0.0513	0.0750	0.0839
Discussion	0.2963	0.1685	0.3243	0.2051	0.3000	0.2589
Maneuver	0.2222	0.1685	0.1622	0.1026	0.1500	0.1611
CR (consistency ratio) = 0.0301 < 0.1				**High consistency**		

Table 5.8. Criteria weights according to pairwise comparison of expert 5 (case 1)

Expert 5	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1967	0.1709	0.2500	0.2553	0.2609	0.2268
Decision making	0.5902	0.5128	0.3750	0.5106	0.4348	0.4847
Suggestion	0.0492	0.0855	0.0625	0.0426	0.0435	0.0566
Discussion	0.0984	0.1282	0.1875	0.1277	0.1739	0.1431
Maneuver	0.0656	0.1026	0.1250	0.0638	0.0870	0.0888
CR (consistency ratio) = 0.0221 < 0.1				**High consistency**		

Table 5.9. Criteria weights according to pairwise comparison of expert 6 (case 1)

Expert 6	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1463	0.1224	0.2000	0.1460	0.1905	0.1611
Decision making	0.2927	0.2449	0.2667	0.2190	0.2857	0.2618
Suggestion	0.0488	0.0612	0.0667	0.0876	0.0476	0.0624
Discussion	0.4390	0.4898	0.3333	0.4380	0.3810	0.4162
Maneuver	0.0732	0.0816	0.1333	0.1095	0.0952	0.0986
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

Table 5.10. Criteria weights according to pairwise comparison of expert 7 (case 1)

Expert 7	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1463	0.1460	0.1905	0.1224	0.2000	0.1611
Decision making	0.4390	0.4380	0.3810	0.4898	0.3333	0.4162
Suggestion	0.0732	0.1095	0.0952	0.0816	0.1333	0.0986
Discussion	0.2927	0.2190	0.2857	0.2449	0.2667	0.2618
Maneuver	0.0488	0.0876	0.0476	0.0612	0.0667	0.0624
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

Figure 5.6 is generated from the data of Tables 5.4-5.10. We can easily see the difference in the criteria weights according to the evaluation of the expert

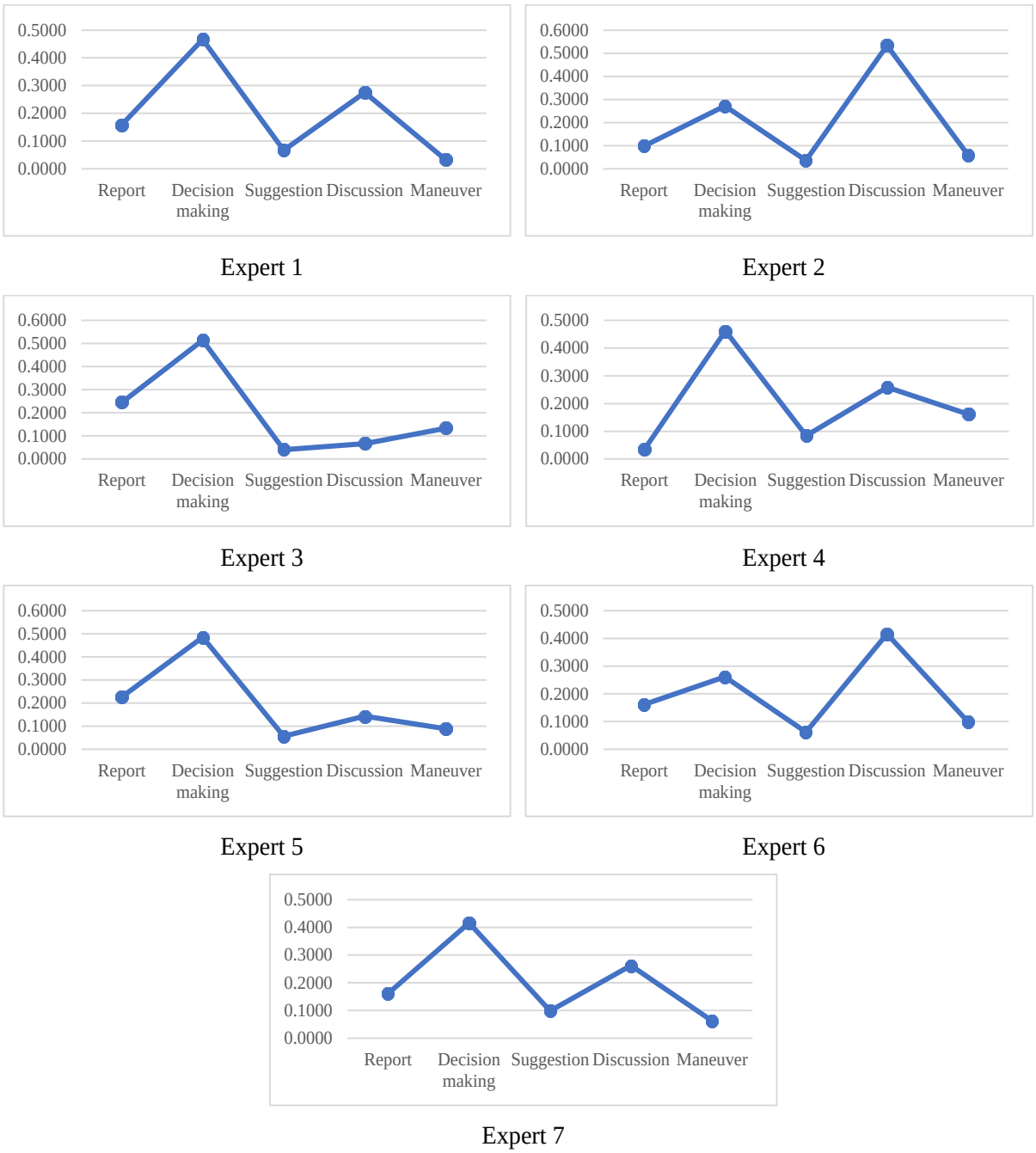


Fig. 5.6. The criteria weights according to pairwise comparison of the experts (case 1)

Table 5.11. The average of criteria weights according to pairwise comparison of the experts (case 1)

Actions (case 1)	Criteria							
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**AVG**
Report	0.1587	0.0983	0.2451	0.0342	0.2268	0.1611	0.1611	0.1550
Decision making	0.4667	0.2712	0.5144	0.4619	0.4847	0.2618	0.4162	0.4110
Suggestion	0.0671	0.0356	0.0405	0.0839	0.0566	0.0624	0.0986	0.0635
Discussion	0.2751	0.5341	0.0668	0.2589	0.1431	0.4162	0.2618	0.2794
Maneuver	0.0324	0.0608	0.1332	0.1611	0.0888	0.0986	0.0624	0.0910

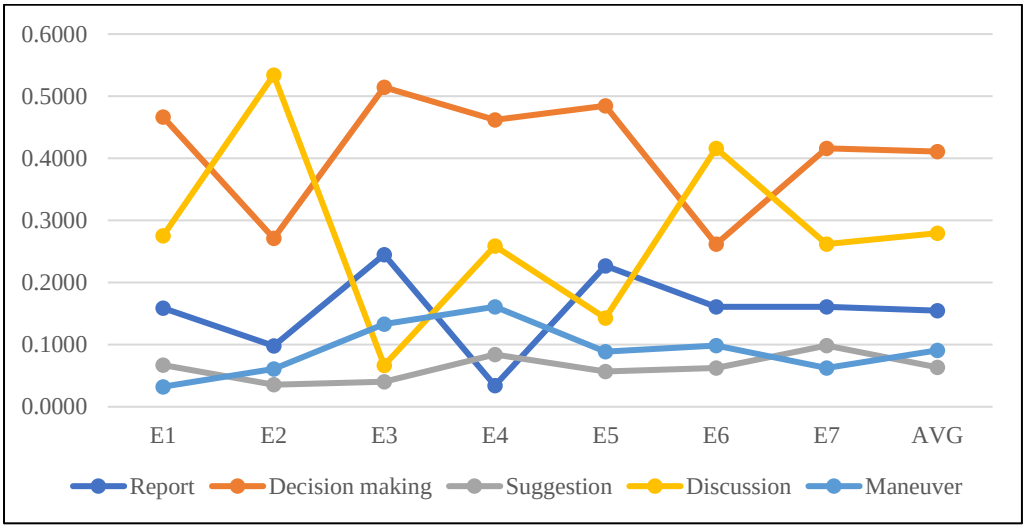


Fig. 5.7. The average of criteria weights according to pairwise comparison of the experts (case 1)

Table 5.11. and Fig. 5.7. shows the average of criteria weights according to pairwise comparison of the experts in case 1.

5.4.1.2. The criteria weights according to the alternatives of the experts

We calculated the normalized pairwise comparison matrix and the criteria weights according to the alternatives. After that, we checked for consistency, and the results are shown in Tables 5.12-5.18.

Table 5.12. Criteria weights according to the alternatives of expert 1 (case 1)

Expert 1	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0978	0.6232	0.2973	0.7380	0.0869
Reduce time of participant response actions	0.7151	0.2395	0.1638	0.0944	0.6393

Increase response actions completion percentage	0.1871	0.1373	0.5390	0.1676	0.2737
CR (consistency ratio)	0.0017 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0079 < 0.1 (High consistency)	0.0122 < 0.1 (High consistency)	0.0466 < 0.1 (High consistency)

Table 5.13. Criteria weights according to the alternatives of expert 2 (case 1)

Expert 2	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0869	0.6080	0.1096	0.7510	0.0669
Reduce time of participant response actions	0.6393	0.1199	0.3092	0.0643	0.6893
Increase response actions completion percentage	0.2737	0.2721	0.5813	0.1847	0.2438
CR (consistency ratio)	0.0466 < 0.1 (High consistency)	0.0639 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)	0.0955 < 0.1 (High consistency)	0.0824 < 0.1 (High consistency)

Table 5.14. Criteria weights according to the alternatives of expert 3 (case 1)

Expert 3	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.1033	0.1199	0.1038	0.6333	0.2766
Reduce time of participant response actions	0.1741	0.6080	0.2311	0.1062	0.1285
Increase response actions completion percentage	0.7225	0.2721	0.6651	0.2605	0.5949
CR (consistency ratio)	0.0252 < 0.1 (High consistency)	0.0639 < 0.1 (High consistency)	0.0750 < 0.1 (High consistency)	0.0334 < 0.1 (High consistency)	0.0048 < 0.1 (High consistency)

Table 5.15. Criteria weights according to the alternatives of expert 4 (case 1)

Expert 4	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0548	0.1788	0.1000	0.7766	0.1788
Reduce time of participant response actions	0.5869	0.7394	0.6000	0.0685	0.7394
Increase response actions completion percentage	0.3583	0.0818	0.3000	0.1549	0.0818

CR (consistency ratio)	0.0320 < 0.1 (High consistency)	0.0882 < 0.1 (High consistency)	0 < 0.1 (High consistency)	0.0708 < 0.1 (High consistency)	0.0882 < 0.1 (High consistency)

Table 5.16. Criteria weights according to the alternatives of expert 5 (case 1)

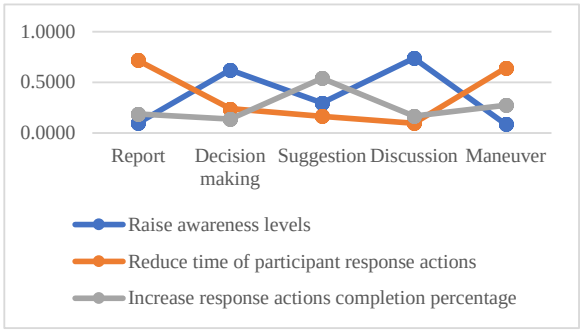
Expert 5	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0819	0.5571	0.1226	0.6853	0.0982
Reduce time of participant response actions	0.5750	0.3202	0.3202	0.0934	0.5679
Increase response actions completion percentage	0.3431	0.1226	0.5571	0.2213	0.3339
CR (consistency ratio)	0.0251 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0467 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)

Table 5.17. Criteria weights according to the alternatives of expert 6 (case 1)

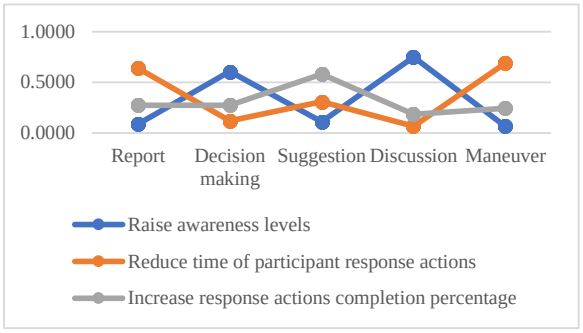
Expert 6	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0703	0.1741	0.0869	0.7672	0.1741
Reduce time of participant response actions	0.5801	0.7225	0.6393	0.0848	0.7225
Increase response actions completion percentage	0.3496	0.1033	0.2737	0.1481	0.1033
CR (consistency ratio)	0.0280 < 0.1 (High consistency)	0.0252 < 0.1 (High consistency)	0.0466 < 0.1 (High consistency)	0.0159 < 0.1 (High consistency)	0.0252 < 0.1 (High consistency)

Table 5.18. Criteria weights according to the alternatives of expert 7 (case 1)

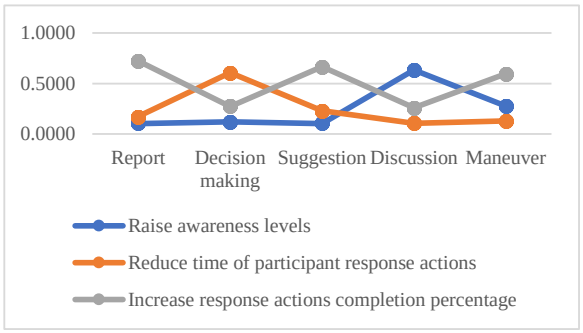
Expert 7	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0934	0.1096	0.1062	0.6806	0.3092
Reduce time of participant response actions	0.2213	0.5813	0.2605	0.1179	0.1096
Increase response actions completion percentage	0.6853	0.3092	0.6333	0.2014	0.5813
CR (consistency ratio)	0.0467 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)	0.0334 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)



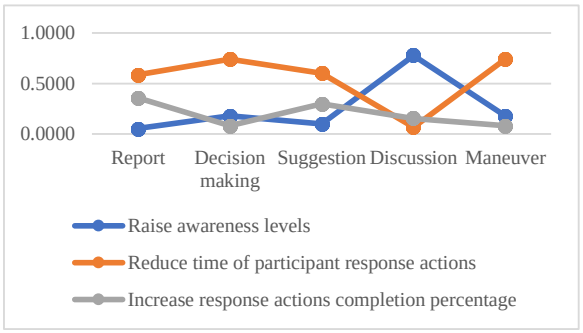
Expert 1



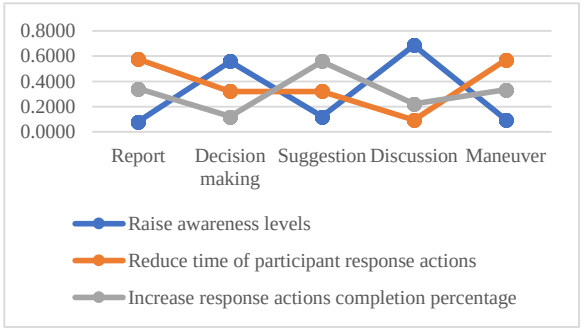
Expert 2



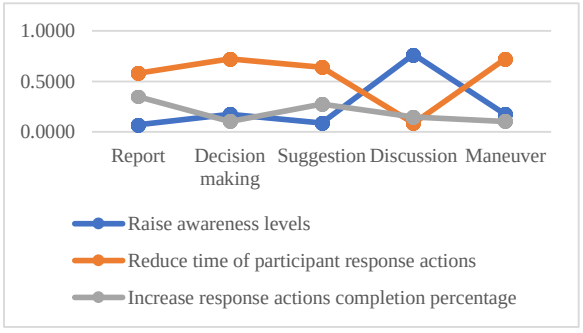
Expert 3



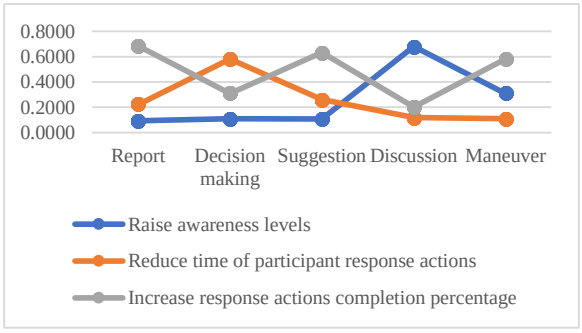
Expert 4



Expert 5



Expert 6



Expert 7

Fig. 5.8. Criteria weights according to the alternatives (case 1)

Figure 5.8 is generated from the data of tables 5.12-5.18. We can easily see the difference in the criteria weights according to the alternatives of the experts.

Table 5.19. The average of criteria weights according to the alternatives of the experts (case 1)

Alternatives (case 1)	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0841	0.3387	0.1323	0.7189	0.1701
Reduce time of participant response actions	0.4988	0.4758	0.3606	0.0899	0.5138
Increase response actions completion percentage	0.4171	0.1855	0.5071	0.1912	0.3161

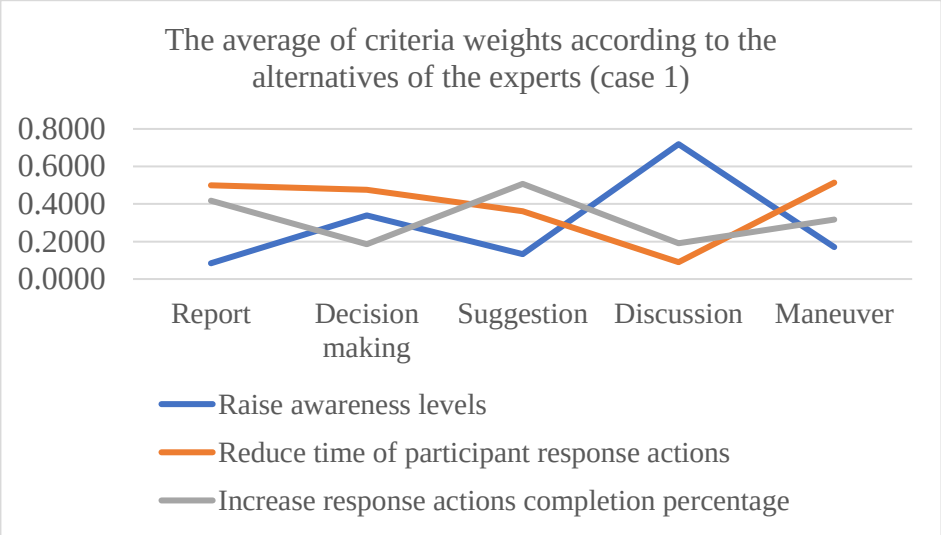


Fig. 5.9. The average of criteria weights according to the alternatives of the experts (case 1)

Table 5.19. and Fig. 5.9. shows the average of criteria weights according to the alternatives of the experts in case 1.

5.4.1.3. The decision weight of alternatives of the experts

The decision weights of the alternatives according to the evaluation of the experts are shown in table 5.20-5.26

Table 5.20. The decision weights of the alternatives according to the evaluation of experts 1 (case 1)

Expert 1	
Alternatives	Criteria weight
Raise awareness levels	0.5322
Reduce time of participant response actions	0.2829
Increase response actions completion percentage	0.1849

Table 5.21. The decision weights of the alternatives according to the evaluation of experts 2 (case 1)

Expert 2	
Alternatives	Criteria weight
Raise awareness levels	0.5825
Reduce time of participant response actions	0.1826
Increase response actions completion percentage	0.2348

Table 5.22. The decision weights of the alternatives according to the evaluation of experts 3 (case 1)

Expert 3	
Alternatives	Criteria weight
Raise awareness levels	0.1704
Reduce time of participant response actions	0.3890
Increase response actions completion percentage	0.4406

Table 5.23. The decision weights of the alternatives according to the evaluation of experts 4 (case 1)

Expert 4	
Alternatives	Criteria weight
Raise awareness levels	0.3227
Reduce time of participant response actions	0.5488
Increase response actions completion percentage	0.1285

Table 5.24. The decision weights of the alternatives according to the evaluation of experts 5 (case 1)

Expert 5	
Alternatives	Criteria weight
Raise awareness levels	0.4024
Reduce time of participant response actions	0.3675
Increase response actions completion percentage	0.2301

Table 5.25. The decision weights of the alternatives according to the evaluation of experts 6 (case 1)

Expert 6	
Alternatives	Criteria weight
Raise awareness levels	0.3988
Reduce time of participant response actions	0.4290
Increase response actions completion percentage	0.1722

Table 5.26. The decision weights of the alternatives according to the evaluation of experts 7 (case 1)

Expert 7	
Alternatives	Criteria weight
Raise awareness levels	0.2686
Reduce time of participant response actions	0.3410
Increase response actions completion percentage	0.3905

Table 5.27. The average decision weight of experts (case 1)

The alternatives	**Decision weight**							
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**AVG**
Raise awareness levels	0.5322	0.5825	0.1704	0.3227	0.4024	0.3988	0.2686	0.3825
Reduce time of participant response actions	0.2829	0.1826	0.3890	0.5488	0.3675	0.4290	0.3410	0.3630
Increase response actions completion percentage	0.1849	0.2348	0.4406	0.1285	0.2301	0.1722	0.3905	0.2545

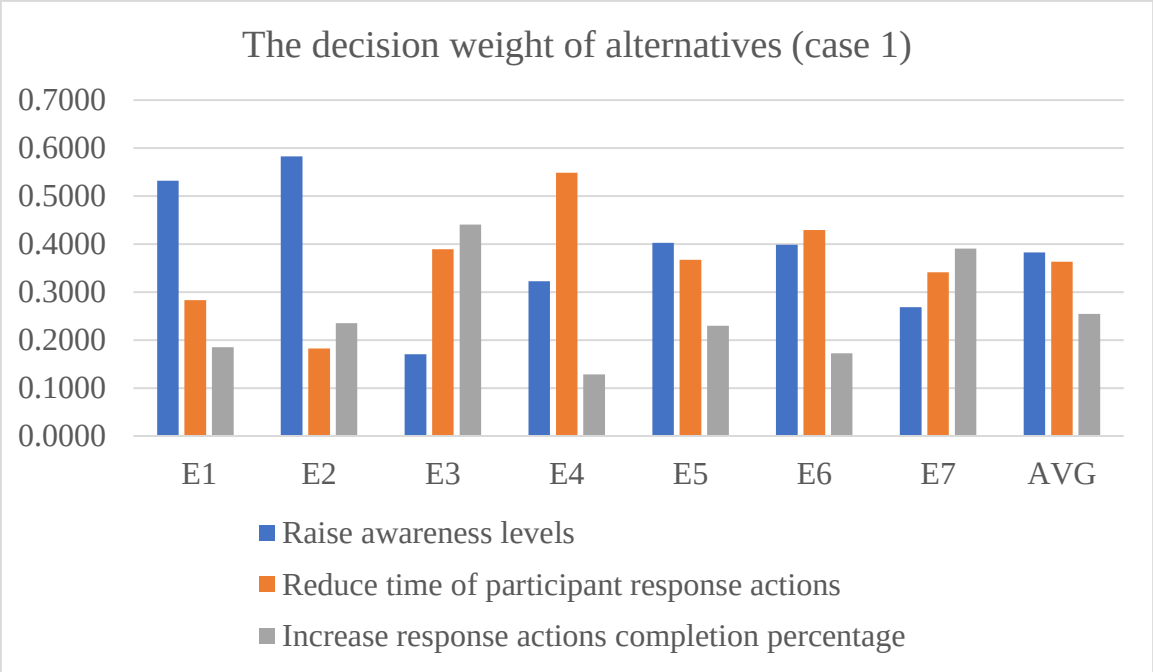


Fig. 5.10. The average decision weight of experts (case 1)

Figure 5.10 is generated from the data of table 5.27. We can easily see the difference in the decision weights of the experts.

5.4.2. The similarities and differences in criteria weights of the action types and alternatives across the different disaster types.

5.4.2.1. The content to be improved for the functional exercise on wildfire response (case 2)

a. The criteria weights according to pairwise comparison (case 2)

We established a pair-wise comparison matrix between the criteria, then calculated the normalized pairwise comparison matrix and the criteria weights. After that, we checked for consistency, and the results are shown in Tables 5.28-5.34.

Table 5.28. Criteria weights according to pairwise comparison of expert 1 (case 2)

Expert 1	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0455	0.0290	0.0187	0.0400	0.0718	0.0410
Decision making	0.2727	0.1739	0.2804	0.3200	0.1435	0.2381
Suggestion	0.2273	0.0580	0.0935	0.1600	0.0957	0.1269
Discussion	0.0909	0.0435	0.0467	0.0800	0.1148	0.0752
Maneuver	0.3636	0.6957	0.5607	0.4000	0.5742	0.5188
CR (consistency ratio) = 0.0625 < 0.1				**High consistency**		

Table 5.29. Criteria weights according to pairwise comparison of expert 2 (case 2)

Expert 2	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0612	0.0816	0.1429	0.0291	0.0544	0.0738
Decision making	0.3673	0.4898	0.3810	0.4660	0.5440	0.4496
Suggestion	0.0204	0.0612	0.0476	0.0388	0.0389	0.0414
Discussion	0.2449	0.1224	0.1429	0.1165	0.0907	0.1435
Maneuver	0.3061	0.2449	0.2857	0.3495	0.2720	0.2917
CR (consistency ratio) = 0.0505 < 0.1				**High consistency**		

Table 5.30. Criteria weights according to pairwise comparison of expert 3 (case 2)

Expert 3	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.2065	0.2637	0.3182	0.3226	0.1778	0.2578
Decision making	0.1032	0.1319	0.1818	0.1935	0.1333	0.1488
Suggestion	0.0295	0.0330	0.0455	0.0323	0.0667	0.0414
Discussion	0.0413	0.0440	0.0909	0.0645	0.0889	0.0659
Maneuver	0.6195	0.5275	0.3636	0.3871	0.5333	0.4862
CR (consistency ratio) = 0.0309 < 0.1				**High consistency**		

Table 5.31. Criteria weights according to pairwise comparison of expert 4 (case 2)

Expert 4	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0455	0.0217	0.0286	0.0675	0.0355	0.0398
Decision making	0.1364	0.0652	0.0571	0.0772	0.0426	0.0757
Suggestion	0.1818	0.1304	0.1143	0.1350	0.0709	0.1265
Discussion	0.3636	0.4565	0.4571	0.5402	0.6383	0.4912
Maneuver	0.2727	0.3261	0.3429	0.1801	0.2128	0.2669
CR (consistency ratio) = 0.0446 < 0.1				**High consistency**		

Table 5.32. Criteria weights according to pairwise comparison of expert 5 (case 2)

Expert 5	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0667	0.0612	0.0476	0.0488	0.0876	0.0624
Decision making	0.2667	0.2449	0.2857	0.2927	0.2190	0.2618
Suggestion	0.1333	0.0816	0.0952	0.0732	0.1095	0.0986
Discussion	0.2000	0.1224	0.1905	0.1463	0.1460	0.1611
Maneuver	0.3333	0.4898	0.3810	0.4390	0.4380	0.4162
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

Table 5.33. Criteria weights according to pairwise comparison of expert 6 (case 2)

Expert 6	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0952	0.0816	0.1250	0.0732	0.1111	0.0972
Decision making	0.2857	0.2449	0.2500	0.2927	0.2222	0.2591
Suggestion	0.0476	0.0612	0.0625	0.0488	0.0741	0.0588
Discussion	0.1905	0.1224	0.1875	0.1463	0.1481	0.1590
Maneuver	0.3810	0.4898	0.3750	0.4390	0.4444	0.4258
CR (consistency ratio) = 0.0111 < 0.1				**High consistency**		

Table 5.34. Criteria weights according to pairwise comparison of expert 7 (case 2)

Expert 7	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0952	0.1095	0.0732	0.1333	0.0816	0.0986
Decision making	0.3810	0.4380	0.4390	0.3333	0.4898	0.4162
Suggestion	0.1905	0.1460	0.1463	0.2000	0.1224	0.1611

Discussion	0.0476	0.0876	0.0488	0.0667	0.0612	0.0624
Maneuver	0.2857	0.2190	0.2927	0.2667	0.2449	0.2618
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

Figure 5.11 is generated from the data of tables 5.28-5.34. We can easily see the difference in the criteria weights according to the evaluation of the experts

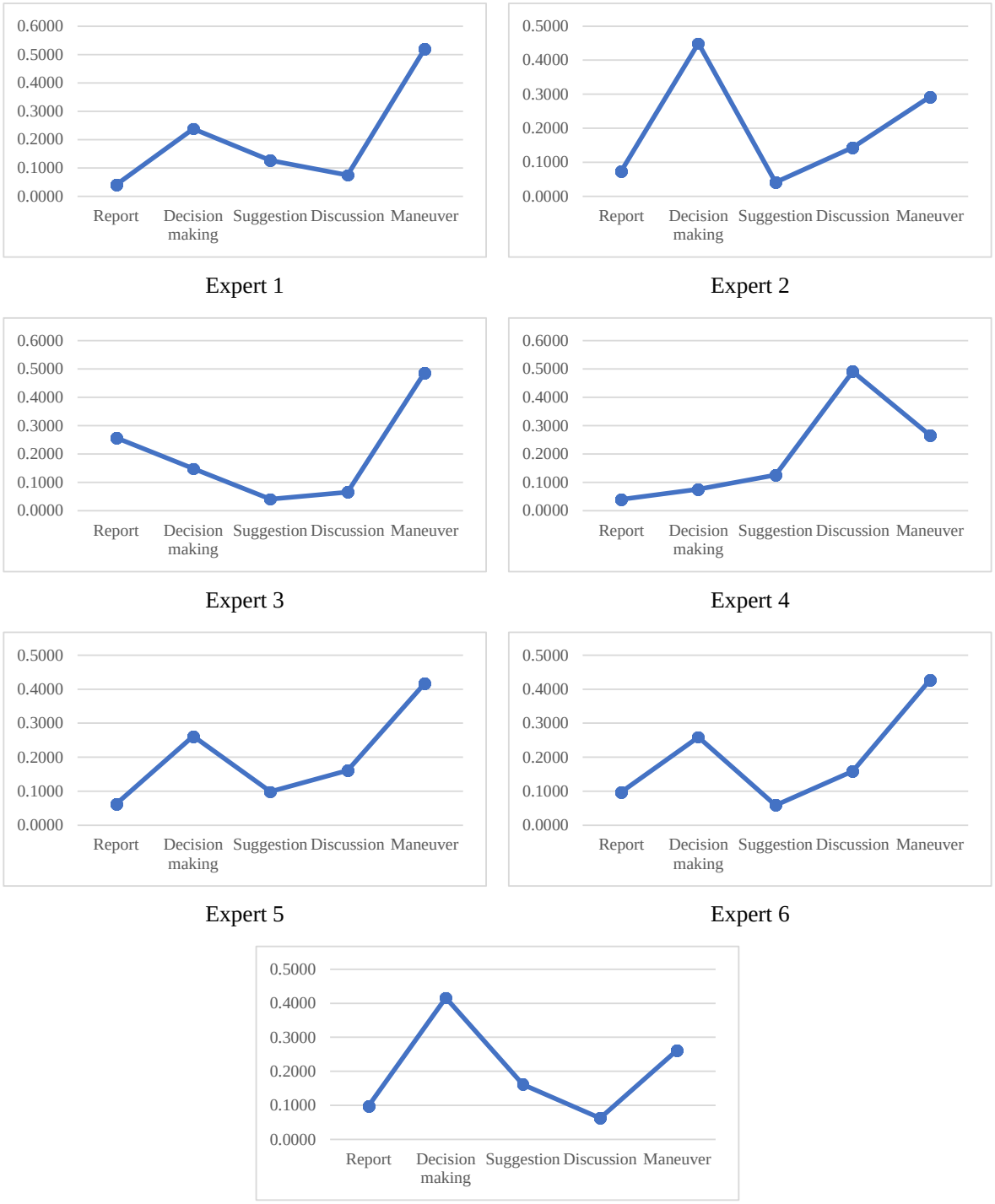


Fig. 5.11. The criteria weights according to pairwise comparison of the experts (case 2)

Table 5.35. The average of criteria weights according to pairwise comparison of the experts (case 2)

Actions (case 2)	Criteria							
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**AVG**
Report	0.0410	0.0738	0.2578	0.0398	0.0624	0.0972	0.0986	0.0958
Decision making	0.2381	0.4496	0.1488	0.0757	0.2618	0.2591	0.4162	0.2642
Suggestion	0.1269	0.0414	0.0414	0.1265	0.0986	0.0588	0.1611	0.0935
Discussion	0.0752	0.1435	0.0659	0.4912	0.1611	0.1590	0.0624	0.1654
Maneuver	0.5188	0.2917	0.4862	0.2669	0.4162	0.4258	0.2618	0.3811

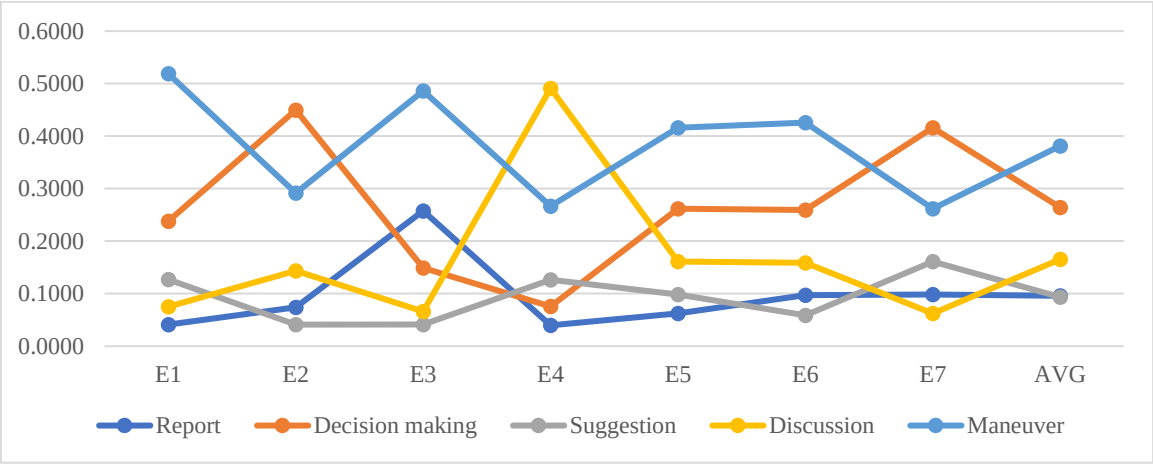


Fig. 5.12. The average of criteria weights according to pairwise comparison of the experts (case 2)

Table 5.35. and Fig. 5.12. shows the average of criteria weights according to pairwise comparison of the experts in case 2.

b. The criteria weights according to the alternatives of the experts (case 2)

We calculated the normalized pairwise comparison matrix and the criteria weights according to the alternatives. After that, we checked for consistency, and the results are shown in Tables 5.36-5.42.

Table 5.36. Criteria weights according to the alternatives of expert 1 (case 2)

Expert 1	Criteria weights according to the alternatives				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.1000	0.6194	0.3202	0.6194	0.0926
Reduce time of participant	0.6000	0.2842	0.1226	0.0964	0.6150

response actions					
Increase response actions completion percentage	0.3000	0.0964	0.5571	0.2842	0.2924
CR (consistency ratio)	0 < 0.1 (High consistency)	0.0747 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0747 < 0.1 (High consistency)	0.0023 < 0.1 (High consistency)

Table 5.37. Criteria weights according to the alternatives of expert 2 (case 2)

Expert 2	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0869	0.6196	0.1226	0.7651	0.0796
Reduce time of participant response actions	0.6393	0.1560	0.3202	0.0740	0.6555
Increase response actions completion percentage	0.2737	0.2243	0.5571	0.1609	0.2648
CR (consistency ratio)	0.0466 < 0.1 (High consistency)	0.0942 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0925 < 0.1 (High consistency)	0.0280 < 0.1 (High consistency)

Table 5.38. Criteria weights according to the alternatives of expert 3 (case 2)

Expert 3	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.1038	0.2222	0.0934	0.6232	0.2766
Reduce time of participant response actions	0.2311	0.6667	0.2213	0.1373	0.1285
Increase response actions completion percentage	0.6651	0.1111	0.6853	0.2395	0.5949
CR (consistency ratio)	0.0750 < 0.1 (High consistency)	0 < 0.1 (High consistency)	0.0467 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0048 < 0.1 (High consistency)

Table 5.39. Criteria weights according to the alternatives of expert 4 (case 2)

Expert 4	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0654	0.1374	0.0869	0.7798	0.1676
Reduce time of participant response actions	0.5934	0.7798	0.6393	0.0828	0.7380
Increase response actions	0.3412	0.0828	0.2737	0.1374	0.0944

completion percentage					
CR (consistency ratio)	0.0158 < 0.1 (High consistency)	0.0304 < 0.1 (High consistency)	0.0466 < 0.1 (High consistency)	0.0304 < 0.1 (High consistency)	0.0122 < 0.1 (High consistency)

Table 5.40. Criteria weights according to the alternatives of expert 5 (case 2)

Expert 5	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0893	0.6232	0.1199	0.7071	0.1096
Reduce time of participant response actions	0.5869	0.2395	0.2721	0.0915	0.5813
Increase response actions completion percentage	0.3238	0.1373	0.6080	0.2014	0.3092
CR (consistency ratio)	0.0079 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0639 < 0.1 (High consistency)	0.0826 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)

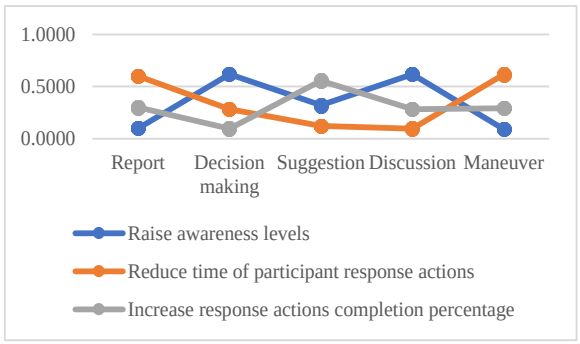
Table 5.41. Criteria weights according to the alternatives of expert 6 (case 2)

Expert 6	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0755	0.1822	0.0819	0.7370	0.2014
Reduce time of participant response actions	0.5907	0.7028	0.5750	0.0768	0.6806
Increase response actions completion percentage	0.3338	0.1149	0.3431	0.1863	0.1179
CR (consistency ratio)	0.0122 < 0.1 (High consistency)	0.0467 < 0.1 (High consistency)	0.0251 < 0.1 (High consistency)	0.0384 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)

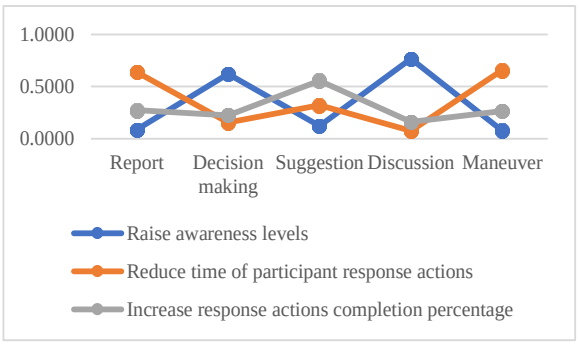
Table 5.42. Criteria weights according to the alternatives of expert 7 (case 2)

Expert 7	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.1062	0.0960	0.0982	0.7225	0.3339
Reduce time of participant response actions	0.2605	0.6530	0.3339	0.1033	0.0982
Increase response actions completion percentage	0.6333	0.2510	0.5679	0.1741	0.5679
CR (consistency ratio)	0.0334 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)	0.0252 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)

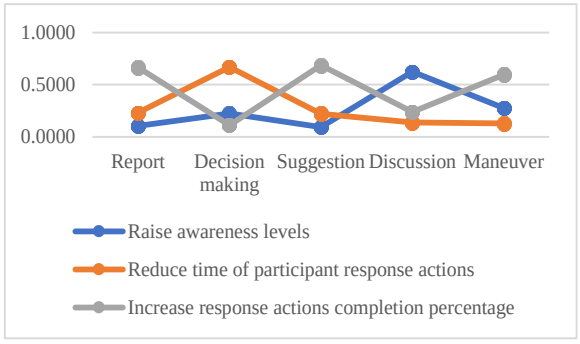
Figure 5.13 is generated from the data of tables 5.36-5.42. We can easily see the difference in the criteria weights according to the alternatives of the experts.



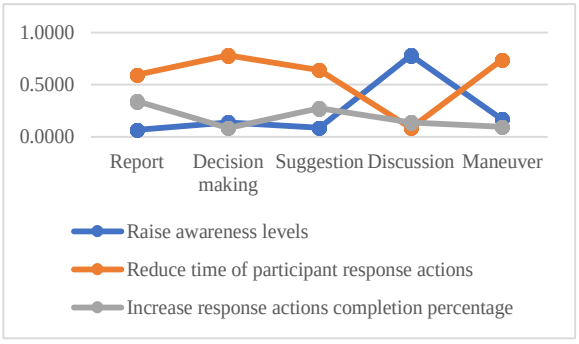
Expert 1



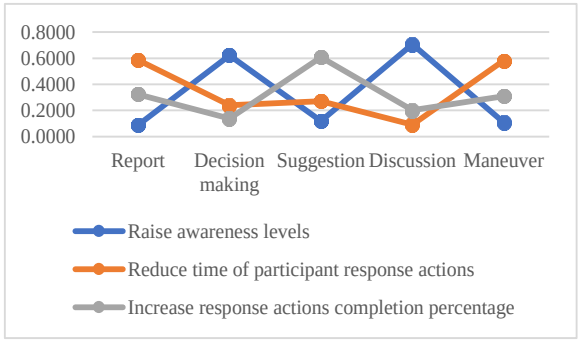
Expert 2



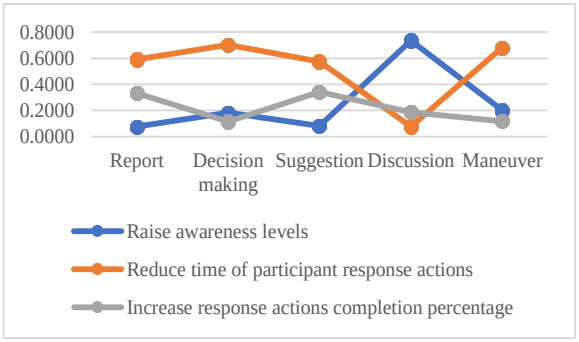
Expert 3



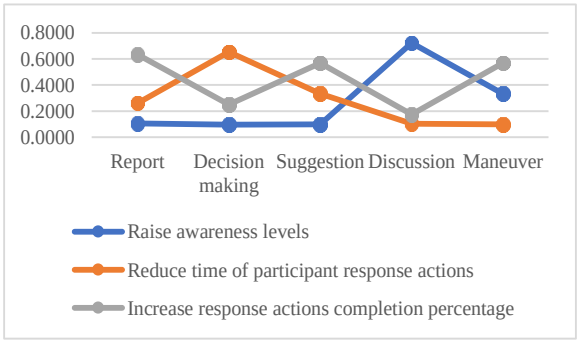
Expert 4



Expert 5



Expert 6



Expert 7

Fig. 5.13. The criteria weights according to the alternatives of the experts (case 2)

Table 5.43. The average of criteria weights according to the alternatives of the experts (case 2)

Alternatives (case 2)	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0896	0.3571	0.1319	0.7077	0.1802
Reduce time of participant response actions	0.5003	0.4974	0.3549	0.0946	0.4996
Increase response actions completion percentage	0.4101	0.1454	0.5132	0.1977	0.3202

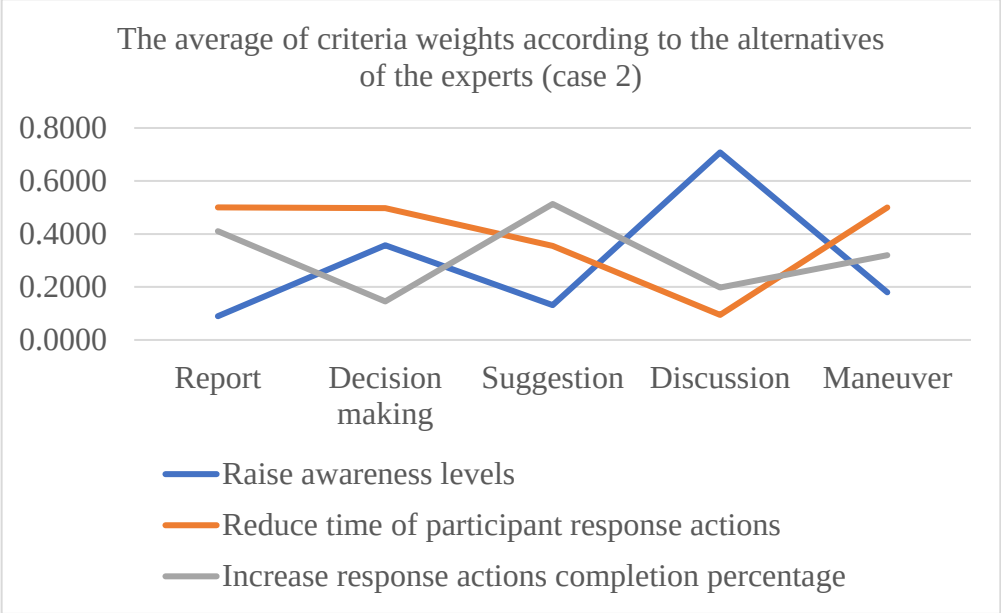


Fig. 5.14. The average of criteria weights according to the alternatives of the experts (case 2)

Table 5.43. and Fig. 5.14. shows the average of criteria weights according to the alternatives of the experts in case 2.

c. The decision weight of alternatives of the experts (case 2)

The weights of the alternatives according to the evaluation of the experts are shown in table 5.44-5.50

Table 5.44. The decision weight of the alternatives according to the evaluation of expert 1 (case 2)

Expert 1	
Alternatives	Criteria weight
Raise awareness levels	0.2868
Reduce time of participant response actions	0.4342
Increase response actions completion percentage	0.2790

Table 5.45. The decision weight of the alternatives according to the evaluation of expert 2 (case 2)

Expert 2	
Alternatives	Criteria weight
Raise awareness levels	0.4231
Reduce time of participant response actions	0.3324
Increase response actions completion percentage	0.2445

Table 5.46. The decision weight of the alternatives according to the evaluation of expert 3 (case 2)

Expert 3	
Alternatives	Criteria weight
Raise awareness levels	0.2393
Reduce time of participant response actions	0.2394
Increase response actions completion percentage	0.5213

Table 5.47. The decision weight of the alternatives according to the evaluation of expert 4 (case 2)

Expert 4	
Options	Criteria weight
Raise awareness levels	0.4518
Reduce time of participant response actions	0.4011
Increase response actions completion percentage	0.1471

Table 5.48. The decision weight of the alternatives according to the evaluation of expert 5 (case 2)

Expert 5	
Options	Criteria weight
Raise awareness levels	0.3400
Reduce time of participant response actions	0.3828
Increase response actions completion percentage	0.2772

Table 5.49. The decision weight of the alternatives according to the evaluation of expert 6 (case 2)

Expert 6	
Options	Criteria weight
Raise awareness levels	0.2623
Reduce time of participant response actions	0.5754
Increase response actions completion percentage	0.1623

Table 5.50. The decision weight of the alternatives according to the evaluation of expert 7 (case 2)

Expert 7	
Options	Criteria weight
Raise awareness levels	0.1987
Reduce time of participant response actions	0.3834
Increase response actions completion percentage	0.4179

Table 5.51. The average decision weight of the experts (case 2)

The alternatives	**Decision weight**							
	E1	**E2**	**E1**	**E4**	**E1**	**E6**	**E7**	**AVG**
Raise awareness levels	0.2868	0.4231	0.2393	0.4518	0.3400	0.2623	0.1987	0.3146
Reduce time of participant response actions	0.4342	0.3324	0.2394	0.4011	0.3828	0.5754	0.3834	0.3927
Increase response actions completion percentage	0.2790	0.2445	0.5213	0.1471	0.2772	0.1623	0.4179	0.2927

Figure 5.15. is generated from the data of Table 5.51. We can easily see the difference in the weights of alternatives according to the evaluation of the experts.

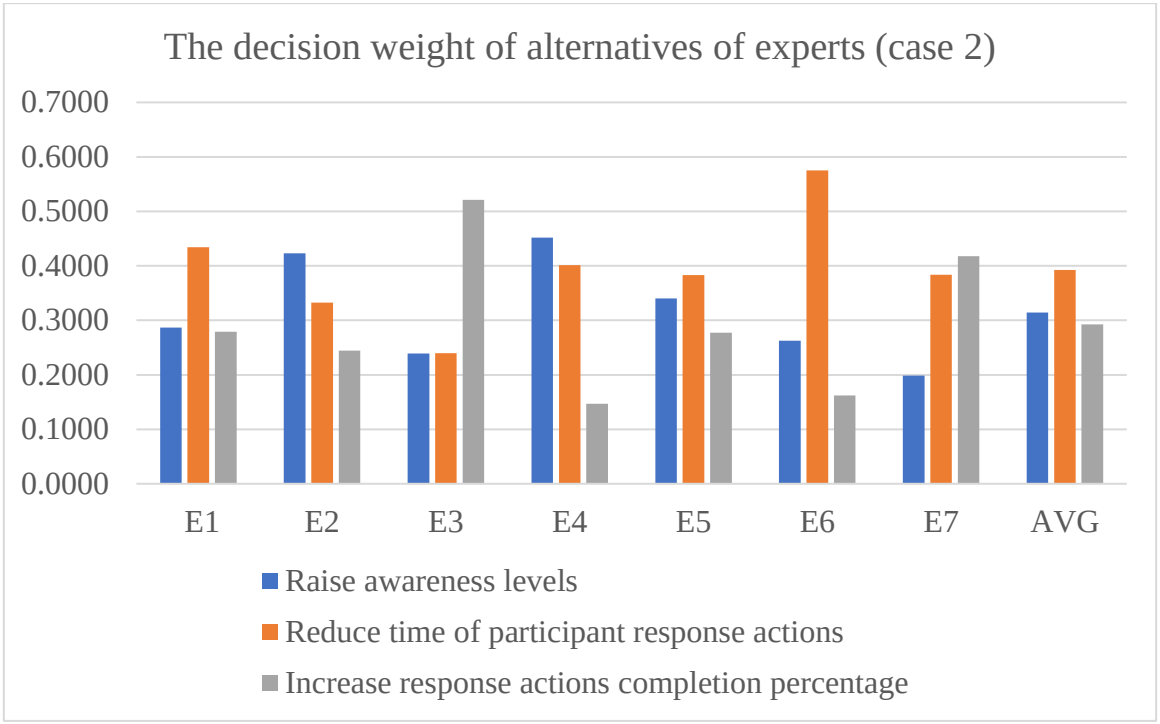


Fig. 5.15. The decision weight of alternatives of experts (case 2)

5.4.2.2. The content to be improved for the functional exercise on flash flood response (case 3)

a. The criteria weights according to pairwise comparison (case 3)

We established a pair-wise comparison matrix between the criteria, then calculated the normalized pairwise comparison matrix and the criteria weights. After that, we checked for consistency, and the results are shown in Tables 5.52-5.58.

Table 5.52. Criteria weights according to pairwise comparison of expert 1 (case 3)

Expert 1	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0667	0.0741	0.0625	0.1176	0.0778	0.0797
Decision making	0.1333	0.1481	0.1250	0.1765	0.1556	0.1477
Suggestion	0.2667	0.2963	0.2500	0.2353	0.2333	0.2563
Discussion	0.1333	0.0370	0.0625	0.0588	0.0667	0.0717
Maneuver	0.4000	0.4444	0.5000	0.4118	0.4667	0.4446
CR (consistency ratio) = 0.0947 < 0.1				**High consistency**		

Table 5.53. Criteria weights according to pairwise comparison of expert 2 (case 3)

Expert 2	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1277	0.1739	0.1181	0.1875	0.1224	0.1459
Decision making	0.0638	0.0870	0.0945	0.1250	0.0816	0.0904
Suggestion	0.5106	0.4348	0.4724	0.3750	0.4898	0.4565
Discussion	0.0426	0.0435	0.0787	0.0625	0.0612	0.0577
Maneuver	0.2553	0.2609	0.2362	0.2500	0.2449	0.2495
CR (consistency ratio) = 0.0142 < 0.1				**High consistency**		

Table 5.54. Criteria weights according to pairwise comparison of expert 3 (case 3)

Expert 3	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1967	0.2609	0.2553	0.2500	0.1709	0.2268
Decision making	0.0656	0.0870	0.0638	0.1250	0.1026	0.0888
Suggestion	0.0984	0.1739	0.1277	0.1875	0.1282	0.1431
Discussion	0.0492	0.0435	0.0426	0.0625	0.0855	0.0566
Maneuver	0.5902	0.4348	0.5106	0.3750	0.5128	0.4847
CR (consistency ratio) = 0.0221 < 0.1				**High consistency**		

Table 5.55. Criteria weights according to pairwise comparison of expert 4 (case 3)

Expert 4	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0667	0.0488	0.0612	0.0476	0.0876	0.0624
Decision making	0.2000	0.1463	0.1224	0.1905	0.1460	0.1611
Suggestion	0.2667	0.2927	0.2449	0.2857	0.2190	0.2618
Discussion	0.1333	0.0732	0.0816	0.0952	0.1095	0.0986
Maneuver	0.3333	0.4390	0.4898	0.3810	0.4380	0.4162
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

Table 5.56. Criteria weights according to pairwise comparison of expert 5 (case 3)

Expert 5	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1463	0.1905	0.1460	0.2000	0.1224	0.1611
Decision making	0.0732	0.0952	0.1095	0.1333	0.0816	0.0986
Suggestion	0.4390	0.3810	0.4380	0.3333	0.4898	0.4162
Discussion	0.0488	0.0476	0.0876	0.0667	0.0612	0.0624
Maneuver	0.2927	0.2857	0.2190	0.2667	0.2449	0.2618
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

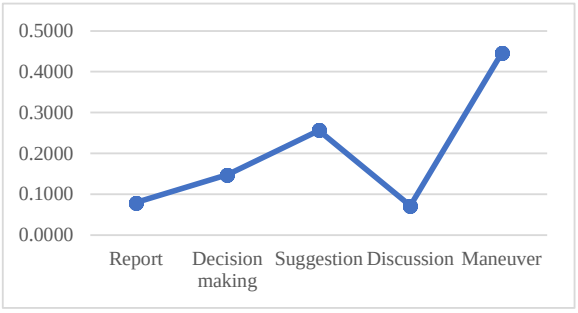
Table 5.57. Criteria weights according to pairwise comparison of expert 6 (case 3)

Expert 6	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.0952	0.0732	0.0816	0.1333	0.1095	0.0986
Decision making	0.1905	0.1463	0.1224	0.2000	0.1460	0.1611
Suggestion	0.2857	0.2927	0.2449	0.2667	0.2190	0.2618
Discussion	0.0476	0.0488	0.0612	0.0667	0.0876	0.0624
Maneuver	0.3810	0.4390	0.4898	0.3333	0.4380	0.4162
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		

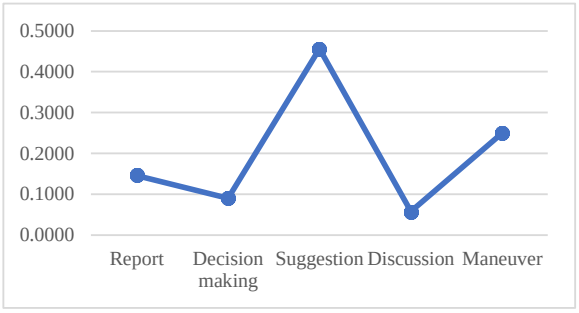
Table 5.58. Criteria weights according to pairwise comparison of expert 7 (case 3)

Expert 7	Report	Decision making	Suggestion	Discussion	Maneuver	**Criteria weight**
Report	0.1463	0.2000	0.1460	0.1905	0.1224	0.1611
Decision making	0.0488	0.0667	0.0876	0.0476	0.0612	0.0624

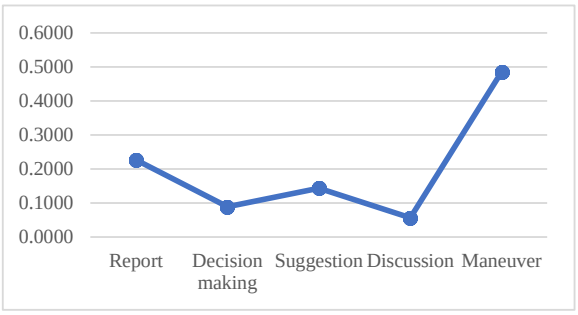
Suggestion	0.4390	0.3333	0.4380	0.3810	0.4898	0.4162
Discussion	0.0732	0.1333	0.1095	0.0952	0.0816	0.0986
Maneuver	0.2927	0.2667	0.2190	0.2857	0.2449	0.2618
CR (consistency ratio) = 0.0153 < 0.1				**High consistency**		



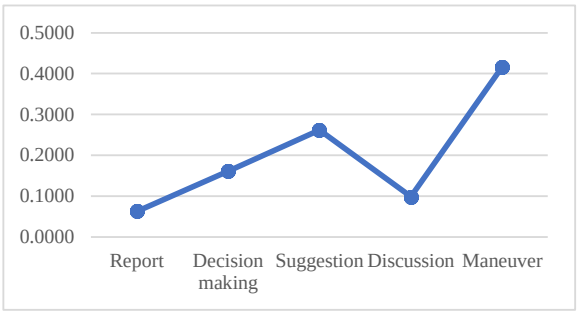
Expert 1



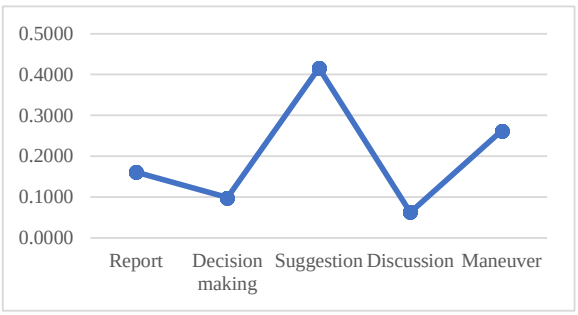
Expert 2



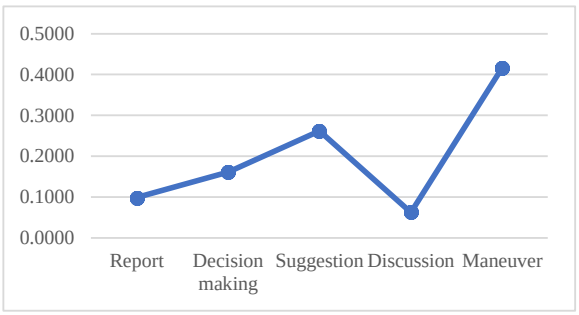
Expert 3



Expert 4



Expert 5



Expert 6

Expert 7

Fig. 5.16. The criteria weights according to pairwise comparison of the experts (case 3)

Table 5.59. The average of criteria weights according to pairwise comparison of the experts (case 3)

Actions (case 3)	Criteria							
	E1	E2	E3	E4	E5	E6	E7	AVG
Report	0.0797	0.1459	0.2268	0.0624	0.1611	0.0986	0.1611	0.1336
Decision making	0.1477	0.0904	0.0888	0.1611	0.0986	0.1611	0.0624	0.1157
Suggestion	0.2563	0.4565	0.1431	0.2618	0.4162	0.2618	0.4162	0.3160
Discussion	0.0717	0.0577	0.0566	0.0986	0.0624	0.0624	0.0986	0.0726
Maneuver	0.4446	0.2495	0.4847	0.4162	0.2618	0.4162	0.2618	0.3621

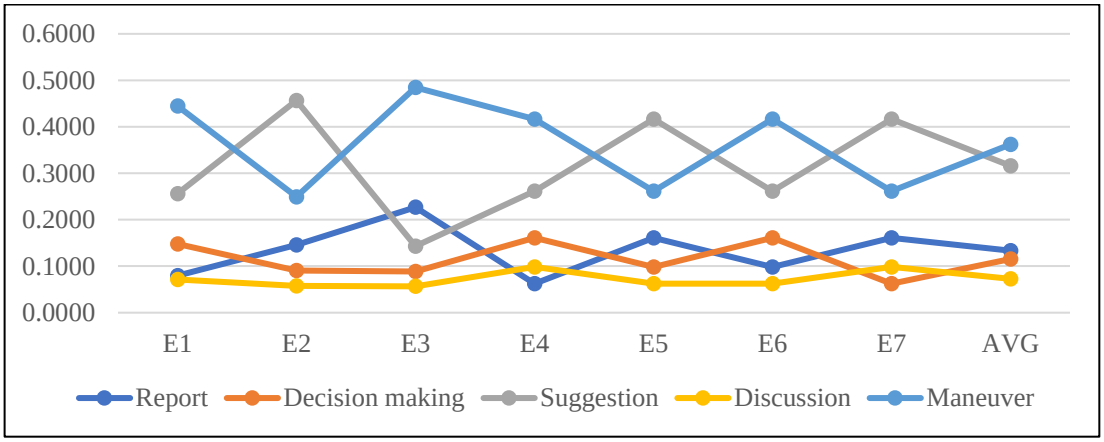


Fig. 5.17. The average of criteria weights according to pairwise comparison of the experts (case 3)

Table 5.59. and Fig. 5.17. shows the average of criteria weights according to pairwise comparison of the experts in case 3.

b. The criteria weights according to the alternatives of the experts (case 3)

We calculated the normalized pairwise comparison matrix and the criteria weights according to the alternatives. After that, we checked for consistency, and the results are shown in Tables 5.60-5.66.

Table 5.60. Criteria weights according to the alternatives of expert 1 (case 3)

Expert 1	Criteria weights according to the alternatives				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0869	0.6806	0.3338	0.6999	0.0893
Reduce time of participant response actions	0.6393	0.2014	0.1416	0.1066	0.5869
Increase response actions completion percentage	0.2737	0.1179	0.5247	0.1935	0.3238
CR (consistency ratio)	0.0466 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)	0.0464 < 0.1 (High consistency)	0.0079 < 0.1 (High consistency)	0.0079 < 0.1 (High consistency)

Table 5.61. Criteria weights according to the alternatives of expert 2 (case 3)

Expert 2	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.1062	0.6232	0.0982	0.7530	0.0796
Reduce time of participant response actions	0.6333	0.1373	0.3339	0.0752	0.6555
Increase response actions completion percentage	0.2605	0.2395	0.5679	0.1718	0.2648
CR (consistency ratio)	0.0334 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)	0.0646 < 0.1 (High consistency)	0.0280 < 0.1 (High consistency)

Table 5.62. Criteria weights according to the alternatives of expert 3 (case 3)

Expert 3	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.1179	0.2395	0.1038	0.5714	0.2299
Reduce time of participant response actions	0.2014	0.6232	0.2311	0.1429	0.1222
Increase response actions completion percentage	0.6806	0.1373	0.6651	0.2857	0.6479
CR (consistency ratio)	0.0213 < 0.1 (High consistency)	0.0158 < 0.1 (High consistency)	0.0750 < 0.1 (High consistency)	0 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)

Table 5.63. Criteria weights according to the alternatives of expert 4 (case 3)

Expert 4	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0641	0.1535	0.1096	0.7672	0.1741
Reduce time of participant response actions	0.6463	0.7545	0.5813	0.0848	0.7225
Increase response actions completion percentage	0.2895	0.0919	0.3092	0.1481	0.1033
CR (consistency ratio)	0.0641 < 0.1 (High consistency)	0.0281 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)	0.0159 < 0.1 (High consistency)	0.0252 < 0.1 (High consistency)

Table 5.64. Criteria weights according to the alternatives of expert 5 (case 3)

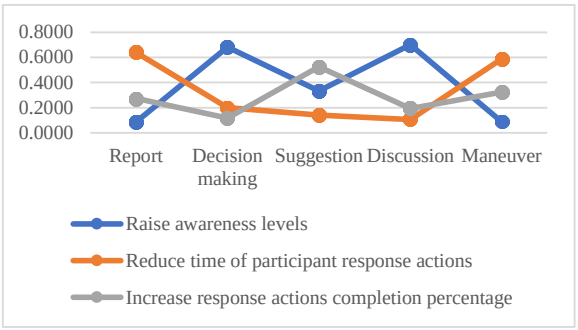
Expert 5	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0869	0.6080	0.1096	0.7235	0.1062
Reduce time of participant response actions	0.6393	0.2721	0.3092	0.0833	0.6333
Increase response actions completion percentage	0.2737	0.1199	0.5813	0.1932	0.2605
CR (consistency ratio)	0.0466 < 0.1 (High consistency)	0.0639 < 0.1 (High consistency)	0.0032 < 0.1 (High consistency)	0.0567 < 0.1 (High consistency)	0.0334 < 0.1 (High consistency)

Table 5.65. Criteria weights according to the alternatives of expert 6 (case 3)

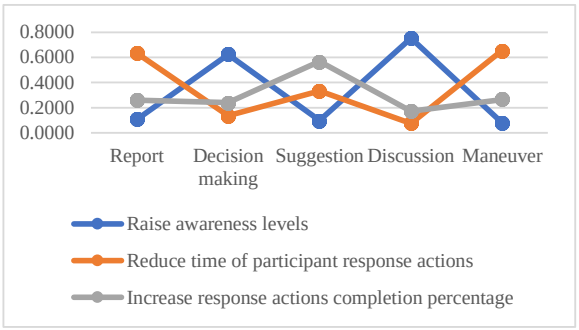
Expert 6	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0819	0.1822	0.0819	0.7394	0.2014
Reduce time of participant response actions	0.5750	0.7028	0.5750	0.0818	0.6806
Increase response actions completion percentage	0.3431	0.1149	0.3431	0.1788	0.1179
CR (consistency ratio)	0.0251 < 0.1 (High consistency)	0.0467 < 0.1 (High consistency)	0.0251 < 0.1 (High consistency)	0.0882 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)

Table 5.66. Criteria weights according to the alternatives of expert 7 (case 3)

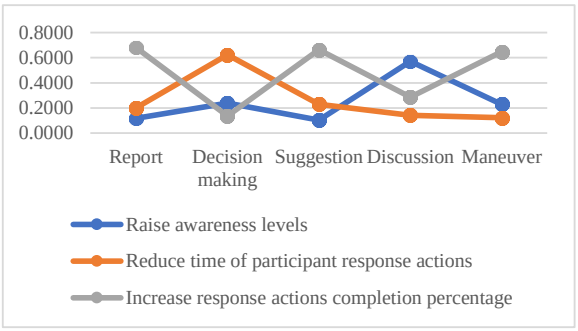
Expert 7	**Criteria weights according to the alternatives**				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0982	0.0982	0.0964	0.7071	0.3339
Reduce time of participant response actions	0.3339	0.5679	0.2842	0.0915	0.0982
Increase response actions completion percentage	0.5679	0.3339	0.6194	0.2014	0.5679
CR (consistency ratio)	0.0213 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)	0.0747 < 0.1 (High consistency)	0.0826 < 0.1 (High consistency)	0.0213 < 0.1 (High consistency)



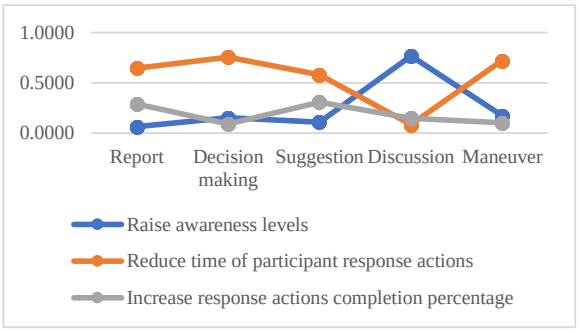
Expert 1



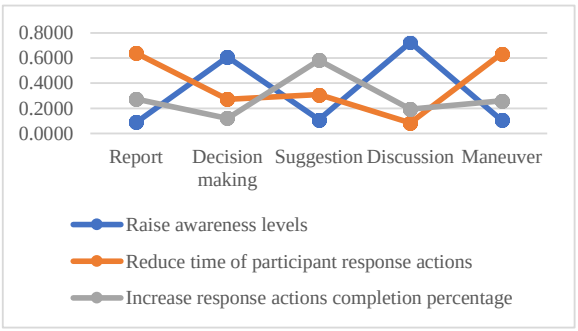
Expert 2



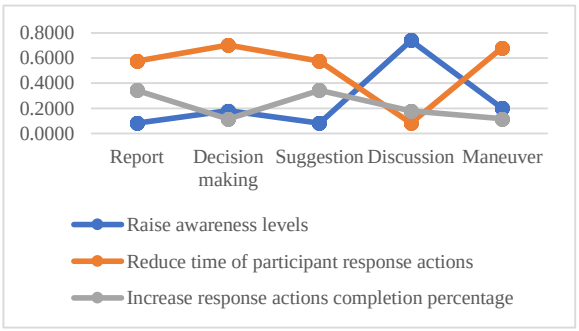
Expert 3



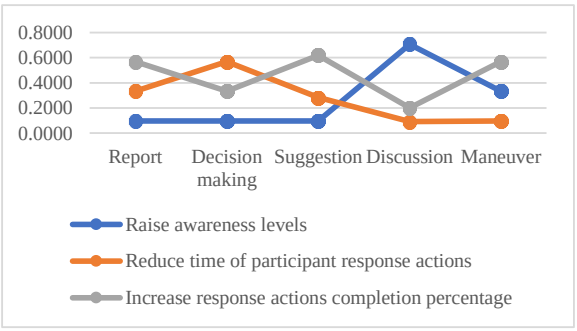
Expert 4



Expert 5



Expert 6



Expert 7

Fig. 5.18. The criteria weights according to the alternatives of the experts (case 3)

Figure 5.18 is generated from the data of tables 5.60-5.66. We can easily see the difference in the criteria weights according to the alternatives of the experts.

Table 5.67. The average of criteria weights according to the alternatives of the experts (case 3)

Alternatives (case 3)	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0896	0.3571	0.1319	0.7077	0.1802
Reduce time of participant response actions	0.5003	0.4974	0.3549	0.0946	0.4996
Increase response actions completion percentage	0.4101	0.1454	0.5132	0.1977	0.3202

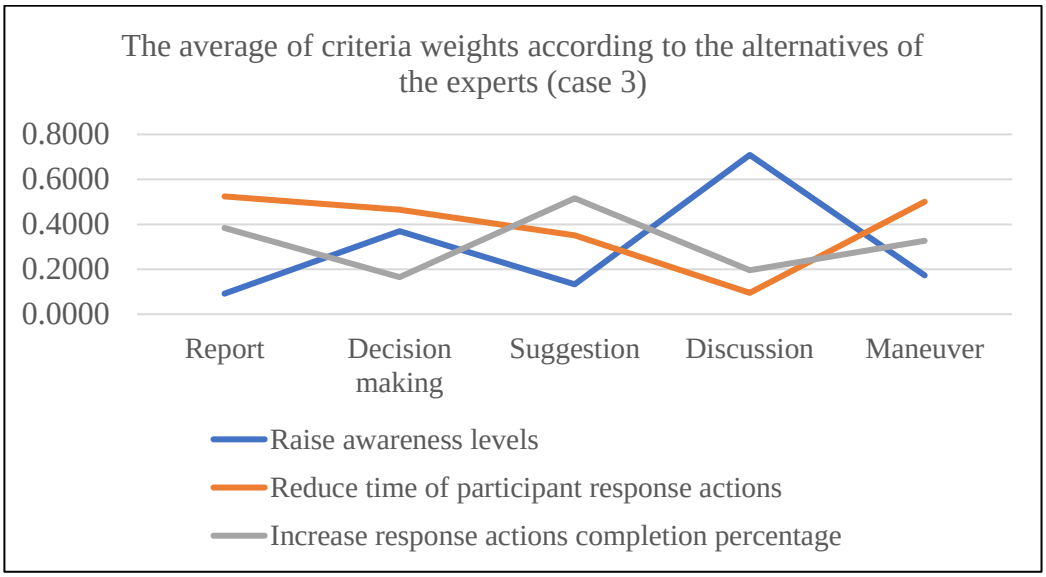


Fig. 5.19. The average of criteria weights according to the alternatives of the experts (case 3)

Table 5.67. and Fig. 5.19. shows the average of criteria weights according to the alternatives of the experts in case 3.

c. The decision weight of alternatives of the experts (case 3)

The weights of the alternatives according to the evaluation of the experts are shown in table 5.68-5.74

Table 5.68. The decision weight of the alternatives according to the evaluation of expert 1 (case 3)

Expert 1	
Alternatives	Criteria weight
Raise awareness levels	0.2829
Reduce time of participant response actions	0.3856
Increase response actions completion percentage	0.3315

Table 5.69. The decision weight of the alternatives according to the evaluation of expert 2 (case 3)

Expert 2	
Alternatives	Criteria weight
Raise awareness levels	0.1800
Reduce time of participant response actions	0.4252
Increase response actions completion percentage	0.3949

Table 5.70. The decision weight of the alternatives according to the evaluation of expert 3 (case 3)

Expert 3	
Alternatives	Criteria weight
Raise awareness levels	0.2067
Reduce time of participant response actions	0.2014
Increase response actions completion percentage	0.5920

Table 5.71. The decision weight of the alternatives according to the evaluation of expert 4 (case 3)

Expert 4	
Alternatives	Criteria weight
Raise awareness levels	0.2055
Reduce time of participant response actions	0.6231
Increase response actions completion percentage	0.1714

Table 5.72. The decision weight of the alternatives according to the evaluation of expert 5 (case 3)

Expert 5	
Alternatives	Criteria weight
Raise awareness levels	0.1925
Reduce time of participant response actions	0.4295
Increase response actions completion percentage	0.3781

Table 5.73. The decision weight of the alternatives according to the evaluation of expert 6 (case 3)

Expert 6	
Alternatives	Criteria weight
Raise awareness levels	0.1888
Reduce time of participant response actions	0.6088
Increase response actions completion percentage	0.2024

Table 5.74. The decision weight of the alternatives according to the evaluation of expert 7 (case 3)

Expert 7	
Alternatives	Criteria weight
Raise awareness levels	0.2192
Reduce time of participant response actions	0.2422
Increase response actions completion percentage	0.5386

Table 5.75. The average decision weight of the experts (case 3)

The alternatives	**Decision weight**							
	E1	**E2**	**E1**	**E4**	**E1**	**E6**	**E1**	**AVG**
Raise awareness levels	0.2829	0.1800	0.2067	0.2055	0.1925	0.1888	0.2192	0.2108
Reduce time of participant response actions	0.3856	0.4252	0.2014	0.6231	0.4295	0.6088	0.2422	0.4165
Increase response actions completion percentage	0.3315	0.3949	0.5920	0.1714	0.3781	0.2024	0.5386	0.3727

Figure 5.20. is generated from the data of Table 5.75. We can easily see the difference in the weights of alternatives according to the evaluation of the experts.

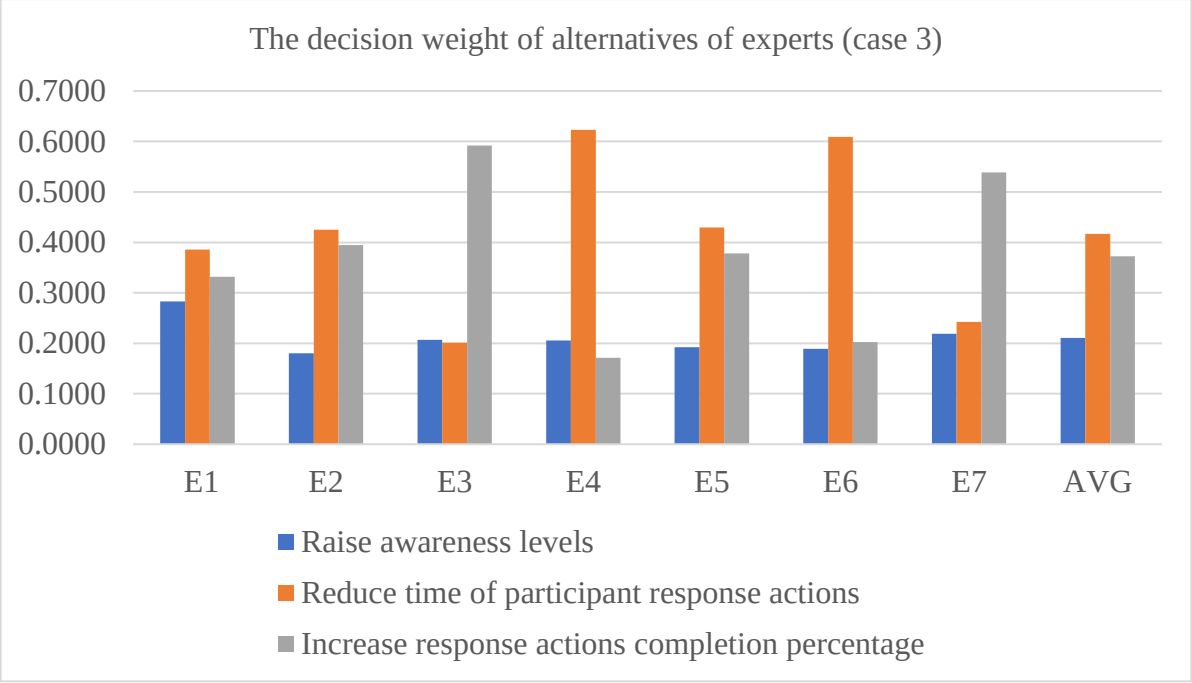


Fig. 5.20. The decision weight of alternatives of experts (case 3)

5.5. Discussion

5.5.1. The content to be improved for the functional exercise on landslide response (case 1)

Figure 5.10 illustrates that experts prioritize different enhancements for the next functional exercise at UFPF. Specifically, E1, E2, and E5 believe that the content in need of improvement is “Raise awareness levels”; E4 and E6 suggest that the focus should be on “Reduce time of participant response actions”; whereas E3 and E7 advocate for improving the content to “Increase response actions completion percentage”. To address research question 1, I relied on the mean values of the decision weights assigned by the experts. According to Table 5.27 and Figure 5.10, the content identified for improvement in the next functional exercise at UFPF is “Raise awareness levels”.

A question arises: How to increase the level of awareness in the next exercise? To answer this question, we need to find the criteria with the highest weight according to the Raise awareness levels alternative. According to Figure 5.9. we can see that, the average values from experts indicate that the criterion with the highest weight according to the alternatives “Raise awareness levels” is the criterion “Discussion”. Therefore, during exercise design, designers should emphasize the “Discussion” action to raise the awareness level of the participants in the next exercise.

5.5.2. The similarities and differences in criteria weights of the action types and alternatives across the different disaster types

Figures 5.10, 5.15, and 5.20 illustrate variations in the content that needs improvement for the next exercises across three disaster scenarios. Specifically, for Case 1, the prioritized improvement is "Raise awareness levels," whereas for Cases 2 and 3, the emphasis is on "Reduce time of participant response actions". To answer this difference, we need to compare the criteria weights according to the alternatives and the criteria weights according to the pairwise comparison of the three cases.

Figures 5.9, 5.14, and 5.19 help us easily recognize that there is no difference in the criteria weights according to the alternatives. Even when comparing the criteria weights according to alternatives of each expert in all three cases (see Figures 5.8, 5.13, and 5.18), there is not a significant difference. Thus, it can be concluded that the criteria weights according to alternatives do not create differences in the decision weights of alternatives in the three disaster cases. More broadly, the importance of each type of response action for the improvement content of the next exercise is not affected by differences in the type of disaster for the functional exercise.

It is easy to see the huge difference between the weights of the criteria according to the pairwise comparison of case 1, 2, and case 3 (Tables 5.11, 5.35, 5.59 and Figures 5.7, 5.12, 5.17). For Case 1, the criteria importance follows the order: Decision making > Discussion > Report > Maneuver > Suggestions. In Case 2, it shifts to Maneuver > Decision making > Discussion > Report > Suggestions. Meanwhile, for Case 3, the order is Maneuver > Suggestions > Report > Decision making > Discussion. This observation underscores the significant impact of criteria weights according to pairwise comparisons on the decision weights of alternatives. Simply put, the importance assigned to each type of response action through pairwise comparisons varies for each disaster type in a functional exercise. Wildfires in Vietnam are disasters that require many forces to work together to conduct a response similar to the response to a landslide and flash flood (Le and Kato, 2022). However, due to the different characteristics of disasters, the priority of response actions for these three types of disasters also changes significantly. This has great significance for designers during the exercise design process.

5.5.3. Recommendations for improving functional exercises

Answer to research question 3: Designers can rely on the relationship between response action types and exercise content to design injects. In order to better understand this point of view, I will take an example and explain it in more detail. First of all, there are 2 points to note:

- There is a point that we need to note here that the criteria in the pairwise comparison are compared with each other when their numbers are equal. In other words, it is the specific weight of each criterion.
- Therefore, when we want to calculate the decision weights of the alternatives of an exercise, we need to pay attention to the coefficients of the criteria. In other words, the number of action types.

Criteria weights according to Pairwise-comparison matrix	X	Criteria weights according to alternatives	=	Decision weights of alternatives

I will consider the exercise at UFPF as a good example to clarify the recommendation.

For example:

Table 5.76. The sum of the weights of each criterion in the exercise at UFPF (for example)

Criteria in FE on landslide response	Criteria weight according to Pair-wise comparison (Table 5.11)	Number of actions (Fig 4.3)	The sum of the weights of each criterion in the exercise
Report	0.155	10	0.155 × 10 = 1.55
Decision making	0.411	40	0.411 × 40 = 16.44

Suggestion	0.064	4	0.064 × 4 = 0.25
Discussion	0.279	12	0.279 × 12 = 3.35
Maneuver	0.091	3	0.091 × 3 = 0.27

Exercise at UFPF	Weight of action according to the alternatives (Table 5.19)				
	Report	Decision making	Suggestion	Discussion	Maneuver
Raise awareness levels	0.0857	0.3825	0.1527	0.7247	0.1523
Reduce time of participant response actions	0.5289	0.4267	0.3260	0.0833	0.5491
Increase response actions completion percentage	0.3854	0.1908	0.5213	0.1919	0.2985

X

Criteria in FE on landslide response	The sum of criteria weights (Table 5.76)
Report	1.341
Decision making	17.14
Suggestion	0.2272
Discussion	3.4044
Maneuver	0.2907

Table 5.77. The decision weights of the alternatives in the exercise at UFPF (for example)

=

Alternatives of the exercise at UFPF	Decision weights of alternatives in the exercise at UFPF
Raise awareness levels	8.19
Reduce time of participant response actions	9.13
Increase response actions completion percentage	4.55

Table 5.77 shows that alternative 2 is the alternative with the highest decision weight.

- Now I will adjust the structure of the next exercise so that this exercise will help the player to raise awareness levels (alternative 1), in other words, the total decision weight of alternative 1 will be greater than the ones of remaining two alternatives.

Examining figure 5.9, we can see that the action types "Report" and "Maneuver" have a large influence on the "Reduce time of participant response actions" alternative. Meanwhile, the action type "Discussion" has a great influence on the alternative "Raise awareness levels". Therefore, in the next exercise I will reduce the number of "Report" and "Maneuver" actions, and increased the number of "Discussion" actions.

Table 5.78. The number of action types (for example)

Actions	Number of actions in exercise	Number of actions in the next exercise
Report	10	5
Decision making	40	40
Suggestion	4	4
Discussion	12	19
Maneuver	3	1

Then we will have the following result:

Table 5.79. The sum of the weights of each criterion in the new exercise (for example)

Criteria in FE on landslide response	Criteria weight according to Pair-wise comparison (Table 5.11)	Number of actions in the new exercise (Table 5.78)	The sum of the weights of each criterion in the exercise
Report	0.155	5	0.155 × 5 = 0.78
Decision making	0.411	40	0.411 × 40 = 16.44
Suggestion	0.064	4	0.064 × 4 = 0.25
Discussion	0.279	19	0.279 × 19 = 5.31
Maneuver	0.091	1	0.091 × 1 = 0.09

New exercise at UFPF	Weight of action according to the alternatives (Table 5.19)				
	Report	Report	Report	Report	Report
Raise awareness levels	0.0857	0.0857	0.0857	0.0857	0.0857
Reduce time of participant response actions	0.5289	0.5289	0.5289	0.5289	0.5289
Increase response actions completion percentage	0.3854	0.3854	0.3854	0.3854	0.3854

X

Criteria in FE on landslide response	The sum of criteria weights (Table 5.79)
Report	0.78
Decision making	16.44
Suggestion	0.25
Discussion	5.31
Maneuver	0.09

Table 5.80. The decision weights of the alternatives in the new exercise (for example)

=

Alternatives of the new exercise	Decision weights of alternatives in the new exercise
Raise awareness levels	9.50
Reduce time of participant response actions	8.83
Increase response actions completion percentage	4.55

According to Table 5.80 we see that the weight of alternative 1 (Raise awareness levels) is already higher than the weight of the other 2 alternatives. (It should be noted that other types of actions such as decision-making, and suggestion also have a certain impact on the total weight of the criteria).

The above is an example of how designers can apply AHP results to functional exercises design.

5.6. Summary of Chapter 5

The three objectives of this chapter were addressed as follows. Firstly, Chapter 5 used an analytic hierarchical process to identify the contents for improvement for the next exercise based on evaluation criteria identified as the types of response actions taken in the functional

exercise on landslide response at UFPF, 2022. The results indicated that the content needs improvement for the next exercise is Raise awareness levels.

Secondly, Chapter 5 analyzed the similarities and differences between the decision weight of the content to be improved according to the criteria of the function exercise for three disaster cases of landslides (case 1), wildfire (case 2) and flash flood (case 3). The results show that the content to be improved for the next exercise for case 1 is Raise awareness levels, while for cases 2 and 3, it is Reduce time of participant response actions. There are two points of view: the importance of each type of response actions for the content to be improved of the next exercise was not affected by the difference in the type of disaster for the functional exercise; the importance of each type of response action according to the pair-wise comparison will be different for each type of disaster in a functional exercise.

Finally, this chapter proposed a method for arranging exercise injects based on the weighting of action types. This chapter provide an example of the development of an exercise structure based on response action weighting. This example is based on the estimated weights, thereby adjusting the number of injects to change the relative importance of the targeted capabilities. This procedure enables exercise designers to create a structure that collectively enhances either a player's specific skills or all of the desired skills in a balanced manner by adjusting the number of injects based on the estimated weights. These research results are easily applicable to the design of functional exercises to respond to disasters in Vietnam and other countries facing similar situations.

6. Conclusion

6.1. Summary of key issues in the thesis

Fire prevention and fighting have been conducted by Vietnamese firefighters and fire prevention and fighting forces of establishments for many years, and they have obtained many achievements in fire prevention and fighting. Vietnamese firefighters' roles have expanded from fire prevention and firefighting to rescue activities in various situations since 2017. Practicing fire fighting plans and practicing rescue plans are two important tasks of Vietnamese firefighters and fire prevention and fighting forces of establishments. However, the practice of rescue plans in Vietnam is facing many difficulties and limitations. This study aims to find out the causes leading to difficulties in practicing rescue plans of Vietnamese firefighters and to research and develop emergency exercises to improve the rescue capacity of firefighters and other fire forces in Vietnam. After proposing solutions to improve the ability to practice rescue plans, this study also develops a method of evaluating functional exercises based on Bloom's taxonomy. Additionally, this study develops an improved content selection method for the next exercise based on an analysis hierarchical process.

Objective A of this study was answered in Chaters 1 and 2. Chapter 1 outlined the background and objectives of this study and Chapter 2 summarized the theoretical and legal basis of current firefighting exercises in Vietnam, reviews previous studies on emergency exercises, and examines documents on emergency exercises in the United States.

Chapter 3 addressed Objective B and showed that the characteristics of the rescue plan exercises in Vietnam closely resembles the full-scale exercise of HSEEP. However, it is not honed and developed through the previous smaller exercises. The reason leading to the limitation in the design and practice of rescue plans for Vietnamese firefighters is the lack of types of exercises; it is too expensive to practice exercises with large-scale incidents and it is not possible to create a hypothetical incident scene. Vietnamese firefighters can apply functional exercise and table-top exercise as a solution to overcome limitations such as cost, and incident scene.

Chapter 4 addressed Objective C and showed that full use of Bloom's taxonomy for firefighter evaluation is necessary. Evaluation methods need to be designed from multiple angles to accurately address the capabilities of students with different backgrounds. Designing a uniform number of injects and response actions for exercise groups can contribute to a more uniform increase in player knowledge. However, further research is required to support this view.

Chapter 5 addressed Objective D and showed that the importance of each type of response action according to the pair-wise comparison is different for each type of incident

and disaster in a functional exercise. Designers can rely on the relationship between response action types and exercise content to design injects. This will make it easier for the exercise to achieve its objectives.

6.2. Further Implications

There would be some suggestions for further extending results from the thesis. The authors referred to HSEEP as a comprehensive and useful guideline for exercises, but HSEEP is not a perfect solution [R. Renger, 2008; L. C. McCormick, 2014]. Further research on effective rescue exercise methods for Vietnam and other developing countries is necessary.

For the development of methods of evaluating functional exercises. More diverse cases, in terms of course topics and student backgrounds, should be studied to generalize the results obtained from this study. To capture the diverse capabilities of students, education criteria other than Bloom’s taxonomy may play important roles, depending on the types of training courses [Slick, 2019; Chan. et al, 2014]. For each taxonomy level, there should be at least three evaluation questions. Future studies should apply Kirkpatrick's Four Levels of Training Evaluation to consider the effects of training on real-world activities following education. Designing a uniform number of input tasks and activities for exercise groups can contribute to a more uniform increase in player knowledge. However, further research is required to support this view. Functional exercise has been shown to have a positive effect on participants' ability to increase knowledge. Therefore, it is recommended that everyone participates in the exercise. However, sometimes the conditions are insufficient for everyone to participate in the exercise. Therefore, methods for increasing observer knowledge need to be studied and developed further.

For using an analytic hierarchical process to identify the contents for improvement for the next exercise based on evaluation criteria identified as the types of response actions. There are two points of view: the importance of each type of response actions for the content to be improved of the next exercise was not affected by the difference in the type of incident and disaster for the functional exercise; the importance of each type of response action according to the pair-wise comparison will be different for each type of incident and disaster in a functional exercise. Furthermore, the assessment of experts may be constrained, as functional exercises related to wildfire and flash flood responses have not been conducted. Assessments of wildfires (Case 2) and flash floods (Case 3) by experts rely solely on their own experiences and knowledge. For different incident and disaster response functional exercises, the type of injects and the type of response action may be different. More functional exercises with more incident and disaster types are needed to identify the main types of response actions that all functional exercises require.

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Appendix 1.

SOCIALIST REPUBLIC OF VIETNAM
Independence - Freedom - Happiness

.....

.....

	Plan approval level:

RESCUE PLANS OF THE FIRE AND RESCUE POLICE

Name of the establishment:

Address:

Tel:

Superior agency:

Tel:

The Fire Prevention and Fighting and Rescue Police Unit manages the area:

...,[date]

A. CHARACTERISTICS RELATED TO RESCUE OPERATIONS

I. Geographic location:

.....

.....

II. Internal and external traffic system:

.....

.....

III. Nature and characteristics related to rescue operation:

.....

.....

IV. Standing force for rescue operation:

1. Organization of rescue force:

.....

.....

2. Standing force for rescue operation:

.....

.....

V. Internal rescue equipment:

.....

.....

B. PLAN FOR A WORST-CASE SCENARIO THAT REQUIRES THE MOBILIZATION OF FORCES AND MEANS OF MANY PARTICIPATING UNITS, AGENCIES, AND ORGANIZATIONS TO RESOLVE IT.

I. Presumptive scenario

.....

.....

II. Tactics, rescue skills

.....

.....

III. Calculating the necessary forces and means for rescue

.....

.....

IV. Expected forces and means to be mobilized

No	Units are mobilized	Tel	Number of people mobilized	Number and types of vehicles mobilized	Note

V. Organization of rescue operation

1. Tasks of the standing force for rescue

.....

.....

2. Specific tasks of the fire prevention fighting and rescue police force

.....

.....

3. Tasks of other forces

.....

.....

VI. Diagram of rescue forces and equipment for the worst-case scenario

C. PLAN FOR OTHER TYPICAL SCENARIOS:

1. Scenario 1:

.....

.....

2. Scenario 2:

.....

.....

Scenario...:

.....

.....

D. REVISION TO RESCUE PLAN:

No.	Date	Revision content	Signature of the person establishing the plan	Signature of the person approving the plan
1	2	3	4	5

E. MONITOR TRAINING AND PRACTICE OF RESCUE PLAN:

Date	Content of training and practice	Scenarios	Human forces and equipment for rescue operations	Comments and results

.....,[date]

APPROVED BY

(15).....

(signature, full name and seal)

.....,[date]

ESTABLISHED BY

(16).....

(signature and full name)

Appendix 2.

Questionnaire on the current status of the design and practice of fire fighting plans and rescue plans of Vietnamese firefighters

Part 1: Information about survey participants

Name and surname:

Gender:

Age:

Qualification:

Position:

Working unit:

Experience:

Part 2: Questionnare

Question 1: Have you ever designed the fire fighting plans?

□ Yes, I have

□ No, I have not

Question 2: (If you choose "Yes") How often are your fire fighting plans designed?

□ A few years: Design one plan.

□ Every year: Design one plan.

□ Design several plans every year.

□ Design one plan every month.

□ Design one plan every week.

□ Design one plan every day.

Question 3: (If you choose "No") Why have you never designed the fire fighting plans?

□ I don't have to design the plan

□ Don't know how to design exercise

□ Only be able to design part of the exercise

□ Another reasons

Question 4: (If you choose "Another reasons".) What other reason do you want to mention?

Answer:

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Question 5: Have you ever designed the rescue plans?

□ Yes, I have

□ No, I have not

Question 6: (If you choose "Yes") What incidents or accidents have you designed rescue plans for? How frequent is the design for each type of incident or accident?

	Incidents									
	Fire	Construction collapse	landslide	When someone is stuck on high, deep down	When someone is trapped in a cave, tunnel, underground construction	Road traffic	Railway traffic	Inland waterway traffic	Drowning in rivers, streams, ponds, lakes, waterfalls, rapids	When responding to floods
Have not ever	□	□	□	□	□	□	□	□	□	□
A few years: Design one plan.	□	□	□	□	□	□	□	□	□	□
Every year: Design one plan.	□	□	□	□	□	□	□	□	□	□
Design several plans every year.	□	□	□	□	□	□	□	□	□	□
Design one plan every month.	□	□	□	□	□	□	□	□	□	□
Design one plan every week.	□	□	□	□	□	□	□	□	□	□
Design one plan every day.	□	□	□	□	□	□	□	□	□	□

Question 7: (If you choose "No") Why have you never designed the rescue plans?

□ Only be able to design part of the exercise

□ Due to the impact of Covid-19

□ Combine firefighting and rescue exercises

□ Can't practice the exercise so the design doesn't make sense

□ Don't know how to design exercises

□ The cost is too expensive

□ Another reasons

Question 8: (If you choose "Another reasons") What other reason do you want to mention?

Answer:

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Question 9: Have you ever practiced the fire fighting plans?

□ Yes, I have

□ No, I have not

Question 10: (If you choose "Yes") How often are your fire fighting plans practiced?

□ A few years: Practice one plan.

□ Every year: Design one plan.

□ Design several plans every year.

□ Design one plan every month.

□ Design one plan every week.

□ Design one plan every day.

Question 11: (If you choose "No") Why have you never practiced the fire fighting plans?

□ The practice form is not suitable for the type of incident

□ The cost of practice is too much

□ Need much specialized equipment to practice

□ Cannot create a hypothetical crash scene

□ Long practice time

□ Need more force to participate in practice

□ Another reasons

Question 12: (If you choose "Another reasons".) What other reason do you want to mention?

Answer:

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Question 13: Have you ever practiced the rescue plans?

□ Yes, I have

□ No, I have not

Question 14: (If you choose "Yes") What incidents or accidents have you practiced rescue plans for? How frequent is the practice for each type of incident or accident?

	Incidents									
	Fire	Construction collapse	landslide	When someone is stuck on high, deep down	When someone is trapped in a cave, tunnel, underground construction	Road traffic	Railway traffic	Inland waterway traffic	Drowning in rivers, streams, ponds, lakes, waterfalls, rapids	When responding to floods
Have not ever	□	□	□	□	□	□	□	□	□	□
A few years: Practice one plan.	□	□	□	□	□	□	□	□	□	□

Every year: Practice one plan.	□	□	□	□	□	□	□	□	□	□
Practice several plans every year.	□	□	□	□	□	□	□	□	□	□
Practice one plan every month.	□	□	□	□	□	□	□	□	□	□
Practice one plan every week.	□	□	□	□	□	□	□	□	□	□
Practice one plan every day.	□	□	□	□	□	□	□	□	□	□

Question 15: (If you choose "No") Why have you never practiced the rescue plans?

□ The practice form is not suitable for the type of incident

□ The cost of practice is too much

□ Need much specialized equipment to practice

□ Cannot create a hypothetical crash scene

□ Long practice time

□ Need more force to participate in practice

□ Another reasons

Question 16: (If you choose "Another reasons".) What other reason do you want to mention?

Answer:

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Q17. In your personal opinion, what factors are currently influencing the ability to practice rescue plans? How significant is the impact of these factors?

	Huge influence	Large influence	Moderate influence	Small influence	Very small effect	No effect
Incident scale	□	□	□	□	□	□
Hypothetical incident scene	□	□	□	□	□	□
Cost of practice	□	□	□	□	□	□
Number of forces participating in the exercise	□	□	□	□	□	□
Number of specialized rescue equipment needed for practice	□	□	□	□	□	□
There are few forms of practice	□	□	□	□	□	□

Other factors	□	□	□	□	□	□

Question 18: (If you choose “Other factors”) What other factors do you want to mention?

Answer:

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Question 19: According to the summary of work in 2020 of the Fire and Rescue Police Department, a large number of provincial and city fire services are facing many difficulties and limitations in the design and practice of the rescue plans. What do you think is the main cause of this problem?

Answer:

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Appendix 3.

Questionnaire on the functional exercise on landslide at UFPF, Vietnam.

(Before training course)

Part 1: Information about survey participants

Name and surname:

Gender:

Age:

Class:

Experience as a firefighter:

Part 2: Questionnaire about the knowledge of landslide rescue operations.

Question 1: Please name the rescue activities at the scene of the landslide incident

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Question 2: Please explain why safety management is an extremely important activity at the site of a landslide incident.

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Question 3: Suppose at 22:15 on May 25, 2022, there was a landslide of 1200m3 of soil that buried a house in province B. At the time of the incident, there were 3 people inside the house. If you are a rescue commander, what activities do you need to do? Explain why you do those activities.

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Question 4: Please analyze the difference between landslide rescue and firefighting work

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Question 5: In your opinion, what are the points that need to be improved in the current landslide rescue work in Vietnam? Why?

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Question 6: Please present your idea for a new landslide response procedure that you think is more suitable for the conditions in Vietnam. What are the new features and advantages of the new process you propose?

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Appendix 4.

Questionnaire on the functional exercise on landslide at UFPF, Vietnam.

(After the exercise)

Part 1: Information about survey participants

Name and surname:

Gender:

Age:

Class:

Experience as a firefighter:

Part 2: Questionnaire about the knowledge of landslide rescue operations.

Question 1: Please name the rescue activities at the scene of the landslide incident

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Question 2: Please explain why safety management is an extremely important activity at the site of a landslide incident.

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Question 3: Suppose at 22:15 on May 25, 2022, there was a landslide of 1200m3 of soil that buried a house in province B. At the time of the incident, there were 3 people inside the house. If you are a rescue commander, what activities do you need to do? Explain why you do those activities.

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Question 4: Please analyze the difference between landslide rescue and firefighting work

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Question 5: In your opinion, what are the points that need to be improved in the current landslide rescue work in Vietnam? Why?

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Question 6: Please present your idea for a new landslide response procedure that you think is more suitable for the conditions in Vietnam. What are the new features and advantages of the new process you propose?

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Part 3: Questionnaire on students' attitudes towards the course

Question 1: Are you satisfied with the course?

□ Very good

□ Good

□ Normal

□ Poor

□ Very poor

Question 2: Was the course useful?

□ Very useful

□ Useful

□ Normal

□ Less useful

□ Not useful

Question 3: Is the content relevant to your future work?

□ Highly relevant

□ Closely related

□ Related

□ Somewhat related

□ Irrelevant

Question 4: Would you recommend the course to others?

□ Definitely, I highly recommend the course to others.

□ Yes, I would recommend the course to others.

□ I might recommend the course to others.

□ I am not sure if I would recommend the course to others.

□ No, I would not recommend the course to others.

Appendix 5.

Questionnaire on the functional exercise on landslide at UFPF, Vietnam.

(After the hot debriefing session)

Part 1: Information about survey participants

Name and surname:

Gender:

Age:

Class:

Experience as a firefighter:

Part 2: Questionnaire about the knowledge of landslide rescue operations.

Question 1: Please name the rescue activities at the scene of the landslide incident

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Question 2: Please explain why safety management is an extremely important activity at the site of a landslide incident.

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Question 3: Suppose at 22:15 on May 25, 2022, there was a landslide of 1200m3 of soil that buried a house in province B. At the time of the incident, there were 3 people inside the house. If you are a rescue commander, what activities do you need to do? Explain why you do those activities.

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Question 4: Please analyze the difference between landslide rescue and firefighting work

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Question 5: In your opinion, what are the points that need to be improved in the current landslide rescue work in Vietnam? Why?

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Question 6: Please present your idea for a new landslide response procedure that you think is more suitable for the conditions in Vietnam. What are the new features and advantages of the new process you propose?

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Part 3: Questionnaire on students' attitudes towards the course

Question 1: Are you satisfied with the course?

□ Very good

□ Good

□ Normal

□ Poor

□ Very poor

Question 2: Was the course useful?

□ Very useful

□ Useful

□ Normal

□ Less useful

□ Not useful

Question 3: Is the content relevant to your future work?

□ Highly relevant

□ Closely related

□ Related

□ Somewhat related

□ Irrelevant

Question 4: Would you recommend the course to others?

□ Definitely, I highly recommend the course to others.

□ Yes, I would recommend the course to others.

□ I might recommend the course to others.

□ I am not sure if I would recommend the course to others.

□ No, I would not recommend the course to others.

Part 4: Feedback from participants

Question 1: What did you enjoy the most from the course?

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Question 2: In your opinion, what should the next functional exercise improve on?

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Appendix 6.

Questionnaire on the importance of post-inject response action types in functional exercises

Part 1: Information about survey participants

Name and surname:

Gender:

Qualification:

Position:

Working unit:

Experience:

Part 2: Questionnare

Question 1: Please evaluate the level of importance among the different types of actions in table 1, 3.

Question 2: Please evaluate the level of importance of the player's response type of action to the contents to be improved of the exercises in table 2, 4.

For example:

If you think action A is 3 times more important than action B, circle 3 on the A side.

	Extremely		Very strongly		Strongly		Moderately		Equally		Moderately		Strongly		Very strongly		Extremely	
A	9	8	7	6	5	4	(3)	2	1	2	3	4	5	6	7	8	9	**B**

Case 1: landslide

Table 1. Please evaluate the level of importance among the different types of actions

Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision Making
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Discussion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver

Table 2. Please evaluate the level of importance of the player's response type of action to the contents to be improved of the exercises

Report	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Decision Making	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Suggestion	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Discussion	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Maneuver	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage

Case 2: Wildfire

Table 3. Please evaluate the level of importance among the different types of actions

Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Decision Making
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Report	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Suggestion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Decision Making	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Discussion
Suggestion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver
Discussion	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Maneuver

Table 4. Please evaluate the level of importance of the player's response type of action to the contents to be improved of the exercises

Report	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Decision Making	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Suggestion	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Di	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant

																			response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
Maneuver	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Reduce time of participant response actions
	Raise awareness levels	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage
	Reduce time of participant response actions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Increase response actions completion percentage