Developing Exercise Design and Evaluation Methods for Professional Emergency Responses

A Dissertation for Acquirement of the Degree of Doctor of Engineering

Course of Environmental and Ecological Systems
Graduate Programs in Environmental Systems,
Graduate School of Environmental Engineering,
The University of Kitakyushu, Japan
by
HOANG LE HONG GIANG

Supervisor: Prof. Takaaki Kato

Kitakyushu, June 2024

ACKNOWLEDGEMENTS

Firstly, I would like to express my sincere gratitude to my advisor Prof. Kato Takaaki name order for the continuous support during my study and for his patience, motivation, and immense knowledge. His guidance helped me in all aspects of research and writing of this dissertation. He made it possible for me to obtain a scholarship from the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

Second, I would like to express my gratitude and appreciation to JICA Vietnam and the project participants of the ongoing JICA Partnership Program in Hai Phong city, who have brought me a lot of precious experience, and intriguing ideas spurred this research.

Thirdly, I thank Colonel, Mr. Hoang Van Binh – Chief of the Fire and Rescue Police Division and all staff, especially the officers of the Firefighting and Rescue Instruction Team. They are my great comrades and their support helped me to conduct my study.

Finally, I would like to thank my family, especially my parents and my wife for supporting me spiritually throughout the writing of this dissertation and my life in general.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AHP: analytic hierarchical process

ASEAN: Association of Southeast Asian Nations

COVID-19: Coronavirus disease 2019

DHS: Department of Homeland Security

DRRE: Disaster Risk Reduction Education

EOC: Emergency Operation Center

EWS: Early warning system

GRDP: Gross regional domestic product

HSEEP: Homeland Security Exercise and Evaluation Program

FEMA: Federal Emergency Management Agency

H-EOC: Health Emergency Operation Center

IAEA: International Atomic Energy Agency

ISO: International Standards Organization in

JANI: Joint Advocacy Network Initiative

MOET: Ministry of Education and Training

NGO: Non-Government Organization

UNISDR: The United Nations Office for Disaster Risk Reduction

US/USA: United States/ United States of America

USD: United States Dollar

VND: Viet Nam Dong

WBS: Work breakdown structure

1. INTRODUCTION

1.1. Background

1.1.1. Hazards and Emergency management

Hazards include "biological, environmental, geological, hydro-meteorological, and technological processes and phenomena (UNISDR, 2016, p. 18). Natural and man-made hazards pose significant risks to communities and the environment. Natural hazards, including earthquakes, floods, hurricanes, and wildfires, are the result of natural processes and can have devastating impacts on human populations and infrastructure. On the other hand, man-made hazards such as industrial accidents, chemical spills, and nuclear accidents are often the result of human activities and technological failures.

Natural hazards are often unpredictable and can have widespread consequences, leading to loss of life, community displacement and economic loss. Climate change also worsens the frequency and intensity of many natural hazards, making them even more difficult to manage.

Man-made hazards, while often preventable, can also have catastrophic consequences. For example, the Chernobyl and Fukushima nuclear disasters have had lasting environmental and public health consequences, highlighting the potential impact of technological hazards. Industrial accidents, such as the Bhopal gas tragedy in India, are a stark reminder of the risks associated with man-made hazards.

Effective hazard management requires a comprehensive understanding of both natural and man-made hazards, as well as the development of strategies to minimize their impacts. This includes implementing early warning systems, land use planning and enforcing safety regulations. Additionally, efforts to build community resilience and preparedness are essential in reducing people's vulnerability to these hazards.

In short, natural and man-made hazards pose complex challenges that require multifaceted approaches to solve. By integrating scientific research, policy development and community engagement, society can work to reduce the risks associated with these dangers and build more resilient communities.

Emergency management is defined as "short-term measures taken to respond to particular hazards, risks or disaster" (Alexander, 2002, p. 309) and sometimes might be interchangeable with the term disaster management.

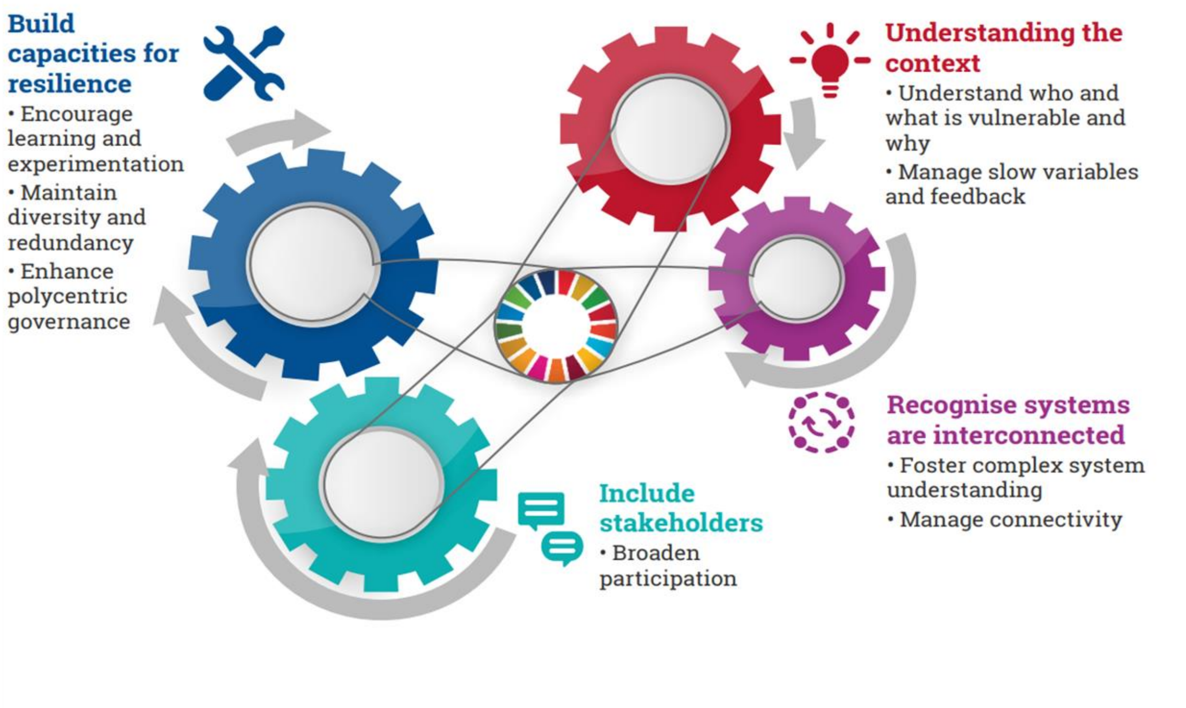
According to the International Standards Organization in ISO 22320 (2011), emergency management is represented by a set of measures that aim to prevent and manage a disaster or a disruptive event before, during, and after its occurrence. The Federal Emergency Management Agency (FEMA) of the United States of America defines emergency management as “a process through which the Nation prepares for emergencies and disasters, mitigates their effects, and responds to and recovers from them.” (ISO 22320, 2011, p. 57). The standardization of emergency management protocols, including exercises for improving the capabilities of emergency management professionals, is considered beneficial (ISO 2018, FEMA 2017). Since several of the concepts and ideas from ISO and FEMA are referred to in our study, we use definitions of emergency management as they are specified by these organizations. In this sense, the definitions of emergency management and disaster management are interchangeable and include the four phases of mitigation, preparedness, response, and recovery from disasters.

Fig. 1-1. The common concept of the disaster management cycle

1.1.2. Exercise programs

Emergency responders are key individuals who respond to emergencies and minimize damage and losses. They are expected to be quick and efficient when responding to an emergency but are often faced with abnormal conditions such as inadequate information, lack of time, stress, or simply the dynamic nature of the emergency (Brehmer, 1996; Flin, 1996). In fact, responders require a comprehensive understanding of different sectors regarding roles, responsibilities and authorities (McKing, 2010; Perry & Lindell, 2003; Prizzia, 2008).

Emergency exercises are a key component for an effective emergency preparedness program while also providing unique insight for the preparedness of emergency response organizations (IAEA, 2005). Exercise programs are a series of exercise activities designed to meet an overall objective or goal” (ISO 22300:2018 Security and resilience — Vocabulary). To enhance the capability of emergency response organizations, exercise programs are designed to train responders, as well as evaluate core capabilities within emergency tasks. Training and exercises help participants improve readiness for emergency response through facilitating plans and operations, reinforcing teamwork, and demonstrating a community's determination to prepare for incidents. Improving communications among responders is a key benefit of implementing exercises into an emergency management program (Canton, 2007, p. 119; Phelps, 2011). Other benefits of exercises include clarifying roles and responsibilities, find resource gaps, develop individual or group performance, and identifying opportunities for improvement as documents of Federal Emergency Management Agency (IS-120.A: An Introduction to Exercises, 2008). Therefore, efforts for making better exercise programs are necessary for all emergency management organizations.



Source: Adapted from (United Nations, 2020)

Fig. 1-2. The purpose of exercise programs

Many key issues need to be identified during assignment design, including needs assessment, assignment scope, and assignment type (IS-139.A: Exercise design and development, n.d.). When assessing the need for emergency exercises, the first step is to identify hazards related to the actual conditions of the organization or community. Identifying hazards is considered an essential and fundamental step in designing successful exercises. After identifying hazards, the exercise planning team needs to select the topic and scope of the exercise (DHS, 2013). Meanwhile, for exercises with participants from different stakeholders, the exercise planning team is formed by bringing together leaders or experts from different areas of expertise to Determine the basis for the exercise. However, an approach that synthesizes the opinions of different members of the planning team is needed to select appropriate exercise topics. Furthermore, the exercise planning team will face additional challenges as they plan to conduct a new type of emergency exercise, as well as involve participants from many different organizations. Therefore, it is necessary to develop a method to synthesize the opinions of members of the exercise planning team to select appropriate topics for emergency exercises.

1.2. Problem statement

Each nation has its own system to manage and respond to emergencies that reflect the characteristics of that nation's government, economy, and culture (To, 2019). Well-known standards of emergency management, such as the National Incident Management System (NIMS) and ISO 22320 define the items to be included in emergency management plans, but these standards do not clearly specify how much detail should be included in the plans (Kato et al., 2022). Emergency management plans need to have flexibility for improvised activities to avoid the mishandling of emergency situations by managerial inflexibility (Turner, 1995; Perry et al., 2007; Kato et al., 2022).

From the problem statement, these research questions are considered in the dissertation:

1. What are the current theories and situation of exercise programs for emergency response?

There may be diversity and uniformity in theories of exercise programs for emergency response among organizations and countries. Some countries have not adopted well-organized emergency management standards. Shortcomings in practical application of different formats in design and evaluation could be an issue.

2. Which methods can be applied to create more efficiency for them?

Mathematical and instructional methods can be applied to improve the efficiency of exercise programs. Innovative methods are feasible to help to access unavailable design and evaluation.

1.3. Research objectives

With the goal of developing a design and evaluation methods to composing effective exercise programs for the emergency response, the research subjects were identified as follows:

1. Approach theoretical frameworks of exercise programs for emergency response.

2. Determine the current situation of exercise programs for emergency response

3. Develop design and evaluation methods by using the Analytic Hierarchy Process and Four-Component Instructional Design.

4. Improve the time-tracking method for evaluating exercise programs.

1.4. Definition of terms

The issues mentioned in this study are closely related to the concept of two international standards, ISO 22300:2018 Security and resilience — Vocabulary and ISO 22320:2018 Security and resilience — Emergency management — Guidelines for incident management. There are also several other specialized documents for reference. To clarify issues within the research framework, we provide some definitions and perspectives on key concepts.

By ISO 22300:2018 Security and resilience — Vocabulary:

"Emergency" is "sudden, urgent, usually unexpected occurrence or event requiring immediate action. Note 1 to entry: An emergency is usually a disruption or condition that can often be anticipated or prepared for, but seldom exactly foreseen".

"Emergency management" is "overall approach for preventing emergencies and managing those that occur. Note 1 to entry: In general, emergency management utilizes a risk management approach to prevention , preparedness, response, and recovery before, during and after potentially destabilizing events and/or disruptions.

"Exercise" is a process to train for, assess, practice and improve performance in an organization. Exercises can be used for validating policies, plans, procedures, training, equipment, and inter-organizational agreements; clarifying and training personnel in roles and responsibilities; improving inter-organizational coordination and communications; identifying gaps in resources; improving individual performance and identifying opportunities for improvement; and a controlled opportunity to practice improvisation.

"Exercise program" is "series of exercise activities designed to meet an overall objective or goal."

According to the Glossary of FEMA training, "Exercise" is "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.

Exercise plays 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 (DHS, 2020).

This study also uses other sources of terminology such as:

Glossary of Terms Commonly Used in Disaster Preparedness and Response.

https://link.springer.com/chapter/10.1007/978-81-322-1566-0_2

Emergency Management Terminology - Conservation Center for Art & Historic Artifacts

https://ccaha.org/emergency-planning-response

1.5. Research structure

To achieve the main purpose and objectives, the research was conducted as follows:

Chapter 1 - Introduction is intended to provide an overview of the research issues, including the background, problem statement, research objectives, definition of terms and research structure.

In chapter 2 - theoretical and practical situation, we focus on addressing objectives 1 and 2, starting with an overview of disasters in the world, some typical types of disasters at identified regions are described. From there, to approach theoretical frameworks of exercise programs for emergency response, including the introduction and comparison of the fundamental principles in the theories of some countries and international organizations, and the classifications of common exercise formats. The actual situation of the exercise program in Vietnam is reported to represent a typical developing country case, revolves around legislation and practical activities. This chapter contained the information from my oral presentation of Disaster risk reduction education with flood management in Viet Nam, which was performed at the 9th International Conferences on Flood Management, Feb 2023 (Hoang & Kato, 2023).

Chapter 3 - Improvement in exercise designing - A case study in Vietnam: Emergency response exercises are a common means for improving the preparedness and resilience of organizations and communities in the face of disasters. It is important to develop an instructional design that can facilitate evaluation and the learner's approach. This chapter introduced a model based on the AHP 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. This model was tested using fire and rescue exercises in a traditional market and an apartment complex in early 2021 in Hai Phong, Vietnam. Our model enables practitioners to determine the need for improvement in any element, allowing for continuous improvements in exercise programs. Chapter 3 included the content of the publication of "Use of analytic hierarchy process and four-component instructional design for improving emergency response exercises", International Journal of Disaster Risk Reduction, Volume 87, 2023, 103583, ISSN 2212-4209 (Hoang & Kato, 2023).

Chapter 4 - Improvement in exercise evaluation - A case study in Japan: It explored the capability of a time-tracking exercise evaluation method to analyze the communication and joint task-processing capabilities of various medical and social welfare organizations in response to a citywide heavy-rain disaster. This method helps to visualize connection behavior, including action tendencies and priorities in a state of overload. Evaluation through recording by a technological system combined with manual monitoring still has its limitations but is easy to conduct. Chapter 4 included the content of the publication of “Evaluating communication capability across diverse groups for disaster medicine: A time-tracking method for functional exercises”, International Journal of Disaster Risk Reduction, Volume 109, 2024, 104590, ISSN 2212-4209 (Hoang et al., 2023).

Chapter 5 is the conclusion with the summary of key issues and further implications.

2. THEORETICAL AND PRACTICAL SITUATION

2.1. Overview of disasters

The standardization level differs among countries. The United States of America is a leading country that has created and implemented standardized emergency management systems. Taiwan has adopted a nationally standardized system of emergency management, whereas Japan uses a local government approach to prepare for and operate emergency responses, municipalities can autonomously decide their disaster risk reduction framework, although these two Asian countries face similar types of natural hazards (Kato et al., 2022). There are sixty-two million people directly affected by disaster in the last two decades living in countries without operational EWS. Developing countries are projected to have higher numbers of people affected by hazards as population growth continues (UN, 2023). It is important to construct an effective coordination and cooperation structure for local medical and social service organizations (Hoang et al., 2024).

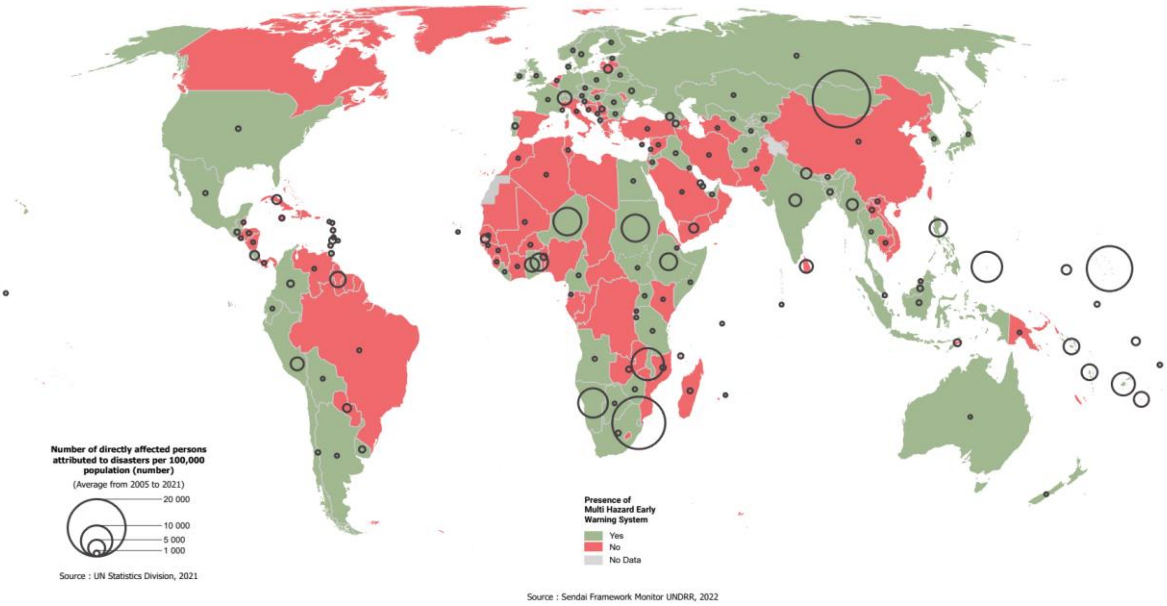


Fig. 2-1. The distribution of early warning systems in the world.
Source: Sendai Framework Monitor UNDRR, 2022

Although Japan is a developed country, it still faces enormous losses caused by disasters. According to a Japanese government report on deaths that occurred among survivors of the Great East Japan Earthquake and tsunami in 2011, during the one-year period after the disaster, a total of 1,632 additional deaths were recorded among the survivors due to the hardships they faced in the aftermath of the disaster. The authors of the report analyzed the 1,263 cases and found that around 90% were ≥70 years old. More than half died within one month of the disaster. Approximately 30% of deaths are attributable to physical and mental deterioration during evacuation (Committee on Indirect Disaster Deaths, Reconstruction Agency, 2012). Among the 270 deaths caused by the Kumamoto earthquake in 2016, a total of 215 indirect deaths occurred after the earthquake shocks, outnumbering the fifty deaths directly caused by seismic events (Committee on Indirect Disaster Deaths, Reconstruction Agency, 2012). A survey conducted by the Kumamoto Prefectural Government showed that of the 197 indirect deaths, more than 80% occurred among individuals aged ≥70 years (Kumamoto Prefecture Government, 2018).

WHO has identified flood disasters as one of the direct causes of death from drowning. Drowning accounts for 75% of deaths in flood disasters. Flood disasters are becoming both more frequent as well as more severe and this trend is expected to continue as part of climate change. Drowning risks increase with floods particularly in low- and middle-income countries where people live in flood prone areas and the ability to warn, evacuate, or protect communities from floods is weak or only just developing. Worldwide in 2019, there were 236,000 people dying from drowning and more than half of them are under the age of thirty.

Fig. 2-2. WHO global data on floods and drowning. *Source: WHO (2021)*

Vietnam now is one of the most dynamic emerging countries in East Asia region (The World Bank, 2021). According to the World Bank's context announcement on Vietnam overview Vietnam's development over the past 30 years has been remarkable. Economic and political reforms under Đổi Mới, launched in 1986, have spurred rapid economic growth, transforming what was then one of the world's poorest nations into a lower middle-income country. Between 2002 and 2018, GDP per capita increased by 2.7 times, reaching over USD2,700 in 2019, and more than forty-five million people were lifted out of poverty. Poverty rates declined sharply from over 70 percent to below 6 percent (USD3.2/day PPP). The vast majority of Vietnam's remaining poor – 86 percent

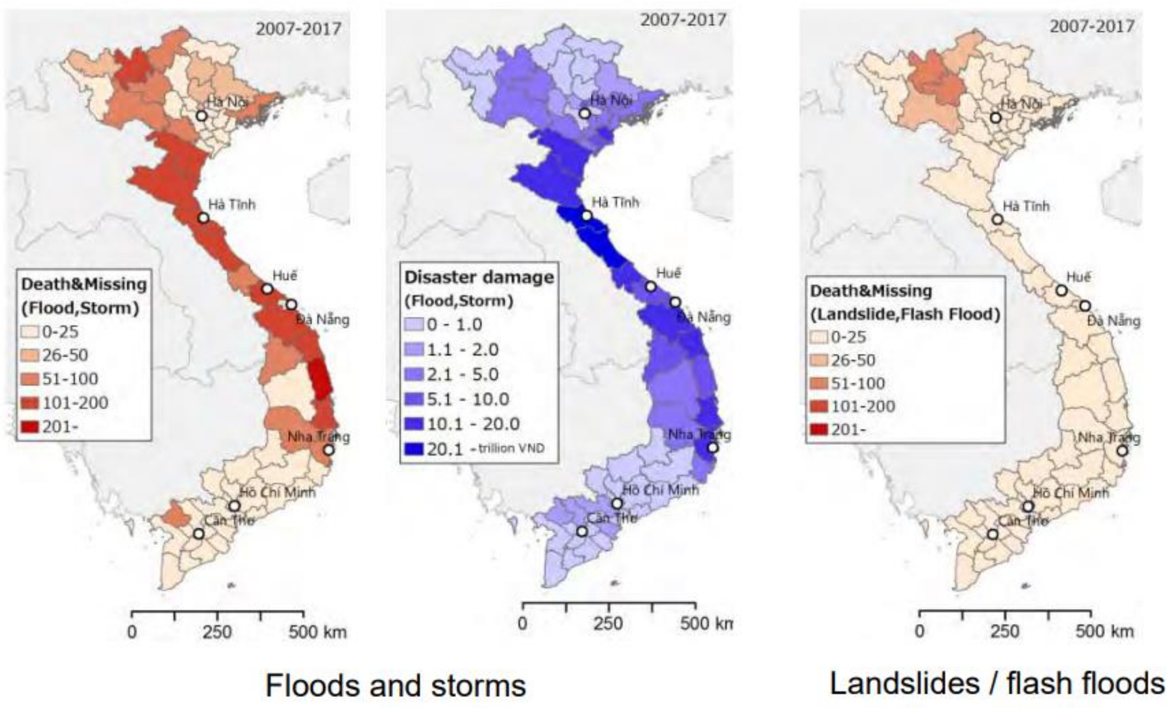


Fig. 2-3. Distribution of some disasters in Vietnam (2007-2017)
Source: JICA, 2018.

– are ethnic minorities.

As mentioned, floods appear and have a comprehensive impact on geographical areas in Vietnam. The riverside or lakeside living habits of many communities in mountainous areas also increase the risk of drowning when flash floods occur suddenly.

Table 2-1. Damage of some floods type in Vietnam from 1900 to 2020

Data source: Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED).

Flood type	Events count	Total Deaths	Total affected	Total damage (thousand USD)
Coastal flood	6	804	4,353,316	749,000
Flash flood	13	481	912,607	516,700
Riverine flood	52	3,644	25,637,158	2,896,407
Other	16	1,012	2,011,287	160,055

Vietnam's rapid growth and industrialization have had detrimental impacts on the environment and natural assets. Electricity consumption has tripled over the past decade, growing faster than output. Given the increasing reliance of fossil fuels, the power sector itself accounts for two-thirds of the country's greenhouse gas emissions. There is an urgent need to accelerate the clean energy transition. Over the past two decades, Vietnam has emerged as the fastest growing per-capita greenhouse gas emitters in the world – growing at about 5 percent annually. Demand for water continues to increase, while water productivity is low, about 12 percent of global benchmarks. Unsustainable exploitation of natural assets such as sand, fisheries, and timber could negatively affect prospects for long-term growth. Compounding the problem is the reality that much of Vietnam's population and economy is highly vulnerable to climate impacts.

Urbanization and strong economic and population growth are causing rapidly increasing waste management and pollution challenges. Waste generation in Vietnam is expected to double in less than 15 years. Linked to this is the issue of marine plastics. Ninety percent of global marine plastic pollution is estimated to come from just ten in-land rivers, and the Mekong River is one of them. Vietnam is among the ten countries worldwide that are most affected by air pollution. Water pollution has significant costs on productivity of key sectors and human health.

Statistical results are divided into two main groups (damage caused by natural disasters and damage caused by civil emergencies) from 2019 to the first half of 2021 as follows:

Table 2-2. Statistics of damage caused by natural disasters and emergency incidents in Vietnam (from 2019 to the first half of 2021) *Data source: Vietnam Disaster management authority (2019 – 2021)*

Year	**Natural disaster**			**Emergency incidents**		
	Category	Casualty	Material loss	Category	Casualty	Material loss
2019	11-13 hurricanes 7 thunderstorms, large hailstorms, 11 earthquakes	133 dead and missing	7,000 billion VND	3,790 fires, 26 explosions,	103 dead, 166 injured	1,527 billion VND and 3,952ha of forest
2020	13 storms, 264 thunderstorms, whirlwinds, rain; 120 floods, flash floods, landslides; 86 earthquakes,	356 people dead and missing	35,181 billion VND.	5,354 fires, 33 explosions	89 people died, 184 people were injured	932.023 billion VND and 1,411.7 hectares of forest.
First half of 2021	17 earthquakes, 32 storms; 04 heavy rains, local floods, of which 01 flash flood and 08 landslides.	08 people died, 09 people were injured	28.2 billion VND.	1,154 fires, 14 explosions	59 people died, 88 people were injured	VND 288.76 billion and 3,146.80 hectares of forest.

Increasing the effectiveness and efficiency of emergency response is considered a key to minimizing socio-economic losses for Vietnam. To achieve this requires attention to research and development of feasible methods, suitable to the reality of each economic sector. One aspect to be considered is the ability to coordinate actions between professional bodies of government and private organizations and the civil community.

Every year, about 2,000 children under 16 years old die from drowning, or in other words, six children drown every day. Flood is one of the causes of this problem. As mentioned, floods appear and have a comprehensive impact on geographical areas in Vietnam. The riverside or lakeside living habits of many communities in mountainous areas also increase the risk of drowning when flash floods occur suddenly (WHO Regional Office for South-East Asia, 2021).

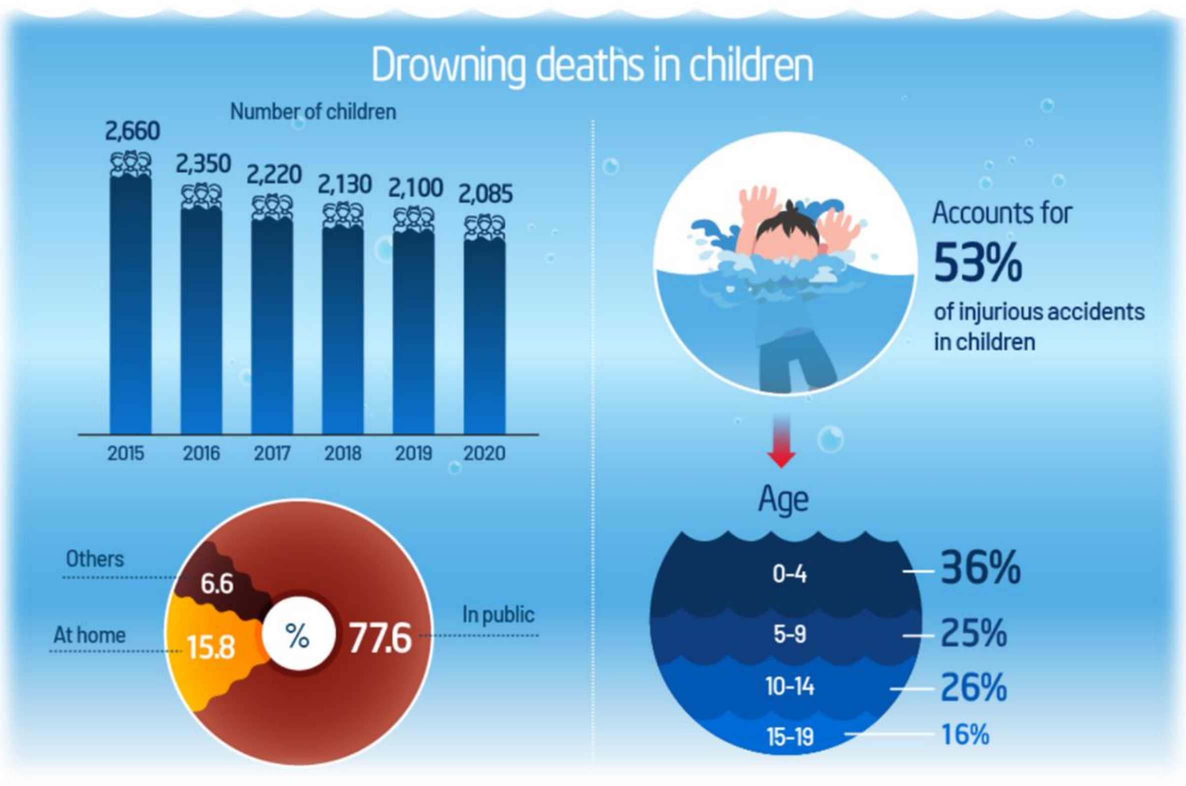


Fig. 2-4. Data on drowning deaths in Vietnamese children.
Source: Ta & Hong (2022)

2.2. Theoretical situation

2.2.1. Principles of emergency exercise

McEntire (2007) mentioned a literature review of prior research and official documents as an approach to provide a better understanding of emergency management in a nation. There is a dialectical relationship between the basic principles of the exercise program and the principles and criteria of the emergency response theories. This study analyzes and compares several theories including the motto "Four on the spot" of Vietnam, the fundamental principles of the Homeland Security Exercise and Evaluation Program (HSEEP) from the U.S. Department of Homeland Security (DHS) and the key components of Hospital emergency response checklist made by The Regional Office for Europe of the World Health Organization.

a, The motto "Four on the spot" in Vietnam

The word 'motto' in the Vietnamese language means a common orientation, strategy, leadership, and response to a problem, situation, or event. In the political system, it can also be understood as the guidelines given by central government authorities or a central responsible agency to vertical line agencies at the province, district, and commune level.

The phrase 'on-the-spot' can be understood as to be at one specific local administrative unit lower than the central level, which can be provincial, district or commune level, or it may simply mean in a certain area (in household or certain placename).

In the booklet produced by the Joint Advocacy Network Initiative (2011), the concept of the motto means that each household or a certain area should prepare all essential items to prevent or respond to a natural disaster, which may occur at any given time.

The motto "four-on-the-spot" was developed from lessons from practical experiences in protecting and strengthening the dike system in the early 1970s (Four on the spot motto in disaster management, 2010). The work required the local leader to be able to organize, coordinate, and mobilize all necessary resources from communities. Moreover, local participants were required to be proactive in taking on specific roles during the protection of the dike system. This idea was gradually developed into the motto "four-on-the-spot" in disaster management which included four components: leadership, human resources, means and materials, and logistics. The ideology underpinning the motto is based on enhancing the capacity of local communities and governments to solve local problems. The key point is to mobilize the power and resources of local forces in times of disaster with the spirit of "self-protection and self-rescue." (Four on the spot motto in disaster management, 2010)

Reflecting through policy, the motto is included in legal documents issued by the Vietnamese government. In 2007, the Vietnamese government approved the National Strategy on Natural Disaster Prevention and Mitigation to 2020 that states clearly in the third guiding principle: “natural disaster prevention and mitigation should be implemented using the motto four on-the-spot in order to assist people to actively prevent, respond in a timely manner to, and promptly.” (No 172/2007/QD-TTg, 2007, p. 2). In 2013, the motto was mentioned as one of basic principles of natural disaster prevention and control in Section 3, Article 4 of the Law on Natural Disaster Prevention and Control (No 33/2013/QH13, 2013, p. 2). However, the definition or concept of the motto “four on-the-spot” was not provided in either of these legal documents.

The ideology underpinning this motto is based on fostering the capacity of local communities and government (on the spot) to solve local problems. It is in line with the motto of relying on people and recognizing the power of the public. The key point is to know how to rely on people and to mobilize the power and resources of local people and local government in the spirit of “self-protection and self-rescue.” In current situations, disaster preparedness needs to be socialized, decentralized, and associated with the responsibilities of all levels of government, mass organizations, enterprises, and the people. For example, using people as the basis by which to ensure public security at the local level. At present, the four on-the-spot motto has been expanded into many other areas of emergency management.

The specific content of this motto is as follows.

Commands on the spot: The people selected to command and operate are local people, grassroots, have knowledge and experience in professional work and characteristics of the actual situation. For example, in disaster prevention, response and recovery activities, the core members of the apparatus are local governments, agencies, political organizations or socio-political organizations. Armed forces and other military contingents in place are the core human resources. The purpose of setting up the apparatus in place and appointing leaders is to ensure that all activities are carried out in a timely and efficient manner.

Manpower on the spot: When a disaster occurs, the fastest and most effective way to respond and provide support is to use the available forces on the spot. This means that each person needs to be equipped with the knowledge, skills to save themselves and the ability to organize when saving others nearby. The use of local staff also helps reduce the challenge for competent agencies.

Understanding the capacity of the human resources in place is important for the command department to be able to assign and operate effectively.

Means on the spot: This idea is that each area should ensure that there are adequate and appropriate materials and supplies available to respond when needed. This is to help respond quickly and promptly, thereby minimizing consequences. In addition to the means and materials prepared and provided by the local government, the private sector should be mobilized to contribute to the preparation of materials and means to strengthen the effectiveness.

Logistics on the spot: The transportation capacity of the area, which needs to meet the ability to evacuate people and assets from the site, transport and gather supplies from outside, or the ability to store essential goods sufficient to response for response time.

b, The fundamental principles of Homeland Security Exercise and Evaluation Program

The HSEEP doctrine states six fundamental principles that underpin a common approach to the exercises. The aim is to increase consistency in exercise conduct and assessment while ensuring exercises remain a flexible, accessible way to improve readiness across the country. The authority asserts that the application of principles to the management of the exercise program and the performance of individual exercises is important for the effective assessment of competencies.

Six fundamental principles of the HSEEP Doctrine (DHS, 2020, page 1-1):

Senior Leader Guidance: The early and frequent engagement of senior leaders is the key to the success of any exercise program. Senior leaders provide the overarching guidance and direction for the exercise and evaluation program as well as specific intent for individual exercises.

Informed by Risk: Identifying and assessing risks and associated impacts helps jurisdictions/organizations identify and evaluate priorities, objectives, and capabilities through exercises.

Capability-Based, Objective-Driven: Jurisdictions/Organizations can use exercises to evaluate current capability levels/targets and identify gaps. Exercises focus on assessing performance against capability-based objectives.

Progressive Exercise Planning Approach: A progressive approach includes the use of various exercises aligned to a common set of program priorities and objectives with an increasing level of complexity over time. Progressive exercise planning does not always imply a linear progression of exercise types.

Whole Community Integration: The use of HSEEP encourages exercise planners, where appropriate, to engage the whole community throughout program management, design and development, conduct, evaluation, and improvement planning.

Common Methodology: HSEEP includes a common methodology for exercises across all mission areas. The methodology enables jurisdictions/organizations a shared understanding of program management, design and development, conduct, evaluation, and improvement planning and fosters exercise-related interoperability and collaboration.

c, Hospital emergency response checklist of WHO (World Health Organization)

The tool is structured according to nine key components, each with a list of priority actions (Hospital emergency response checklist, 2011). They are Command and control, Communication, Safety and security, Triage, Surge capacity, Continuity of essential services, Human resources, Logistics and supply management, and Post-disaster recovery. Each key component is detailed by a separate checklist of specific contents. Surge capacity is the ability of a health service to expand beyond normal capacity to meet an increased demand for clinical care. Triage is the process of categorizing and prioritizing

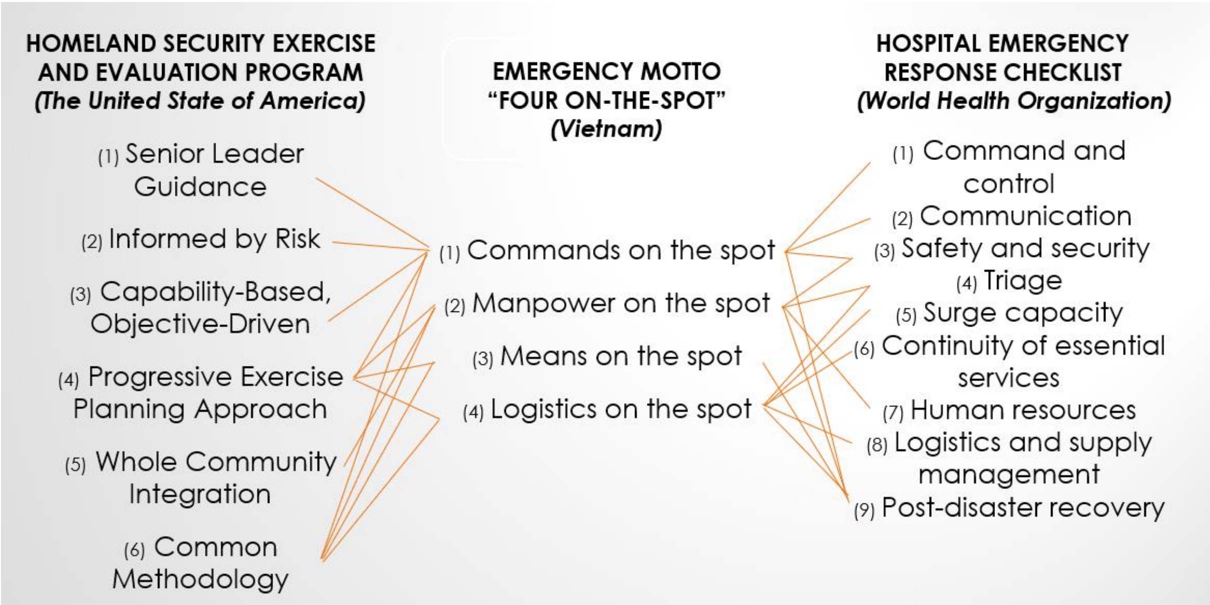


Fig. 2-5. The relationship among typical principles

patients with the aim of providing the best care to as many patients as possible with the available resources.

Through the listed contents and analysis of the emergency response theory, we can identify the relevance in the content of the principles. We can see that Commands on the spot have a strong connection to Senior Leader Guidance of HSEEP and Command and Control from HERC. Besides that, it is relevant to other principles such as Informed by Risk, Capability-Based, Objective-Driven, Progressive Exercise Planning Approach, Common Methodology of HSEEP and Communication, Safety and security, Post-disaster recovery of HERC. Figure 2-5 depicts those relationships for other principles.

Besides the similarities, each theory has its own differences that are created to match the policies and behaviors associated with the unique characteristics of the organization. We conclude that the motto “Four on the spot” has a full coverage of the remaining two theories content. These principles are applied in the establishment of the evaluation model presented in the next sections of the study.

2.2.2. Exercise Categories

The standard training program mentioned in the HSEEP by the US Department of Homeland Security includes seven types of exercises across two categories. Discussion-based exercises include seminars, workshops, tabletop activities and games. Operation-based exercises include drill, functional, and full-scale exercises (DHS, 2020).

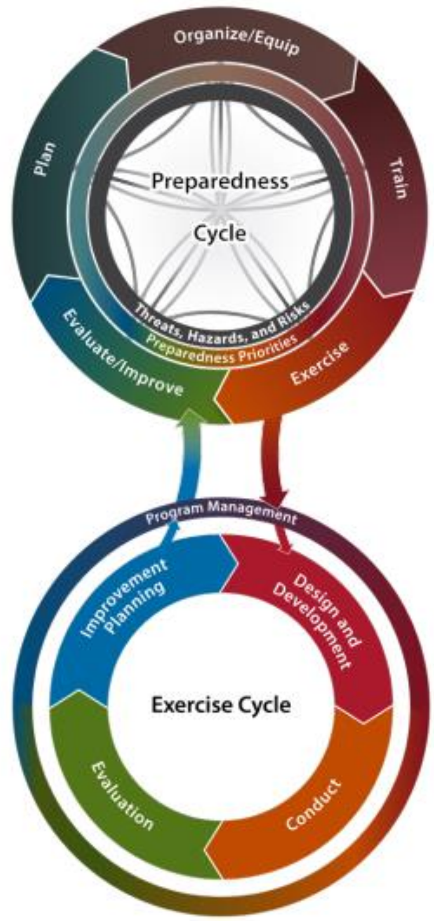


Fig. 2-6. The relationship of Preparedness cycle and Exercise cycle. Source: DHS, 2020

Discussion-based exercises focus on strategic, policy-oriented issues, and facilitators or presenters lead the discussion, keeping participants moving towards meeting the exercise objectives.

- Seminars
- Workshops
- Tabletop exercises
- Games

Operations-based exercises: aim to validate plans, policies, procedures, and agreements; clarify roles and responsibilities; and identify resource gaps.

- Drills
- Functional exercises
- Full-scale exercises

2.2.3. Exercise evaluation

Most part of this review is due to Hoang et al. (2024). A review by Skryabina et al. (2017) revealed that most studies on health emergency preparedness exercises used qualitative data from self-reporting and participants' perceptions of exercise outcomes. Synthesizing both qualitative and quantitative information is important to understand players' actions and the reasons for those actions from multiple perspectives. The HSEEP doctrine involves direct observation, documentation review, feedback forms and surveys, interviews, and hotwash and debrief to collect data and evaluate exercises (DHS, 2020). These methods provide both qualitative and quantitative information. There are varying levels of quantification ranging from knowledge tests and action checklists (Gundran et al., 2022) to action time measurement as shown below.

Table 2-3. Qualitative evaluation methods for exercise programs

Research/doctrine	**Methods**
DHS (2020) HSEEP doctrine	Observation, documentation review, feedback forms/surveys, interviews, hotwash /debrief
Gundran et al. (2022)	Knowledge tests and action checklists

Table 2-4. Key features of time tracking/recording studies

Research	Key points/outcomes
To et al. (2019)	The evaluation by player response times
Russo et al. (2014)	the principal aim of exercise and training is to reduce response time in an actual emergency
Vukmir (2006).	number of lives saved was proportional to the speed and efficiency of the emergency medical operations
The HSEEP (2020)	recommends specifying capability targets composed of critical tasks, impacts, and timeframes.
Emergo Train System	Real-time simulation of the training system
Public Health Emergency Exercise Toolkit (2006),	Provides a timesheet for recording "time in" and "time out"

The use of player response times in exercise evaluation is a significant area of potential research (To et al., 2019). Russo et al. (2014) noted that the principal aim of exercise and training is to reduce response time in an actual emergency. The number of lives saved was proportional to the speed and efficiency of the emergency medical operations (Vukmir, 2006). The HSEEP (2020) doctrine recommends specifying capability targets composed of critical tasks, impacts, and timeframes. The Emergo Train System simulates the deterioration of a patient's health and visualizes the objective outcomes of players' total responses. Real-time simulation of the training system enables this feature. The Public Health Emergency Exercise Toolkit (2006), which was developed at Columbia University, provides a timesheet for recording "time in" and "time out" at stations involved in a full-scale public health exercise.

2.2.4. Problems of exercise design and evaluation theories

Studies have shown that exercise programs are effective in improving a community's or organization's preparedness and ability to respond to emergency situations. However, designing exercises according to available methods has challenges that must be faced and reduces their effectiveness, typically:

Flexible customization: Design methods follow a theoretical and spread-out pattern, making it difficult for designers to choose priority criteria for the exercise and lead to sensory decisions.

Evaluability: Common evaluation mechanisms focus on qualitative assessments, making it difficult to evaluate the effectiveness of exercises quantitatively. Integrating a quantitative or blended assessment mechanism into assignment design is not common.

Ability to cooperate: To et al. (2019) declared that evaluation is an essential part of exercise management programs to consider how an exercise met its objectives and how emergency work was performed by players. However, research on in-depth evaluation of collaborative capacity between multiple organizations or groups of players in exercises is sorely lacking. The interaction between participants has the potential to increase the strain on the ability to cooperate. The exercise models do not clarify how to evaluate each group of subjects in exercises with many different participants.

Thus, the need to develop flexible and measurable methods for designing and evaluating exercise programs exists. This is an important addition to the available models. Chapter 3 of this dissertation will introduce and explain a possible conceptual model for integrating qualitative assessment into exercise design. Chapter 4 will discuss developing analytical extensions for an existing evaluation method.

2.3. Practical situation

2.3.1. The lack of diversification in exercise conduct

In Vietnam, existing international studies of Vietnamese emergency management (Chau et al., 2014; Garschagen, 2016; Lebel et al., 2009) focus on the specific organizational structures of natural disaster risk management or flood management. There is a lack of publications that review Vietnamese emergency management that specify related organizations in charge of responding in natural and man-made disasters. Moreover, Katarzyna in the research “Emergency Coordination Framework in Vietnam” (2001) stressed that there is a need to improve the communication, coordination, and cooperation of different Vietnamese stakeholders during a disaster.

Emergency management of natural and man-made incidents in Vietnam is regulated by different laws, which means that there are many separate departments for each type of object. For example, Law on Natural Disaster Prevention and Control (No 33/2013/QH13, 2013) mentions that all local governments need to conduct seminars, workshops, and drills for stakeholders according to natural disaster management plans. The Decree on detailing the implementation of several articles of the Law on Fire Prevention and Fighting (No. 136/2020/ND-CP) requires facilities to conduct drills at least once a year, while the decision to promulgate the regulation on oil spill response (No 02/2013/QD-TTg) requires ports/facilities conducting drills one time in six months. Through these legal documents, the drill is the main type of emergency exercise for forces in Vietnam.

The program of fire response and rescue exercises has the coordination of budget expenditures of both the government, organizations, and businesses. This is the most popular exercise program because of its legal requirements and necessity. Statistics from the Fire and Rescue Police Department, Ministry of Public Security of Vietnam show that in 2020, professional fire services have organized 7,240 firefighting exercises and 1,653 rescue exercises; guiding organizations and enterprises to develop 93,294 firefighting exercise plans and 43,046 rescue exercise plans; supplement and revise 17,637 firefighting plans and 12,742 rescue exercises; instructions to perform more than 71,281 fire drills and 33,571 rescue exercises. These figures show the popularity of this exercise program.

Exercises to respond to natural disasters are often organized by authorities at all levels according to their respective sizes when diverse types of natural disasters are forecasted to be imminent, often focusing on storm and heavy rain situations. Response exercises Many types of disasters such as floods and landslides are planned and published in theory but rarely rehearsed, while less common types in Vietnam such as earthquakes, Tsunamis and tornadoes are almost nonexistent.

By summarizing the legal regulations, professional firefighting and rescue services (or the official name in Vietnam is the Police of Fire Prevention, Fighting and Rescue) is the leading force and the front line in emergency response at initial level. This force is responsible for guiding and training organizations, businesses and communities in knowledge and skills of emergency response, as well as the capacity to set up and conduct exercise programs.

The study by T. T. M. Tong et al analyzed 14 DRRE projects and programs that were conducted in schools in Vietnam from 2010 to 2020. The authors examined five key areas of focus, including school facility and building safety, integration of DRR content into the curriculum, extracurricular activities, injury prevention and swimming lessons, and raising awareness among parents and communities. The study found that the programs and projects were conducted by different organizations such as the Ministry of Education and Training (MOET), NGOs, and other organizations. The MOET and government agencies primarily focused on school safety and development of teaching and learning materials, while NGOs and other organizations primarily focused on extracurricular activities and raising awareness in communities and among parents.

Fig. 2-7. DRRE projects and programs in Vietnam

The Ministry of Culture, Sports and Tourism is responsible for the 2021-2030 Safe Swimming Program to prevent child drowning. Targets include all provinces and cities under central government implementing the program by 2025. By then, the program aims to have 60-70% of children aged 6-16 possess water safety skills, with 50-60% able to swim safely. By 2030, swimming, diving, and water recreation facilities must have trained staff, proper equipment, and safety certification. The program aims to have 90-95% of households able to access information on child drowning prevention by 2025 and reduce child drowning deaths by 10% in 2025 and by 20% after 2025.

The Program on Safe swimming to prevent child drowning in term of 2021-2030 according to Decision 3246/QD-BVHTTDL dated December 14, 2021 of the Ministry of Culture, Sports and Tourism

- 100% of the provinces and cities directly under the Central Government implement the program of safe swimming to prevent and prevent drowning for children.

- Striving for 60% of children from six to under 16 years old to know safety skills in the water environment by 2025 and 70% by 2030; 50% of children aged six to under sixteen can swim safely by 2025 and 60% by 2030.

- Ensure that 100% of establishments that organize swimming, diving, and water entertainment activities have coaches, swimming instructors, and drowning rescuers trained in professional knowledge by the facility. Competent agencies certify and ensure the conditions of professional equipment, hygiene and safety as prescribed by law.

- 90% of households will have access to information, knowledge and skills on child drowning prevention and control by 2025 and 95% by 2030.

- Reduce the number of children dying from drowning by 10% by 2025 and 20% by 2030 compared to 2020.

An emergency response improvement project is being implemented by the Center for Disaster Countermeasures, the University of Kitakyushu, Japan, and its local counterpart, Hai Phong Fire and Rescue Police Division, Vietnam, supported by the Japan International Cooperation Agency Partnership Program and relevant local governments. It was launched in August 2018 after a two-year preparation period and is scheduled to continue until August 2022.

Fig. 2-8. A functional exercise was held by JICA project of the University of Kitakyushu and Hai Phong Fire and Rescue Police Division *(Source: Hai Phong Fire & Rescue Division)*

The objective of this project is to develop exercise methods that are suitable for enhancing cooperation and coordination capability among various emergency management organizations in Hai Phong city and use those methods to conduct exercises. Some specific goals and targets can be reviewed as follows:

- The Fire and Rescue Police force clearly understands the importance of joint and coordinated exercise management methods in responding to disasters and incidents, and types of common exercises.

- The Fire and Rescue Police force can guide the method of joint exercise management for the safety management department of civil facilities such as residential apartments or hospitals and can organize joint exercises with the above units.

- Civil facilities understand the importance of joint and coordinated exercise management in responding to disasters, incidents, and types of common exercises.

- At least fifty officers of the Fire and Rescue Police force and one hundred staff from the safety management department of civil facilities are allowed to participate in training and exercises.

This project is expected to bring practical effects to emergency response, contributing to improving the capacity of managers from both public and private sides. Composing good textbooks is an important part of this project and we have been studying the method for designing textbooks. The contribution of this study to the project was to develop a design and evaluation method to compose effective textbooks for the emergency response specialist side and citizen communities as first affected organizations.

Fig. 2-9. Functional exercises and tabletop exercises organized by Vietnamese and ASEAN military medicine to respond to the COVID 19 pandemic. *Source: PANO (2020)*

Format of functional exercises and tabletop exercises just found in military section. For example, some of them was organized by Vietnamese and ASEAN military medicine to respond to the COVID-19 pandemic.

2.3.2. The need to develop exercise evaluation methods

A comparison between standard operating procedures and flexibility issues in emergency management of Japan and Taiwan by Kato et al. (2022) pointed that Japan uses a local government approach to prepare and operate the core of its emergency responses. Japanese municipalities can autonomously decide their disaster risk reduction framework, however a detailed common emergency management standard for Japanese local governments has not yet been established (Kato et al., 2022).

A functional exercise model for medical organizations in emergency situations developed in Kitakyyushu city, Japan has established systematic time-tracking evaluation mechanisms which developed by Taninobu and Kohriyama (2011) and To et al. (2019). This model was detailed in Chapter 4 of this dissertation. In general, these methods do not fully utilize information on player response times to evaluate the effectiveness of emergency plans. Thus, it needs to expand the analysis of evaluating communication capability across diverse groups.

2.4. Summary

It is important to construct an effective coordination and cooperation structure for local medical and social service organizations. The standardization of emergency management protocols (including exercises) is considered beneficial, but the standardization level differs among organizations and countries.

Developing countries, typically Vietnam, are increasingly negatively affected by disasters while their resilience capacity is limited.

Diversity and uniformity in theories of exercise programs for emergency response among organizations and countries.

Synthesizing both qualitative and quantitative information is important to understand players' actions and the reasons for those actions from multiple perspectives. Shortcomings in practical application of different formats in design and evaluation. Innovative methods are feasible to help countries to access unavailable exercises.

3. IMPROVEMENT IN EXERCISE DESIGNING: A CASE STUDY IN VIETNAM

3.1. Introduction

3.1.1. Background

Although the standardization of emergency management protocols, including exercises for improving the capabilities of emergency management professionals, is considered beneficial (ISO 2018, FEMA 2017), the standardization level differs among countries. The United States of America is a leading country that has created and implemented standardized emergency management systems. Taiwan has adopted a nationally standardized system of emergency management, whereas Japan uses a local government approach to prepare for and operate emergency responses, although these two Asian countries face similar types of natural hazards (Kato et al., 2022). A solution for improving the exercise design procedure is to adopt established design criteria. For example, the Homeland Security Evaluation and Exercise Program of the United States of America has six fundamental principles (DHS, 2020), and the hospital emergency response checklist created by the World Health Organization Europe Region has nine key components (WHO, 2011).

However, many developing countries have not adopted well-organized emergency management standards, as in the case of our study site, Vietnam – a nation in the process of industrialization and urbanization**.** Meeting all the abovementioned criteria is a major challenge for exercise designers in Vietnam because of the diversity in ideas and objectives and differences in the perceived effectiveness of the exercises among the participants. Without the International Organization for Standardization standards, the understanding of prioritized exercise objectives can differ even among emergency experts, reducing the effectiveness of emergency exercises. Designing effective emergency management exercises is difficult because, in these cases, exercise designers must create exercise plans without a framework or scope of standards. In Vietnam, exercise designers rely on the available reviews and judgments of exercise participants to determine what exercises need to be focused on and what problems need to be addressed in future programs.

Regulations regarding fire response exercises have been updated every few years. Government Decree no. 136, which was issued on November 24, 2020, is the latest version, which became effective on January 10, 2021 (Viet

Nam Government, 2020). The decree consists of two main parts. The first part presents a list of factors related to fire safety and responses, such as the geographical location of the facility; traffic and water resources; properties of fire, explosions, and poisons; and information about firefighting teams and on-site equipment. The second part presents guidelines for making plans to respond to certain scenarios and provides illustrations of overly complicated situations, along with response diagrams for each situation. However, the designs of the hypothetical situations in the second part are not clearly stated, and specific guidance from the Fire and Rescue Police (the official title of the authorities on the state management of fire prevention, fighting, and rescue in Vietnam) is required. This agency is responsible for guiding and training government organizations, businesses, and communities in the knowledge and skills of emergency response and for organizing and conducting exercises. The law on fire prevention and fighting requires that each installation conduct fire drills at least once a year (To et al 2018). Thus, fire service departments must adopt new methods to design effective exercises.

Although the motto "four-on-the-spot" is not mentioned in the law or official documents, it plays a central role in many Vietnamese emergency services in designing exercises and conducting operations. This motto was developed from practical experiences in protecting and strengthening the dike system in the early 1970s (JANI, 2011). This motto has been expanded to many other emergency management areas. The four elements include commands on the spot (the people selected for command and operation must be residents, have knowledge and experience of professional work, and have knowledge of the characteristics of the actual situation), manpower on the spot (the available forces on the spot need to be equipped with the knowledge and skills to save themselves and those in proximity to them), means on the spot (each area should have adequate and appropriate materials and supplies available), and logistics on the spot (the transportation and equipment capacity of the area needs to be sufficient to evacuate people and assets from the site, transport and gather supplies from outside, and store essential goods to respond to the emergency). These four elements of the motto are comparable to the elements of the Incident Command System: command and control, operation, planning, logistics, and finance and administration (FEMA, 2018).

Most of the information in this chapter is due to Hoang and Kato (2023).

3.1.2. Chapter objectives

A procedure is required to identify the necessary exercise targets and select suitable implementation methods by objectively summarizing the knowledge of emergency management professionals. The integration of the conventional qualitative approach with our quantitative approach would be able to identify the emergency elements that need to be improved, thereby creating opportunities for the continuous improvement of exercise programs. This study has three research objectives:

1. Design and test a method to determine exercise objectives and select implementation methods in the absence of predesigned detailed emergency standards

2. Compare the results of two exercises based on the proposed method for different types of fire scenarios

3. Determine the differences in the understanding of exercise objectives and implementation methods among exercise participants

3.2. Method

3.2.1. The Analytic Hierarchical Process (AHP)

Herein, an AHP model was applied to evaluate and optimize the instructional design of an emergency response exercise. Among the different multi-criteria methods, AHP is one of the most widely implemented in real-world applications as it has proven to be a well-established technique for addressing complex decisions and obtaining a priority ranking of alternatives (Saty 2003, 2008, 2012). AHP allows the evaluation of quantitative and/or qualitative criteria and factors on the same measurement scale, and the initial decision problem can be deconstructed into a hierarchy in which unidirectional hierarchical relationships between levels are established. The top of the hierarchy is represented by the main goal of the decision problem, whereas the criteria and sub-criteria, which contribute to the goal, are placed at lower levels, and the alternatives to be evaluated are placed at the bottom level (Saaty, 2012). It is a quantifying tool and a multi-criteria technique that provides an effective and precise means for choosing options, (Saaty 2003, 2008). This method helps with the problem of multi-criteria decision-making for situations in which there is a prioritization of factors (Yadollahi et al., 2011). AHP has been applied in many disciplines including planning, resource allocation, priority setting, and selection of alternatives (Bhushan et al., 2004). The AHP is a common method for considering decision-making processes based on multiple attributes (Yadollahi et al., 2011).

AHP has been used in flood disaster management (Nivolianitou et al., 2015) and pre-disaster rehabilitation project ranking (Yadollahi et al/, 2011). Gulum et al. (2021) developed a two-level interval valued neutrosophic AHP-integrated TOPSIS methodology for post-earthquake fire risk assessments. Hoscal et al. proposed an AHP model to determine emergency assembly points for industrial accidents (Hoscan et al., 2021). Ortiz-Barrios et al. developed a fuzzy hybrid decision-making framework for increasing hospital disaster preparedness using the Intuitionistic Fuzzy AHP to assign relative weights for several disaster preparedness criteria considering uncertainty (Ortiz-Barrios et al., 2022). Panchal and Shrivastava used AHP to assess landslide hazards on highways in India (Panchal et al., 2022). Thus, AHP is one of the most widely adopted multi-criteria methods for solving various decision problems in emergency management.

A Tutorial of the AHP calculation is further explained in the paper of Teknomo (2006). The normal process of AHP to calculate normalize weight is as follows:

- Consider n elements to be compared, Ci ... Cn and denote the relative "weight" (or priority) of Ci with respect to Cj by aij and form a square matrix A=(aij) of order n with the constraints that aij = 1/aji, for i ^ j, and aii = 1, all i. This is a reciprocal matrix.

- Calculate the sum of each column of the reciprocal matrix. After we divide each element of the matrix with the sum of its column, we have relative weight. The sum of each column is one. The normalized principal Eigen vector can be obtained by averaging across the rows. The normalized principal Eigen vector is also called priority vector. This vector shows normalized weight among elements that we compare.

Check the consistency of the answer through the Consistency Ratio (CR). If CR is less than 10%, then the matrix can be considered as having an acceptable consistency. CR is the ratio of consistency index (CI) and the random index (RI). The Consistency Index (CI) can be calculated from CI = (Xmax - n)/(n - 1). Where Xmax (Principal Eigen) value is obtained from the summation of products between each element of the Eigen vector and the sum of columns of the reciprocal matrix. RI is Random Consistency Index.

Currently, there are software developed based on the AHP method to conduct analysis and calculation conveniently. In this study, we used the software "SuperDecision V3.2" to compare the results and check, as well as correct the consistency of the answers.

3.2.2. Four components of instructional design (4C/ID)

Effective training is crucial in manufacturing for both skill development and ensuring process safety. Well-designed training programs that address learning styles and use diverse methods can keep trainees engaged and motivated. To achieve this, various instructional design theories have been adopted. These theories provide a structured approach to creating learning experiences that are efficient, engaging, and lead to desired outcomes. By following a structured approach, instructional design theories help ensure training programs are well-designed, meet specific needs, and lead to improved skills and knowledge.

Among these are the ADDIE model and Bloom's taxonomy (Khalil et al., 2016). ADDIE stands for Analyze, Design, Develop, Implement, and Evaluate (Molenda, 2003; Branch, 2009). This model provides a step-by-step framework for developing training programs. In manufacturing, ADDIE can be used to analyze training needs based on skill gaps and safety risks; design training content that addresses those needs and incorporates adult learning principles; develop engaging training materials, such as simulations, case studies, or hands-on activities; implement the training program effectively, considering factors like scheduling and instructor training; evaluate the training program's effectiveness in achieving its objectives and make necessary improvements. Meanwhile, Bloom's Taxonomy categorizes different levels of learning objectives. It ranges from basic knowledge to complex skills like evaluation and creation. In manufacturing training, Bloom's Taxonomy helps to define clear learning objectives for each training module.

We referred to the 4C/ID model proposed and developed by J. J. G. van Merriënboer et al. in 2000. The adopted concept of the 4C/ID (Van Merriënboer et al., 2018) includes learning tasks, supportive information, procedural information, and part-task practices.

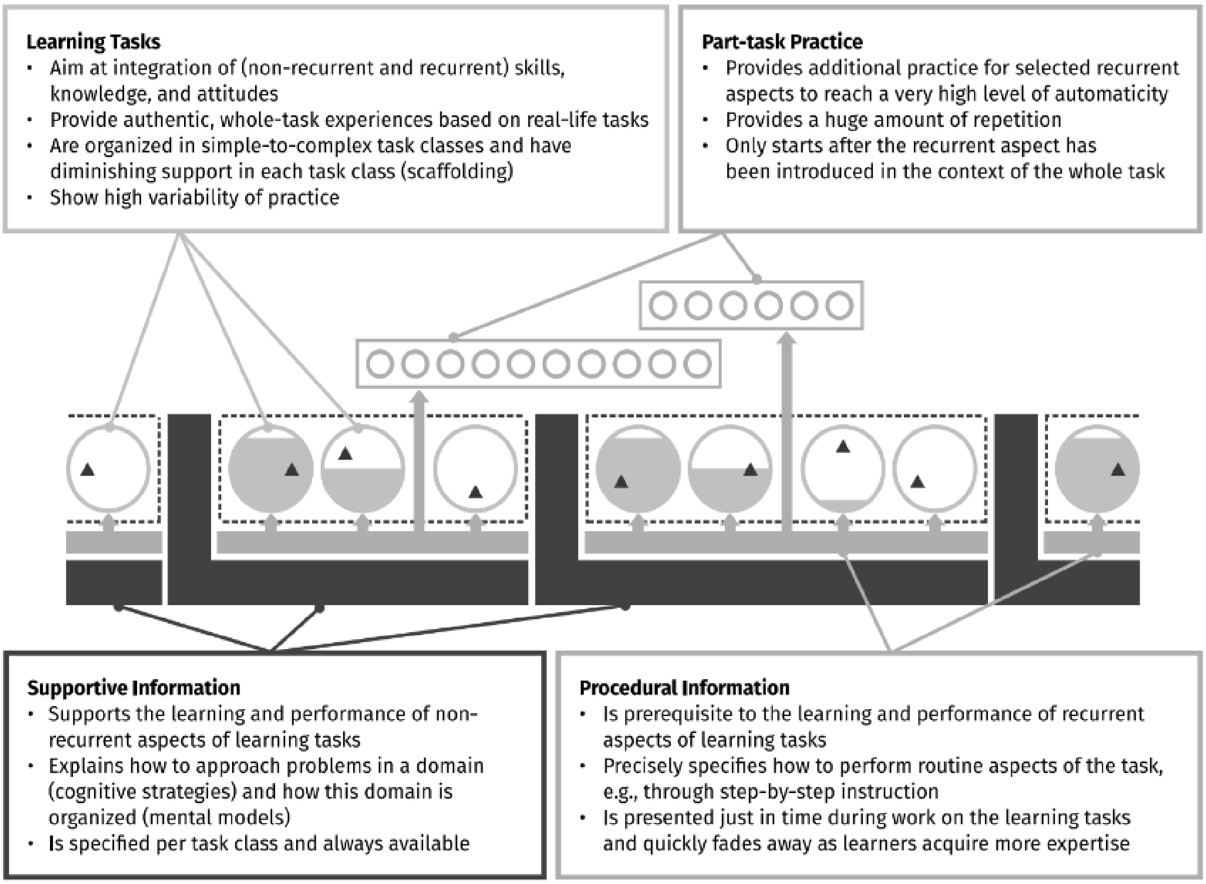


Fig. 3-1. The four components of Instructional Design (Van Merriënboer, 2019, p.4)

According to Merriënboer et al. (2019), learning tasks must typically be based on real-life or professional tasks that provide concrete experiences to learners. A series of learning tasks serves as the backbone of an educational program. Supportive information can help learners engage in non-routine aspects (problem-solving, reasoning, and decision-making) of learning tasks; it can be presented to them before they start working on the learning tasks and/or while they are working on the tasks. Procedural information shows learners how to perform routine aspects of the tasks ("how-to" instruction); it is best presented to them just in time, specifically when they need it during their work on learning tasks. Part-task practice allows more practice of the routine aspects of learning tasks that need to be fully automated; it is provided only after learners become familiar with the routine aspect in the context of meaningful learning tasks (Van Merriënboer, 2019).

Merriënboer claims that the instructional design model has gained much attention because it fits the current trends in education: (a) a focus on the development of complex skills or professional competencies; (b) increasing transfer of what is learned in school to new situations, including the workplace; and (c) the development of twenty-first-century skills that are important for lifelong learning (Van Merriënboer, 2019). Recently, the 4C/ID model was applied to emergency medical exercises (Brooks et al., 2021). For medical education, a systematic review of simulation-based interventions focusing on instructional design features identified the following best practices: range of difficulty, repetitive practice, distributed practice, cognitive interactivity, multiple learning strategies, individualized learning, mastery learning, feedback, longer time spent learning, and clinical variation (Cook et al., 2013) These features are present in the 4C/ID model and align with the principles of game-based learning (Van Merriënboer, 2019).

Van Merriënboer and Kirschner (2018) provides the Ten Steps as ten design activities that result in an educational blueprint describing the program in terms of the four components. Table 3-1 shows an overview of the four components of the 4C/ID model, their essential learning processes, and the corresponding Ten Steps approach.

Table 3-1. Ten steps of Four components instructional design (Van Merriënboer and Kirschner, 2018)

<table>
<tr><td>Learning Tasks</td><td>1 - Design learning tasks
2 - Design performance assessment
3 – Sequence learning tasks</td><td>Whole tasks</td></tr>
<tr><td>Supportive Information</td><td>4 - Design Supportive Information
5 - Analyze cognitive strategies
6 - Analyze mental models</td><td>Non–routine aspects</td></tr>
<tr><td>Procedural Information</td><td>7 - Design Procedural Information
8 - Analyze cognitive rules
9 - Analyze prerequisite knowledge</td><td rowspan="2">Routine aspects</td></tr>
<tr><td>Part-Task Practice</td><td>10 - Design part-task practice</td></tr>
</table>

In this list, steps 1, 4, 7, and 10 refer to the design steps for the four main components. Steps 2–3, 5–6, and 8–9 describe additional activities that inform the design of these four components. These auxiliary steps were integrated in a cognitive task analysis, consisting of detailed observations and in-depth interviews with experts to uncover the skills they perform, the knowledge they possess, how they apply this knowledge, how they approach problems, and how they reason (Clark et al., 2008).

Many key issues need to be defined during the exercise design process, including need assessment, exercise scope, and exercise type (DHS, 2020*).* In this study, we consider it necessary to focus on developing the four main design steps (steps 1, 4, 7, and 10 of the Ten Steps of Van Merriënboer and Kirschner 's model). Auxiliary steps are developed within the main steps.

a, Learning Tasks

This step describes the design of the backbone of the exercise program: learning tasks that are based on real-life professional tasks and that allow the learner to practice all the non-routine and routine aspects simultaneously. Make sequentially injects (scenarios) for individuals and groups, from easy to difficult, simple to complex, while gradually reducing outside support or guidance.

Learning tasks for emergency response exercises can be defined as a system of situations, tasks are set for individuals, groups according to divergent functions. This sequence of tasks can follow a connected event circuit or follow unexpected events. Following the 4C/ID theory, tasks for learners should be supplied incrementally from easy to difficult, simple to complex, while gradually reducing outside support or guidance. Learning tasks need to be selected specifically, with high practicality.

The program should involve instructors (fire service staff or specialists), supporting staff, and the leader (or owner) to allow for close collaboration, discussion, and coaching among participants. Secondly, learning tasks should engage instructors in meaningful discussion, observation of others, planning of lessons, and practicing skills in the classroom. These guidelines were strongly in line with the task-centered approach advocated by 4C/ID. In addition, learning tasks should represent the range of possible real-life tasks that the instructors can do. Finally, the program should be content-focused and address how learners get knowledge and skills, how instructors can diagnose gaps in understanding, and how they can adjust their instruction accordingly.

Design performance assessment**:** A checklist is created and provided to the instructor at the beginning of the exercises to determine what learners can do after the program, goals have been created for each component skill. Based on information gathered in consultation with experts and school inspectors, thirty standards were established. This checklist can be customized for each different exercise but should be consistent in scale to quantify changes in learners' awareness and skills. Instructors also develop additional goals at the beginning of the curriculum for the areas they feel most need improvement. This added feasibility and a sense of autonomy, as individual teachers may have different individual learning goals (Louws et al., 2017).

Sequence learning tasks: It is essential to order the learning tasks in a way that does not overwhelm the learner with too much complexity. For this reason, it is recommended to group learning tasks together based on their complexity and to present these groups of tasks in order from simple to complex, as much as can be done at the end of the exercise.

b, Supportive information

Design Supportive information: Establish general knowledge or skills on functional response, and information for specific cases (such as geographical characteristics, environment, etc.) according to the learning task sequence.

Supportive information for the exercise program is divided into two main groups, general knowledge or skills on functional response and information for specific cases such as geographical characteristics, environment, population density. birth... for each exercise. This information needs to be supplied according to the learning task sequence.

Analyze cognitive strategies: Strategies should be diverse and dictated by contextual factors such as learner needs, institution rules, and available documents. To decide whether gaps in knowledge should be addressed, instructors require knowledge and experience of the emergency response characteristics of the facility and surrounding area. They also need to be clearly aware of the needs of their learners. Strategies to elicit those needs include advanced analysis of test results and questioning methods. And from there form emphatic approaches to each specific task.

c, Procedural information

Make detailed processes to deal with each different type of task: Procedural information is the listed processes to go ahead with each different type of task. An important improvement of this model is the classification of procedural information according to predefined criteria so that individuals or groups of learners can grasp both separate tasks and other tasks at the same time.

Procedural information helps learners build appropriate cognitive rules in long-term memory to perform routine aspects. Practice a piece of repetitive practice work for common aspects that require a high degree of automation. a primarily cognitive task that is very feasible and involves a great deal of reasoning, decision making, and problem solving.

d, Part-task Practice

Make a way to help learners approach tasks step-by-step. Diversifying the type of practice is a good approach, such as a combination of tabletop exercises, functional exercises, and drills.

When four components were applied to design an exercise, they were present inside each part of the structure. Thus, we can evaluate them to analyze the result and use them to improve.

3.2.3. Case study site

The study site was in Hai Phong City, Vietnam. Hai Phong City has a population of 2,053,493 with an average population density of 1,315 people/km^2 (as of 2019, Vietnam General Statistics Office). Located approximately 120 km east of the capital, Hanoi, Hai Phong is not only the largest coastal city in the northern region of Vietnam but also one of the major economic centers of the nation (Luong et al., 2022). Recently, Hai Phong managed to maintain its position among the top two localities with the fastest-growing gross regional domestic product in Vietnam. The average annual growth rate of Hai Phong in 2017–2021 was 15.26%, which is almost double that of 2012–2016 and 2.9 times higher than the national average (Luong et al., 2022). As a coastal city, Hai Phong is at the risk of many natural hazards, particularly typhoons and floods. Owing to rapid economic development, man-made risks such as fires associated with industrial and service activities are also becoming a recurring hazard.

Hai Phong is a coastal city located downstream of the Thai Binh river system in the Red River Delta, The North and Northeast borders Quang Ninh province, the Northwest borders Hai Duong province, the Southwest borders Thai Binh province and the East is the East Sea with a coastline of 125km, where there are 5 large estuaries: Bach Dang, Cua Cam, Lach Tray, Van Uc and Thai Binh River.

The total area of Hai Phong city is 1,519 km^2 including island districts (Cat Hai and Bach Long Vi). Hills and mountains account for 15% of the area, distributed in the North, so the northern terrain has the shape and geological structure of the midland region with plains interspersed with hills; In the south, the terrain is low and quite flat, typical of a plain inclined to the sea, with an altitude of 0.7 - 1.7 m above sea level. The sea with Cat Ba Island is likened to the pearl of Hai Phong, a beautiful and largest island in the archipelago with more than 360 large and small islands gathered around it and connecting with the islands of Ha Long Bay. The main island of Cat Ba is at an altitude of 200m above sea level, with an area of about one hundred km^2, 30 nautical miles from the city. More than 90 km from Cat Ba to the Southeast is Bach Long Vi Island, which is quite flat and has a lot of white sand.

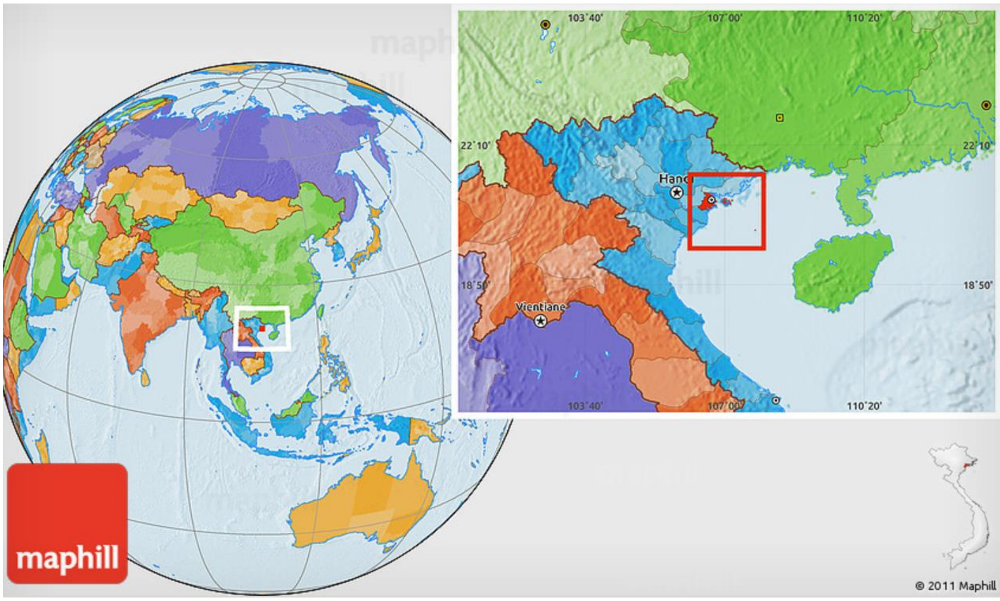


Fig. 3-2. Geographical location of Hai Phong city, Vietnam.

Souce: Maphill (2011)

The northern topography of Hai Phong is the midland area, with hills alternating with plains and gradually lowering to the south to the sea. This hilly area is related to the Quang Ninh mountain system, the vestiges of the ancient fold foundation below, where the sagging process with small intensity previously occurred, including sandstone, shale and rock. Limestone of different ages is distributed in continuous strips in the Northwest - Southeast direction from the mainland to the sea, including two main ranges. The range runs from An Lao to Do Son intermittently, extending for about 30 km with the

Northwest - Southeast direction, including mountains: Elephant, Phu Lien, Xuan Son, Xuan Ang, Do mountain, Do Son, Hon Dau. The Ky Son - Trang Kenh and An Son - Nui Deo ranges, including two branches: An Son - Nui Deo branch, composed of sandstone with northwest-southeast direction, including Phu Luu, Thanh Lang and Nui Deo mountains; and Ky Son - Trang Kenh branch with west-northwest - southeast direction, including many limestone mountains.

Hai Phong coast is over 125 km^2 long, low, and quite flat, mostly sandy and muddy from 5 main estuaries pouring into the sea. Because of this, the Do Son beach is often cloudy, but after reclamation, the seawater has become cleaner, with fine golden sand and beautiful scenery. In addition, Hai Phong also has Cat Ba Island which is a world biosphere reserve with beautiful beaches, white sand, clear blue water, and Lan Ha bay.... beautiful and interesting. Cat Ba is also the largest island in the Ha Long Bay area.

Rivers in Hai Phong are quite abundant, with an average density of 0.6 - 0.8 km/1 km^2. The slope is quite small, flowing in the direction of Northwest Southeast. This is where all the downstream of the Thai Binh River empties into the sea, creating a fertile downstream area with abundant fresh water for human life here. Hai Phong has sixteen main rivers spreading throughout the city with a total length of over 300 km.

Hai Phong today consists of fifteen administrative units, including 7 districts (Hong Bang, Le Chan, Ngo Quyen, Kien An, Hai An, Do Son, Duong Kinh), 8 rural districts (An Duong, An Lao, Bach Long). Vi, Cat Hai, Kien Thuy, Tien Lang, Thuy Nguyen, Vinh Bao), with 217 administrative units of communes, wards and towns

The population of Hai Phong is 2,053,493 people; The average population density is 1,315 people/km^2. The population of urban areas is 932,547 people, accounting for 45.9%; Males accounted for 49.45% and females accounted for 50.55% of the population. The average population growth rate in the period 2011-2021 is 0.94%/year. The number of laborers aged 15 years and over working in economic sectors is 1,075.7 thousand people, accounting for 52.38% of the total population and 97.87% of the total labor force.

Hai Phong has long been famous as the largest seaport in the North, an important traffic hub with the domestic and international waterway, land, rail, aviation, and sea transport systems. capital Hanoi and the northern provinces;

is an important traffic hub of the Northern Key Economic Region, on two corridors - a belt of economic cooperation between Vietnam and China. Therefore, in the socio-economic development strategy of the Red River Delta, Hai Phong is identified as a growth pole of the Northern dynamic economic region (Hanoi - Hai Phong - Quang Ninh). Ninh); is a general economic - scientific - technical center of the Northern Coast region and one of the development centers of the Northern Key Economic Region and the whole country (Decision 1448/QD-TTg dated 16/03/QD-TTg dated 16/06/07/Decision No. September 2009 by the Prime Minister).

Hai Phong has extraordinarily rich natural conditions, rich in beauty and diversity and has many unique features with nuances of the tropical monsoon landscape. Cat Ba National Forest - the World Biosphere Reserve - is a famous primeval tropical forest, especially rich in the number of species of flora and fauna, many of which are classified as rare. of the world. At the same time, this place also has a delta in the delta of the Red River Delta, creating an agricultural landscape of wet rice cultivation, which is a feature of the northern coastal tourist area and a whole sea. wide with extremely rich resources, many rare seafood and beautiful beaches.

Hai Phong weather is typical of the weather in the North of Vietnam: hot, humid, rainy, there are four seasons: Spring, Summer, Autumn, and Winter. In which, from November to April next year is the climate of a cold and dry winter, winter is 20.3°C; From May to October is the climate of summer, cool and rainy, the average temperature in summer is about 32.5°C.

The average rainfall is from 1,600 to 1,800 mm/year. Due to its proximity to the sea, in winter, Hai Phong is 1°C warmer and 1°C cooler in summer than Hanoi. The average temperature of the year is from 23°C to 26°C, the hottest month (July and July) can reach 44°C and the coldest month (January and February) the temperature can drop below 5°C. The average humidity is about 80-85%, the highest is in July, August, September and the lowest is January and December.

In the first six months of 2021, Hai Phong city's economy was significantly affected by the Covid-19 pandemic. GRDP in the first 6 months of 2021 is estimated to increase by 13.52% over the same period last year, higher than the increase of 10.87% in the first 6 months of 2020, despite being affected by the COVID-19 epidemic but Hai Phong still maintains a high growth rate compared to other provinces and cities across the country (ranked fourth in the country, second in the Northern key region), showing the drastic and timely direction and administration. of the city's leaders and the efforts of all levels, sectors, people and businesses to continue effectively implementing the dual goal of "both disease prevention and economic development".

In the first six months of 2021, freight transport is estimated at 115.4 million tons, up 16.84% over the same period last year, freight turnover is estimated at 50,036.1 million tons.km, down 0.71% compared to the same period last year. with the same period. Passenger transport in the first six months of 2021 was estimated at 21.9 million turns, down 10.78% over the same period last year. Passenger turnover was estimated at 882.7 million Hk.km, down 10.05% over the same period last year.

From the beginning of the year to June 15, 2021, the whole city has thirty new projects from 09 countries and territories with an investment capital of 187.34 million USD, equaling 49.92% over the same period last year. prior to. Adjusted to increase investment capital, there are thirty-one projects, with an increased capital of 946.34 million USD. New projects and capital increase are in the processing and manufacturing industry. Total new grant and capital increase in the whole city has sixty-one projects, investment capital reached 1,133.68 million USD.

As of June 14, 2021, there were forty-five fires in the city, an increase of 60% compared to the same period in 2020, causing 01 death; some forest vegetation fires caused estimated damage of 12.28 ha. Thus, thanks to the well-implemented implementation of many disaster risk reduction policies and programs, we can see that Hai Phong city has curbed the impact of natural disasters and incidents on people's lives. Specialized emergency management agencies continue to research and develop innovative ideas to further improve the achieved results. Emergency management organizations—both public and private—are essential to save lives and reduce property damage in case of large-scale emergencies. For full efficiency, interoperability across government and private organizations is necessary (Flach et al., 2017).

Two fire and rescue exercises in Hai Phong City were selected to determine how they could be improved. Table 3-2 summarizes the features of these exercises. Figure 3-3 shows the exercise scenes. The first exercise was conducted at a newly built apartment complex: Cat Bi Apartment Complex, and the second was conducted at the Tam Bac market, a traditional and busy market. Both were full-scale exercises including tabletop discussion exercises and field drills. The main aim of these exercises was to train emergency response teams that function as initial response services when hazards such as fires or other unsafe situations occur. The second aim pertained to the fire service department, which is both a coordinated response agency and provider of exercise instructions and commands. Moreover, other agencies such as district and police authorities and hospitals played auxiliary roles in these exercises.

Table 3-2. Overview of two targeted exercises

	Exercise 1: apartment complex	Exercise 2: traditional market
Assumed situation	● Leaked gas accumulation caused an explosion and fire at apartment 4A building M5 in The Cat Bi Apartment Complex, No. 27 Le Hong Phong, Dong Khe ward, Ngo Quyen district, Hai Phong city. ● The assumed fire area was 980 m^2. ● Thirty panicked people hid in enclosed areas from the third to seventh floor and roof areas crying out for help.	● A short circuit caused fire at kiosk No. 241 of Tam Bac Market, No. 4 Hoang Ngan, Phan Boi Chau ward, Hong Bang district, Hai Phong city. ● The assumed fire area was 2000 m^2. ● Ten people were injured and trapped in the fire.
Objectives	● To raise awareness and knowledge of fire prevention among all people in the apartment complex, rescue everyone, and assess the ability of firefighting forces to handle such situations ● To check the operational status of fire and rescue systems and equipment on the spot, detect shortcomings, and promptly set out remedial measures to proactively prevent the risk of fire and be ready to participate in fire and rescue and minimize the damage caused by fire ● To help firefighting forces and other forces in gaining a strong grasp of the area, traffic characteristics, water sources, fire risk,	

	and risk of toxicity at the facility so that they can use appropriate firefighting measures and techniques with high efficiency. ● To assess the ability of the forces to cooperate and coordinate in terms of the firefighting and rescue commands and operations and ensure safety when a large fire occurs. ● To launch a movement wherein all the people participate in fire prevention and rescue operations, thus contributing to social safety in the city	
Number of participants and vehicles	● 650 participants ● 57 vehicles including fire engines, ladders, ambulances, and other specialized vehicles	● 650 participants ● 50 vehicles including fire engines, ladders, ambulances, and other specialized vehicles
Firefighting and rescue tactics	*Firefighting tactics:* ● Use water to fight fires and cool down the area. ● Fight the fire according to the fire surface, and gradually narrow the fire area. ● Approach the fire area along the stairs in the main direction and other directions, cool down the construction components, and prevent the fire from spreading. ● Ladder vehicles will rescue victims from high floors and simultaneously engage in the tasks of firefighting, using anti-collapse components and preventing the fire from spreading. ● Use smoke suction machines and demolition equipment to	*Firefighting tactics:* ● Use water to fight fires and cool down the area. ● Fight the fire according to the fire surface, and gradually narrow the fire area. ● Approach the fire area along the stairs in the main direction and other directions, cool down the construction components, and prevent the fire from spreading. ● Ladder vehicles perform the tasks of cooling down the area, using anti-collapse components, and preventing the fire from spreading. ● Use smoke suction machines and demolition equipment to escape smoke;

	escape smoke; support the forces involved in the operation. *Evacuation and rescue tactics:* ● Mobilize forces to coordinate the tasks of guiding escape, searching and rescuing people, and moving vehicles and assets out of the fire area. ● Use an internal speaker system/portable speaker to instruct people to calmly exit to a safe place. Use ladders, inclined wire bridges, and lifesaving ropes, and deploy air cushions to rescue people trapped on high floors. Move the victim to a safe place. Use radio detectors to search for victims	support the forces involved in the operation. *Evacuation and rescue tactics:* ● Mobilize forces to coordinate the tasks of guiding escape, searching and rescuing people, and moving vehicles and assets out of the fire area. ● Use an internal speaker system/portable speaker to instruct people to calmly exit to a safe place. Move the victims to a safe place. Use radio detectors to search for victims

Fig. 3-3. Exercises conducted at Cat Bi Apartment Complex (left image) and Tam Bac market (right image). *Source: Hai Phong Fire and Rescue Police Division*

The two exercises had similar scales and forms; however, there were specific differences between the hypothetical situations: the exercise at the apartment complex (Case 1) involved operations on the high floors of a highrise apartment, and the exercise at the traditional market (Case 2) involved operations in a large area containing a large volume of hazardous goods. Comparing experts' assessments of the need for improvement between these two exercises, which have such common and unique characteristics, can help clarify their views on the research purpose.

3.2.4. Framework of exercise design

As described, there are no detailed standardized criteria for designing exercises for large fire cases in Vietnam. Thus, a framework was created to design exercises by observing the present work procedure of the Fire and Rescue Police exercise designers and combining the “four-on-the-spot” motto and 4C/ID model, as shown in Table 3-3. To determine the importance of each cell in this table, we surveyed fire experts and analyzed their answers using AHP. Our objective was to identify the importance of each cell in the table by extracting and summarizing the expert knowledge.

Table 3-3. Exercise design framework

	Learning tasks	Supportive information	Procedural information	Part-task practice
Command				
Manpower				
Means				
Logistics				

3.2.5. Research flow

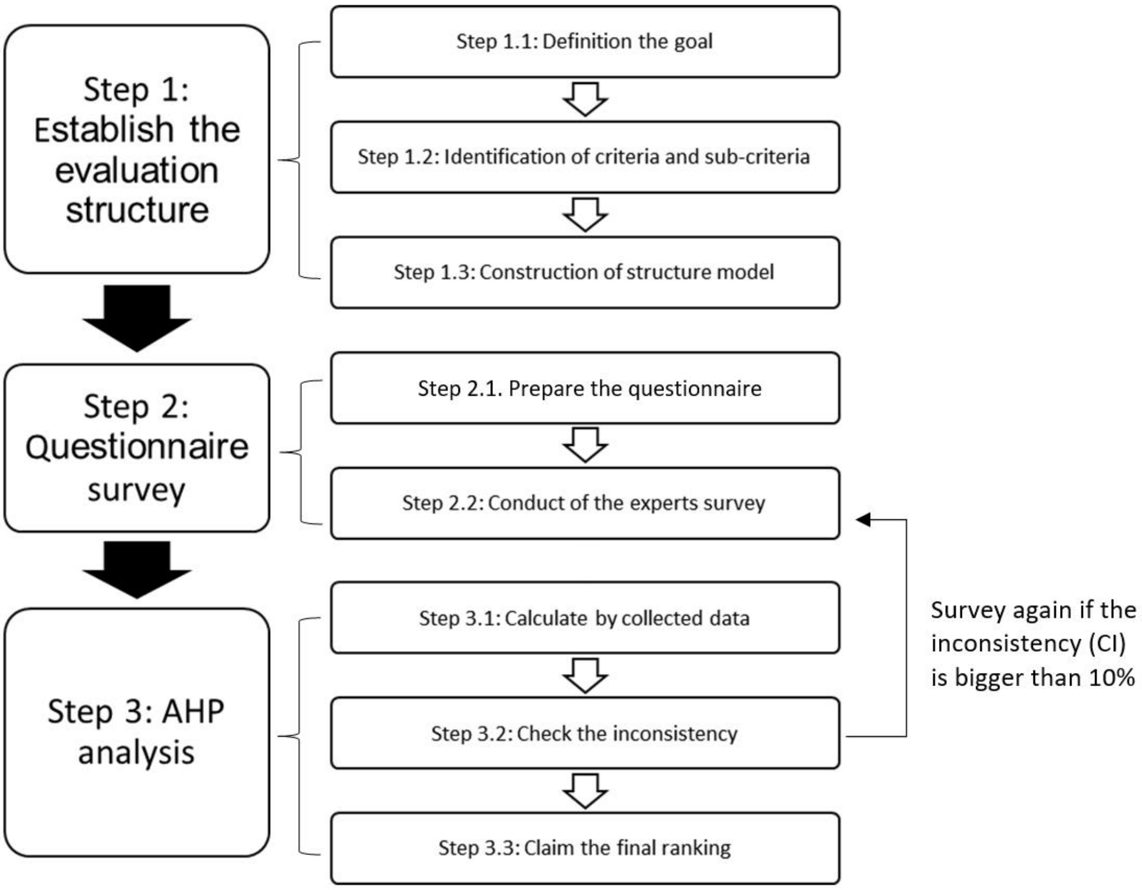


Fig. 3-4. Research flow

To apply AHP, we need to define a hierarchical model of decision-making. Figure 3-4 illustrates the proposed model. The top layer describes the decision-making objectives. The second layer from the top and bottom layers reflects the "four-on-the-spot" motto and 4C/ID elements, respectively. Employing only four elements of the motto is insufficient to express some important exercise content, hence, we decided to add a middle layer to the model after interviewing fire service experts in Hai Phong City. Specifically, the sub-criteria "basic skills and situation understanding," "executive capacity," and "communication and information capacity" were under the "command and control" criteria. The sub criteria "functional response capacity" and "communication capacity" were under the "manpower" criteria.

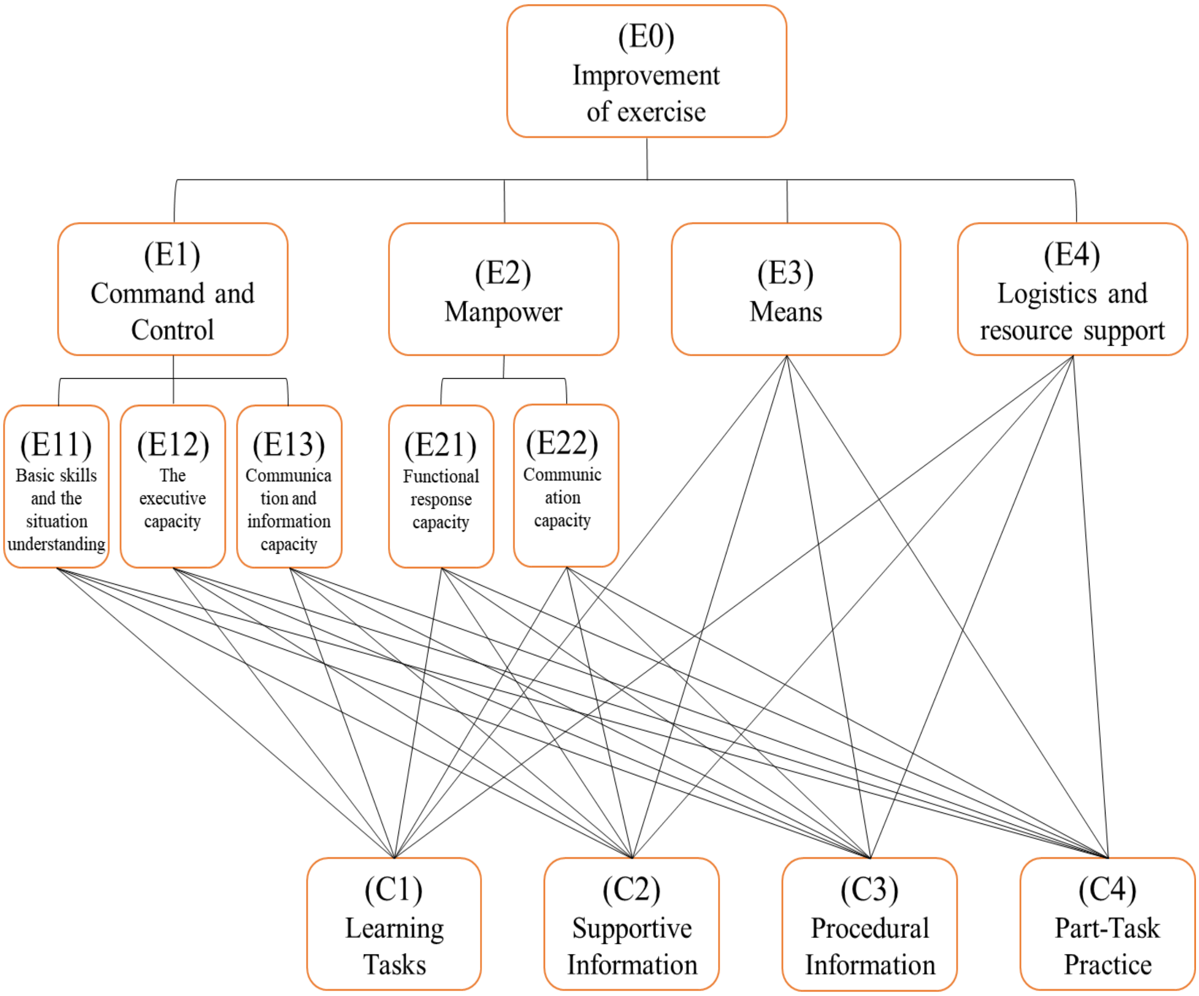


Fig. 3-5. Hierarchical model for designing exercises

The values of the elements in the structure are denoted as follows:

E1: Command and Control

E2: Manpower

E3: Means

E4: Logistics and resource support

E11: Basic skills and the situation understanding

E12: The executive capacity

E13: Communication and information capacity

E21: Functional response capacity

E22: Communication capacity

C1: Learning Tasks

C2: Supportive Information

C3: Procedural Information

C4: Part-Task Practice

3.2.6. Data collection

Our survey was conducted through an online discussion with the following five fire officers in Hai Phong City in the first quarter of 2021: the Chief of Hai Phong Fire and Rescue Division (Respondent 1: R1), the Chief Commander of the Central Fire and Rescue Station (R2), Chief Commander of The Fire and Rescue Instruction Team (R3), Vice Commander of The Fire and Rescue Instruction Team (R4), and a senior officer of The Fire and Rescue Instruction Team (R5). R1 and R2 acted as commanders during the exercise. R3–R5 worked as exercise designers.

The survey began with an explanation of the relationship between the four components of instructional design and emergency exercise. For example, the learning tasks where exercise injects or problem sets, procedural information was specialized knowledge and regulations, supportive information included geographical characteristics and traffic situations, and part-task practice was repeated training of actions and decisions. A series of pairwise questions were then provided for the AHP model estimation *(Appendix 1).* The first author of this paper moderated the survey procedure, and it took approximately 1 h for each officer to complete the survey.

3.2.7. Calculation procedure

For the AHP questions, officers were instructed to compare each pair of elements in the model shown in Figure 3-4. An example of port facilities and solid waste was provided to help them understand how to answer pair-wise questions. We then asked AHP questions regarding Exercises 1 and 2. We used the Saaty Comparison Scale (2008), as shown in Table 3, to quantify the answers to the pairwise questions.

Table 3-4. Saaty Comparison Scale (2008)

<table>
<tr><th>Score</th><th>Interpretation</th><td rowspan="4">If the ratio of the importance of factor i to j is a_{ij}, the ratio of the importance of factor j to i is a_{ji}:</td></tr>
<tr><td>1</td><td>Factor i and factor j are equal</td></tr>
<tr><td>3</td><td>Factor i is moderately more important than factor j</td></tr>
<tr><td>5</td><td>Factor i is obviously more important than factor j</td></tr>
</table>

7	Factor i is strongly more important than factor j	$a_{ji} = 1/a_{ij}$
9	Factor i is extremely more important than factor j	
2, 4, 6, 8	The median of the above adjacent judgments	

The pairwise comparison between the four criteria, denoted by values from E1 to E4 (explained in Section 2.4) in the answer given by the Chief of Hai Phong Central Fire Station, the main commander of exercise 1, was used to describe the calculation procedure.

pairwise comparison of key factors																		
E1	9	8	7	6	5	4	3	2	1	2	3	4	(5)	6	7	8	9	E2
E1	9	8	7	6	5	4	3	2	(1)	2	3	4	5	6	7	8	9	E3
E1	9	8	7	6	5	4	3	2	1	2	(3)	4	5	6	7	8	9	E4
E2	9	8	7	6	5	4	(3)	2	1	2	3	4	5	6	7	8	9	E3
E2	9	8	7	6	5	4	3	2	1	2	(3)	4	5	6	7	8	9	E4
E3	9	8	7	6	5	4	3	2	1	2	3	4	(5)	6	7	8	9	E4

Fig. 3-6. Answer sample

First, we transformed the answer into a comparison matrix and summed the value of each column. If the ratio of the importance of factor i to j is a_{ij}, then the ratio of the importance of factor j to i is a_{ji}:

$$a_{ji} = \frac{1}{a_{ij}}$$

Table 3-5. Comparison matrix

	E1	E2	E3	E4
E1	1	1/5	1	1/3
E2	5	1	3	1/3
E3	1	1/3	1	1/5
E4	3	3	5	1
Sum	10	4.533	10	1.867

Then, we divided each cell by the total number of the columns and calculated the average value of each row, which provided the overall priority (P_E).

Table 3-6. Complex matrix of overall priority

	E1	E2	E3	E4	P_E
E1	0.1000	0.0441	0.1000	0.1786	0.1057
E2	0.5000	0.2206	0.3000	0.1786	0.2998
E3	0.1000	0.0735	0.1000	0.1071	0.0952
E4	0.3000	0.6618	0.5000	0.5357	0.4994

An important aspect of this method is the consistency test. The calculations are accepted only if the consistency ratio is < 10%. We multiplied each column of the comparison matrix (Table 3-6) by the corresponding P_E and summed the values of each row.

Table 3-7. Weighted matrix of overall priority

	E1	E2	E3	E4	Sum (Wi)
E1	0.1057	0.0600	0.0952	0.1665	0.4273
E2	0.5284	0.2998	0.2855	0.1665	1.2801
E3	0.1057	0.0999	0.0952	0.0999	0.4006
E4	0.3170	0.8994	0.4758	0.4994	2.1916

Each cell of the sum column was divided by the corresponding PE, and the average value was calculated to obtain λmax (n=4).

$$\lambda\text{max} = \frac{\Sigma(\frac{\text{Wi}}{\text{PEi}})}{n} = (\frac{0.4273}{0.1057} + \frac{1.2801}{0.2998} + \frac{0.4006}{0.0952} + \frac{2.1916}{0.4994})/4 = 4.22796$$

The consistency index was calculated as follows:

$$\text{CI} = \frac{\lambda max - n}{n-1} = \frac{4.22796-4}{4-1} = 0.0760$$

Table 3-8. Consistency indices for randomly generated matrices (Saaty, 2008)

n	1	2	3	4	5	6	7
RI	0	0	0.52	0.89	1.11	1.24	1.34

When n = 4, RI = 0.89 (Saaty, 2008)

The consistency ratio was calculated as follows:

$$CR = \frac{CI}{RI} = \frac{0.0760}{0.89} = 0.0854$$

The CR was <0.10; therefore, it passed the consistency test.

Continuing in the same way for the other sections, we calculated the overall priorities of the sample (Table 3-9).

Table 3-9. Index samples

				C1	**C2**	**C3**	**C4**
E1	0.1057	**E11**	0.0211	0.0036	0.0078	0.0056	0.0041
		E12	0.0211	0.0063	0.0058	0.0047	0.0043
		E13	0.0634	0.0126	0.0280	0.0132	0.0096
E2	0.2998	**E21**	0.2248	0.0957	0.0455	0.0499	0.0338
		E22	0.0749	0.0167	0.0157	0.0194	0.0232
E3	0.0952			0.0171	0.0321	0.0321	0.0137
E4	0.4994			0.0751	0.0751	0.1449	0.2044

Thus, with this answer sample, we obtained the following hierarchy of improvement required for this exercise.

Table 3-10. Hierarchy analysis sample

Hierarchy of indexes	Order of need for improvement
E4 > E2 > E1 > E3	Logistics and resource support > Manpower > Command and Control > Means
E13 > E12 = E11	Communication and information capacity > Basic skills and the situation understanding = The executive capacity
E21 > E22	Functional response capacity > Communication capacity

The AHP model was used for each exercise case by each respondent. We calculated the consistency ratio for each respondent, and if the score exceeded 10%, the respondent was asked to answer the questions again. After the completion of the procedure, the overall inconsistency score was 6.87%.

As introduced, the software "SuperDecision V3.2" was used by us in this study to verify the results. By setting up the structure on this software, we can easily input the answers and get the results immediately for each response. An important effect is that we can use this software to check the consistency of the answers, and it also gives suggestions to correct that inconsistency.

The first step is to set up the AHP evaluation structure on the software interface. The established structure will appear as Figure 3-7 as follows:

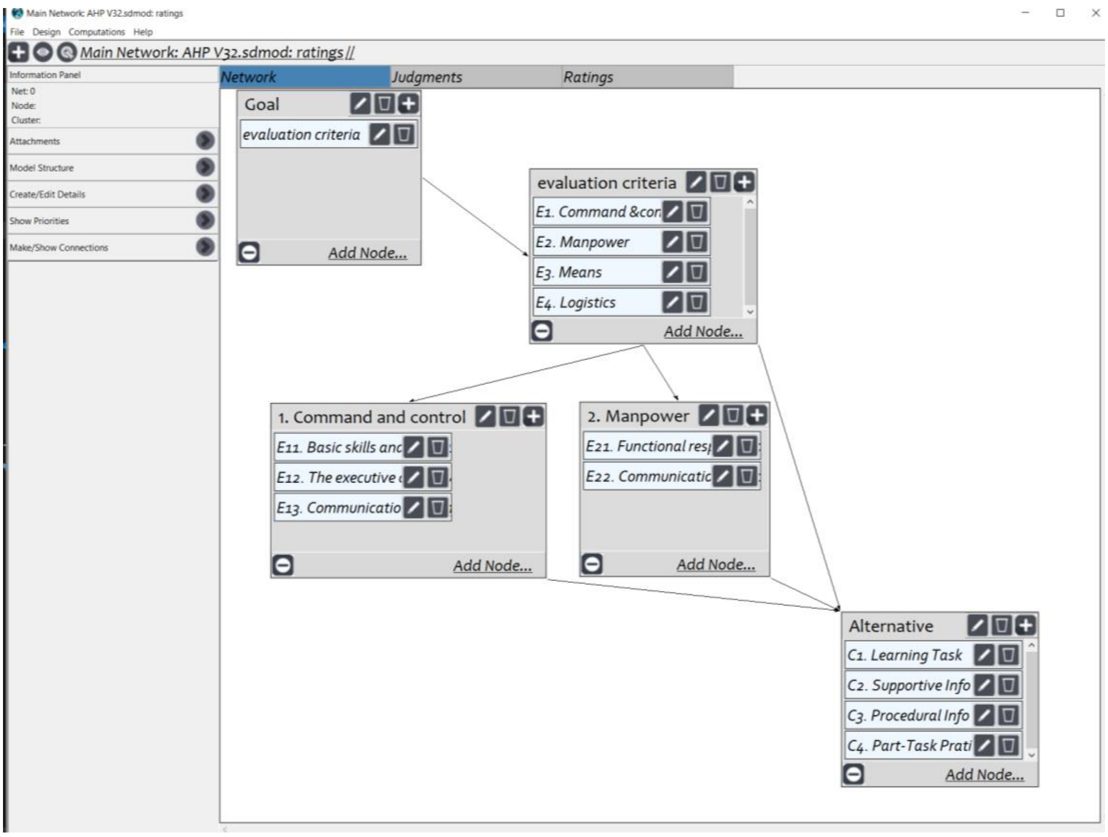


Fig. 3-7. Structure network setting interface on software "SuperDecision V3.2"

The next step is to enter the pairwise comparisons from the questionnaires into the corresponding interface. Immediately, the P values and consistency are calculated and represented by the software.

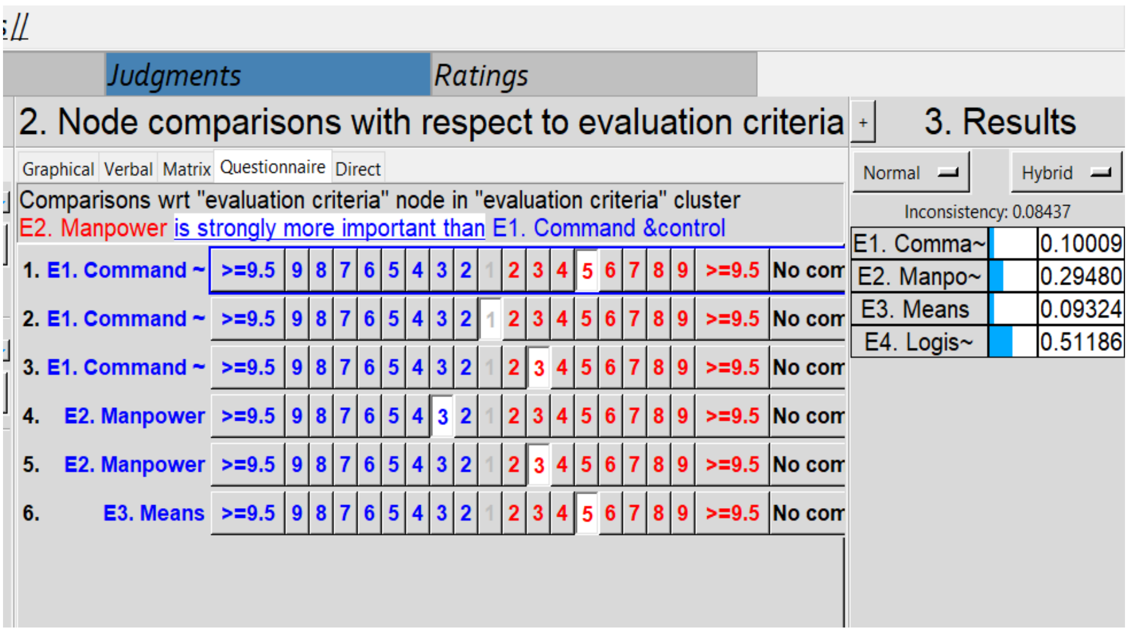


Fig. 3-8. Questionnaire input interface of four criteria on the software "SuperDecision V3.2"

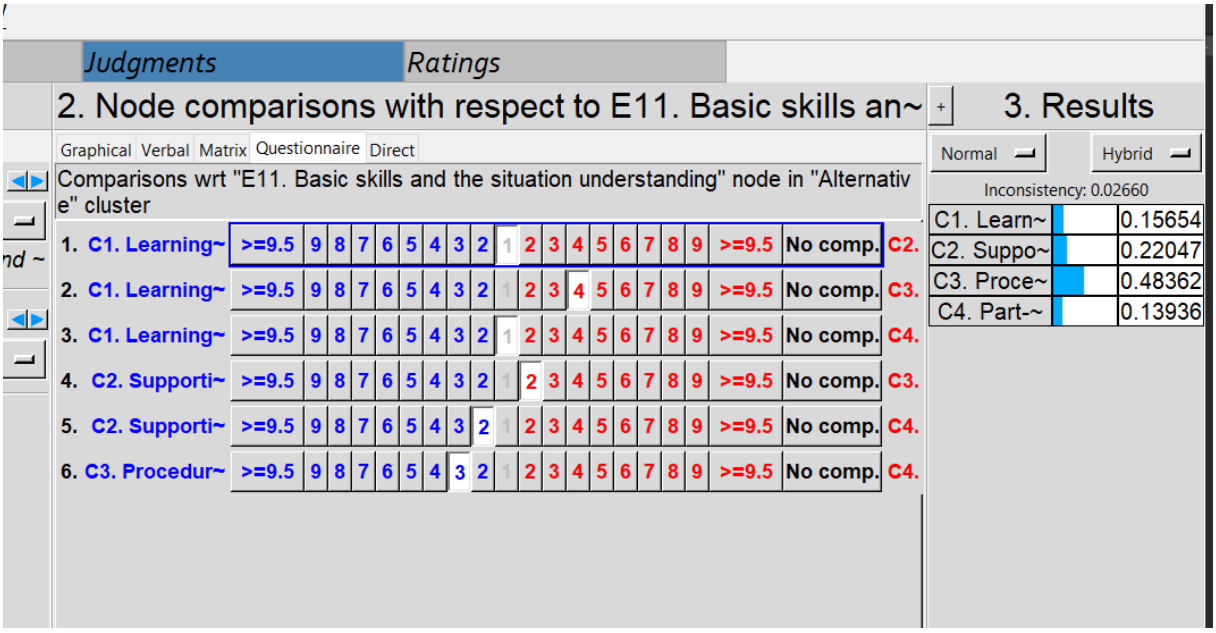


Fig. 3-9. Questionnaire input interface for sub-criteria on the software "SuperDecision V3.2"

The software also has a suggestion function to adjust the answers to increase consistency. Many answers have inconsistencies beyond 10%. Our approach is to contact the respondent again to discuss and jointly consider changing the rating. However, in a few cases, the respondents did not change their opinion and we considered the meaning of the consistency of the five responses. Results are still accepted if the average inconsistency is less than 10%.

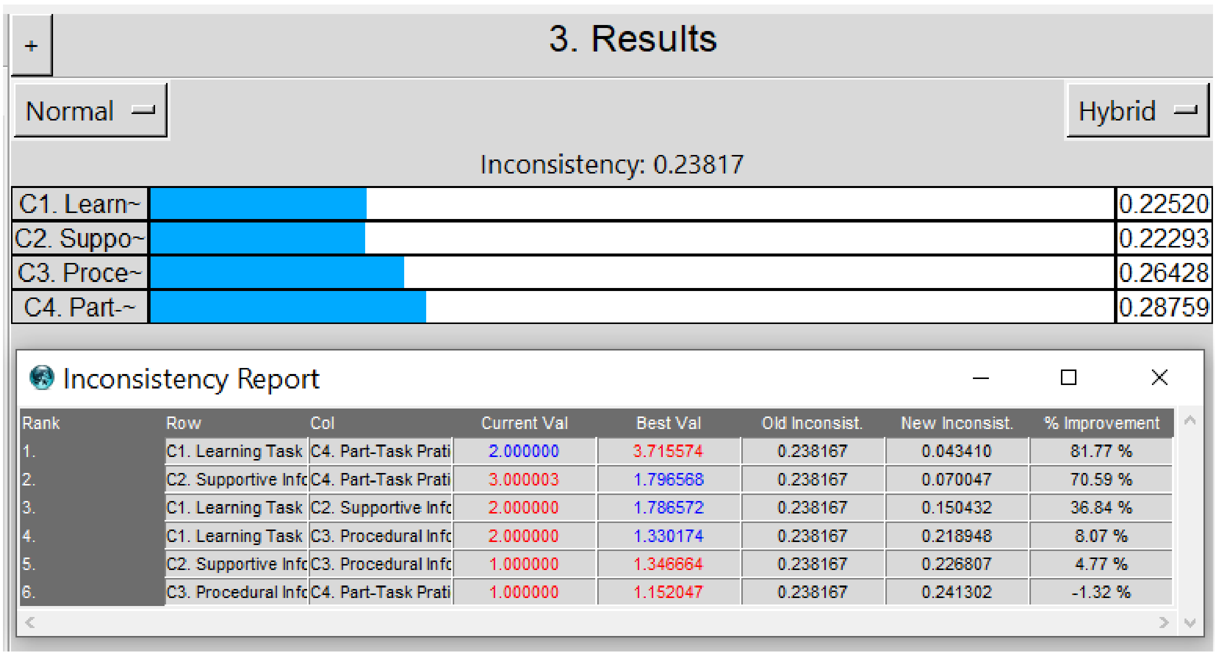
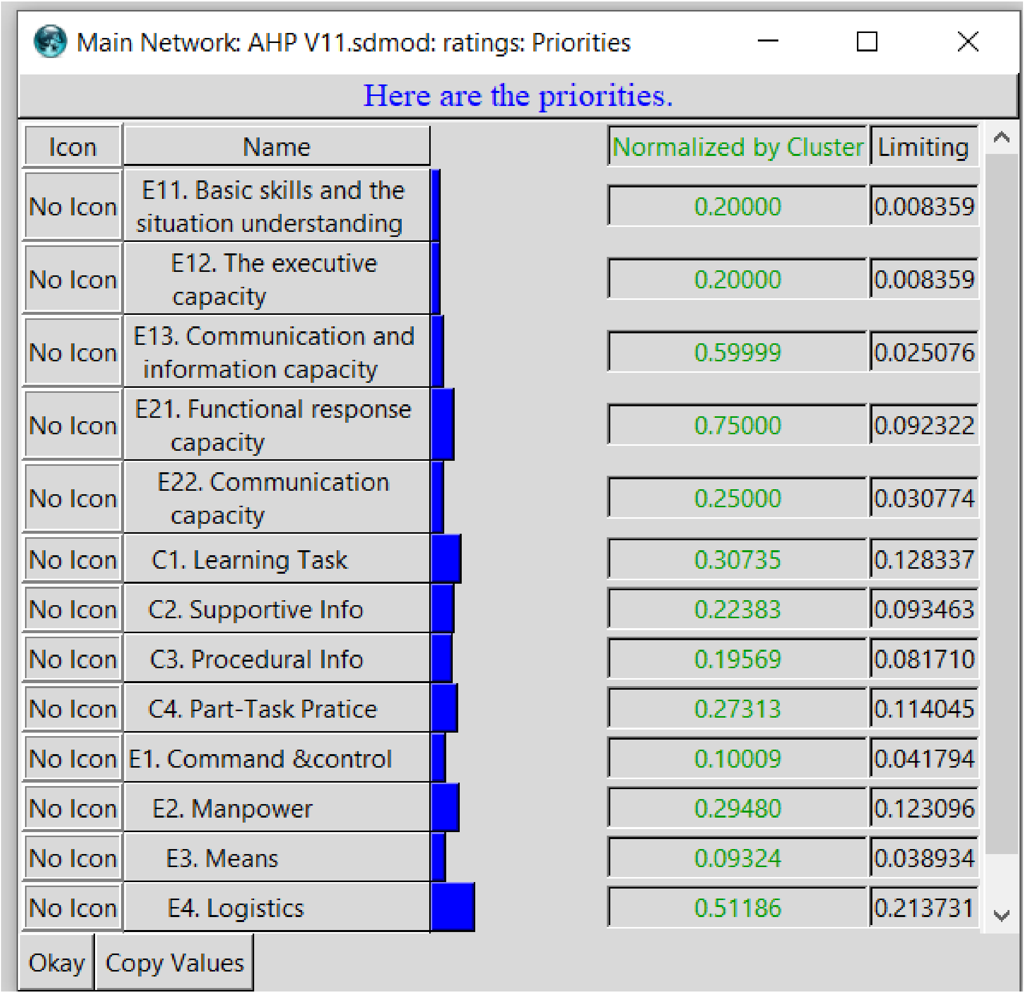


Fig. 3-10. Inconsistency check interface on software "SuperDecision V3.2"

After the input process, we can get the result set as shown in the illustration. However, we noticed a difference between the results calculated by the software and the manual method. This is explained by the automatic rounding errors.


Main Network: AHP V11.sdmod: ratings: Priorities

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	E11. Basic skills and the situation understanding	0.20000	0.008359
No Icon	E12. The executive capacity	0.20000	0.008359
No Icon	E13. Communication and information capacity	0.59999	0.025076
No Icon	E21. Functional response capacity	0.75000	0.092322
No Icon	E22. Communication capacity	0.25000	0.030774
No Icon	C1. Learning Task	0.30735	0.128337
No Icon	C2. Supportive Info	0.22383	0.093463
No Icon	C3. Procedural Info	0.19569	0.081710
No Icon	C4. Part-Task Pratice	0.27313	0.114045
No Icon	E1. Command &control	0.10009	0.041794
No Icon	E2. Manpower	0.29480	0.123096
No Icon	E3. Means	0.09324	0.038934
No Icon	E4. Logistics	0.51186	0.213731

Okay | Copy Values

Fig. 3-11. An automatic result by software "SuperDecision V3.2"

3.3. Results

3.3.1. Decision weights for each respondent

Decision weights of each respondent are showed as follows in Table 3-11a to Table 3-11j:

Table 3-1a. Decision weights of R1 in Case 1.

R1	C4	>	C3	>	C1	>	C2
				C1	**C2**	**C3**	**C4**
E1	0.1057	**E11**	0.0211	0.0036	0.0078	0.0056	0.0041
		E12	0.0211	0.0063	0.0058	0.0047	0.0043
		E13	0.0634	0.0126	0.0280	0.0132	0.0096
E2	0.2998	**E21**	0.2248	0.0957	0.0455	0.0499	0.0338
		E22	0.0749	0.0167	0.0157	0.0194	0.0232
E3	0.0952			0.0171	0.0321	0.0321	0.0137
E4	0.4994			0.0751	0.0751	0.1449	0.2044
Sum of Cn				0.2271	0.2100	0.2698	0.2931

Table 3-11b. Decision weights of R2 in Case 1.

R2	C3	>	C1	>	C4	>	C2
				C1	**C2**	**C3**	**C4**
E1	0.1146	**E11**	0.0268	0.0046	0.0058	0.0128	0.0037
		E12	0.0214	0.0069	0.0061	0.0063	0.0021
		E13	0.0664	0.0174	0.0270	0.0121	0.0098
E2	0.3116	**E21**	0.2415	0.1094	0.0431	0.0497	0.0393
		E22	0.0701	0.0141	0.0151	0.0176	0.0234
E3	0.0828			0.0137	0.0243	0.0295	0.0153
E4	0.4911			0.0763	0.0763	0.1952	0.1432
Sum of Cn				0.2424	0.1977	0.3231	0.2369

Table 3-11c. Decision weights of R3 in Case 1.

R3	C4	>	C3	>	C1	>	C2
				C1	**C2**	**C3**	**C4**
E1	0.2887	**E11**	0.0763	0.0134	0.0134	0.0229	0.0267
		E12	0.1175	0.0220	0.0318	0.0318	0.0318
		E13	0.0949	0.0174	0.0300	0.0300	0.0174
E2	0.2887	**E21**	0.2045	0.0491	0.0288	0.0576	0.0690
		E22	0.0842	0.0133	0.0263	0.0263	0.0183
E3	0.2470			0.0708	0.0337	0.0597	0.0828
E4	0.1756			0.0246	0.0436	0.0546	0.0528
Sum of Cn				0.2106	0.2077	0.2830	0.2988

Table 3-11d. Decision weights of R4 in Case 1.

R4	C4	>	C2	>	C3	>	C1
				C1	**C2**	**C3**	**C4**
E1	0.2045	**E11**	0.0352	0.0078	0.0118	0.0078	0.0078
		E12	0.1071	0.0147	0.0332	0.0232	0.0359
		E13	0.0622	0.0133	0.0215	0.0158	0.0116
E2	0.1420	**E21**	0.1065	0.0202	0.0252	0.0148	0.0463
		E22	0.0355	0.0075	0.0088	0.0103	0.0088
E3	0.4009			0.1048	0.0789	0.0720	0.1451
E4	0.2527			0.0288	0.0536	0.0856	0.0847
Sum of Cn				0.1971	0.2331	0.2295	0.3403

Table 3-11e. Decision weights of R5 in Case 1.

R5	C1	>	C3	>	C4	>	C2
				C1	C2	C3	C4
E1	0.1732	E11	0.0330	0.0055	0.0083	0.0124	0.0068
		E12	0.0342	0.0073	0.0115	0.0075	0.0078
		E13	0.1061	0.0255	0.0278	0.0141	0.0387
E2	0.5327	E21	0.3996	0.1586	0.0778	0.1122	0.0509
		E22	0.1332	0.0224	0.0371	0.0310	0.0426
E3	0.1554			0.0250	0.0380	0.0423	0.0501
E4	0.1387			0.0325	0.0170	0.0460	0.0432
Sum of Cn				0.2768	0.2175	0.2655	0.2402

Table 3-11f. Decision weights of R1 in Case 2.

R1	C4	>	C2	>	C1	>	C3
				C1	C2	C3	C4
E1	0.0818	E11	0.0273	0.0060	0.0063	0.0067	0.0082
		E12	0.0273	0.0032	0.0121	0.0055	0.0065
		E13	0.0273	0.0032	0.0132	0.0046	0.0063
E2	0.3005	E21	0.2254	0.1148	0.0186	0.0539	0.0381
		E22	0.0751	0.0202	0.0105	0.0155	0.0288
E3	0.2268			0.0327	0.0901	0.0408	0.0631
E4	0.3909			0.0555	0.1273	0.0612	0.1469
Sum of Cn				0.2357	0.2781	0.1883	0.2980

Table 3-11g. Decision weights of R2 in Case 2.

R2	C4	>	C1	>	C2	>	C3
				C1	C2	C3	C4
E1	0.0923	E11	0.0308	0.0036	0.0082	0.0073	0.0117
		E12	0.0308	0.0032	0.0155	0.0056	0.0065
		E13	0.0308	0.0038	0.0135	0.0065	0.0070
E2	0.4418	E21	0.3129	0.1534	0.0321	0.0814	0.0460
		E22	0.1289	0.0371	0.0179	0.0296	0.0443
E3	0.2347			0.0300	0.0906	0.0417	0.0724
E4	0.2312			0.0353	0.0765	0.0319	0.0875
Sum of Cn				0.2664	0.2542	0.2040	0.2753

Table 3-11h. Decision weights of R3 in Case 2.

R3	C4	>	C3	>	C2	>	C1
				C1	C2	C3	C4
E1	0.2887	E11	0.0722	0.0126	0.0126	0.0217	0.0253
		E12	0.0722	0.0135	0.0195	0.0195	0.0195
		E13	0.1443	0.0265	0.0457	0.0457	0.0265
E2	0.2887	E21	0.1564	0.0375	0.0220	0.0441	0.0527
		E22	0.1323	0.0196	0.0285	0.0285	0.0558
E3	0.2470			0.0708	0.0337	0.0597	0.0828
E4	0.1756			0.0246	0.0436	0.0546	0.0528
Sum of Cn				0.2052	0.2057	0.2737	0.3154

Table 3-11i. Decision weights of R4 in Case 2.

R4	C4	>	C3	>	C2	>	C1
				C1	**C2**	**C3**	**C4**
E1	0.2929	**E11**	0.0586	0.0092	0.0080	0.0098	0.0316
		E12	0.1171	0.0256	0.0243	0.0205	0.0468
		E13	0.1171	0.0239	0.0405	0.0239	0.0288
E2	0.2929	**E21**	0.2074	0.0494	0.0318	0.0534	0.0729
		E22	0.0854	0.0116	0.0175	0.0272	0.0292
E3	0.2071			0.0492	0.0419	0.0698	0.0463
E4	0.2071			0.0485	0.0566	0.0396	0.0624
Sum of Cn				0.2173	0.2205	0.2442	0.3180

Table 3-11j. Decision weights of R5 in Case 2.

R5	C4	>	C2	>	C1	>	C3
				C1	**C2**	**C3**	**C4**
E1	0.2695	**E11**	0.0712	0.0182	0.0134	0.0134	0.0262
		E12	0.1097	0.0217	0.0302	0.0153	0.0425
		E13	0.0885	0.0175	0.0243	0.0124	0.0343
E2	0.4168	**E21**	0.2952	0.0549	0.0857	0.0347	0.1200
		E22	0.1216	0.0211	0.0288	0.0167	0.0550
E3	0.1209			0.0294	0.0247	0.0201	0.0468
E4	0.1928			0.0503	0.0373	0.0380	0.0672
Sum of Cn				0.2131	0.2443	0.1506	0.3919

The weights can be used to understand the relative importance of the elements. For example, the results of R1 for Exercise 1 show that the respondent considered logistics to be the most important in improving the capability tested in this exercise, because the weight of 0.499 for logistics was larger than those of the other three elements of emergency management.

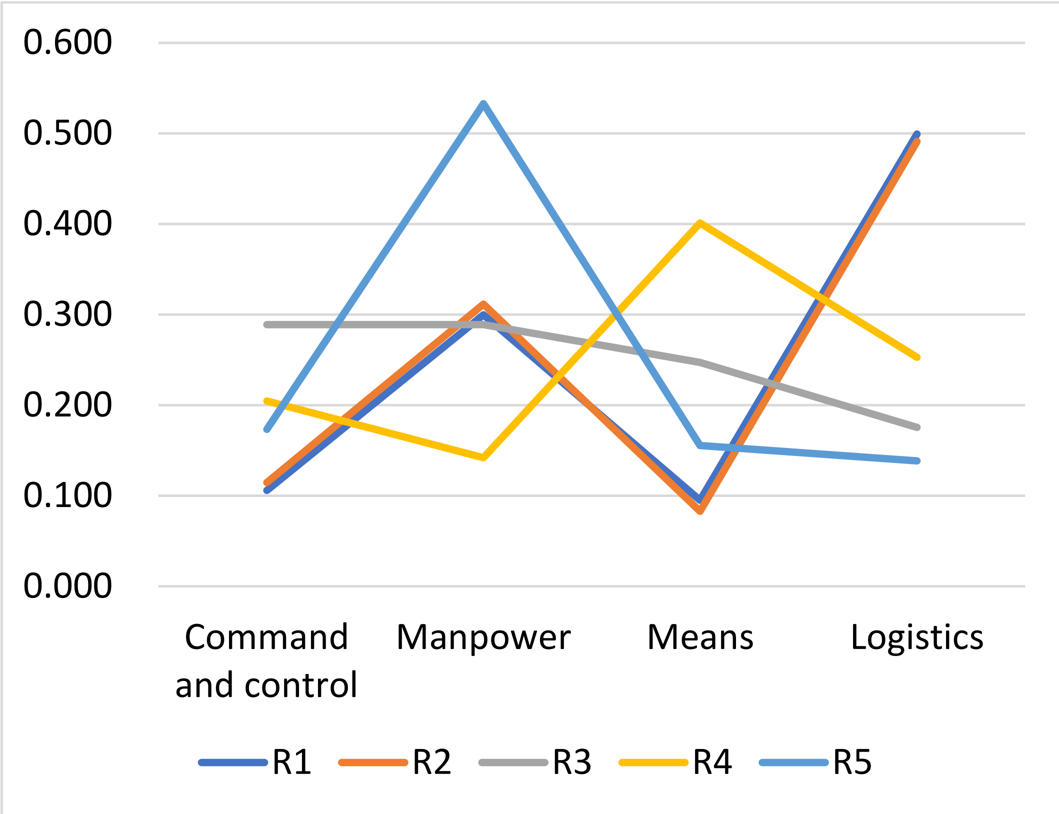


Fig. 3-12a. Decision weights for four elements of emergency management in exercise case 1

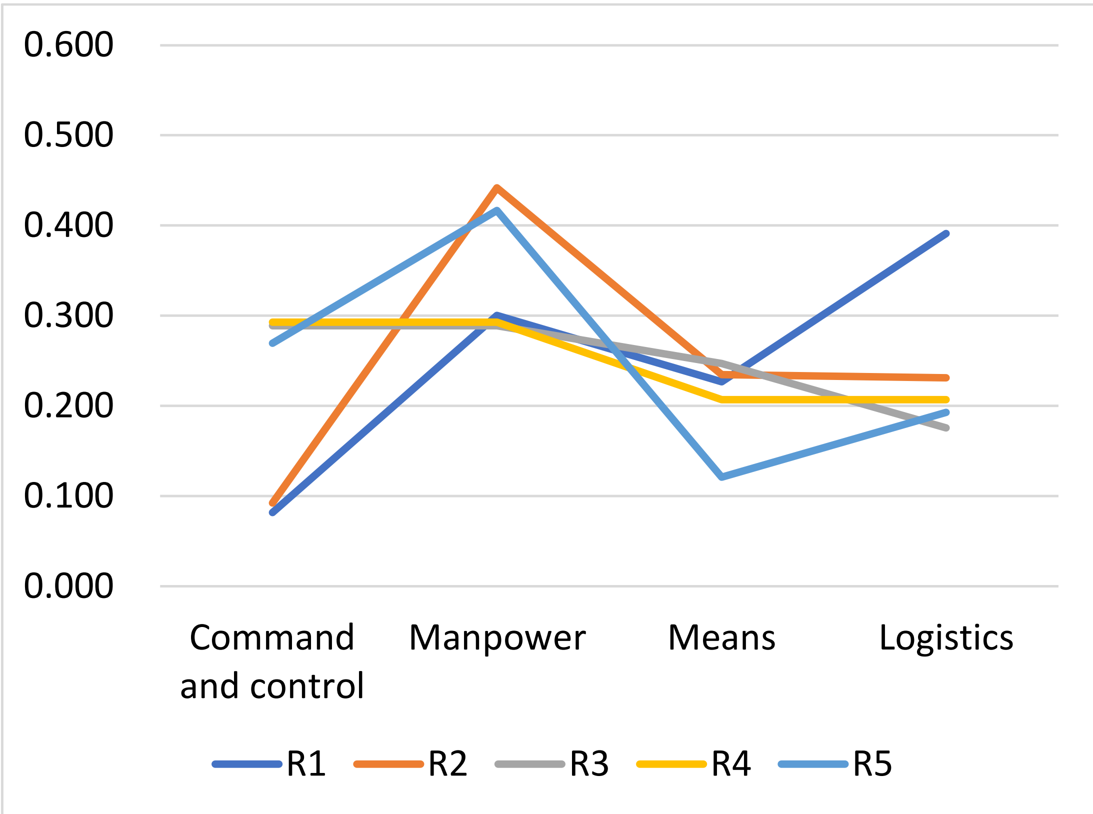


Fig. 3-12b. Decision weights for four elements of emergency management in exercise case 2.

Figure 3-12a and b show the weight pattern of each respondent across the four emergency management elements. For Exercise 1, the weights assigned to the four elements by commanders R1 and R2 are similar. They assigned large weights to logistics and small weights to command and control and means. The answers from the three exercise designers (R3, R4, and R5) did not converge into one pattern; they assigned larger weights to the command and control elements and smaller weights to the logistics element as opposed to that assigned by the commanders. For Exercise 2, the two commanders showed similar weight patterns, which were not significantly different across the three exercise designers, unlike the observations in Exercise 1. The exercise designers assigned larger weights to the command and control elements compared to that assigned by the two commanders. The weight allocations of the respondents, except R3, to the four elements differed between the two exercises. Most respondents thought that important elements of the emergency management protocol should change according to the exercise content.

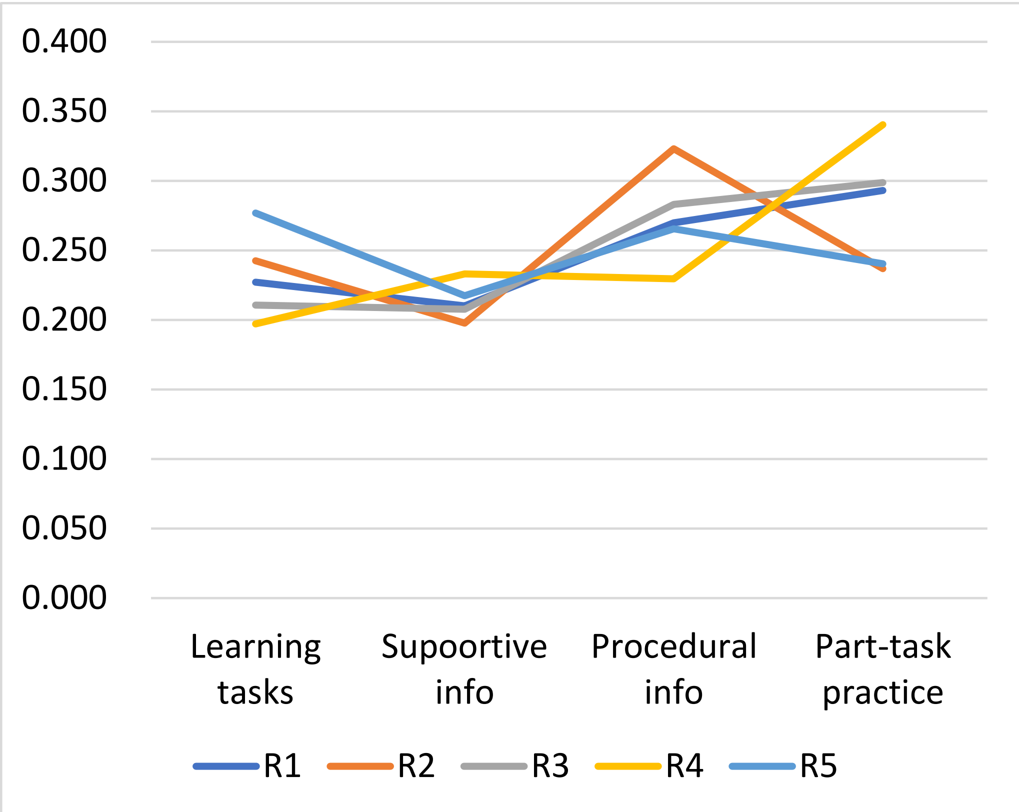


Fig. 3-13a. Decision weights for four components of instructional design in exercise case 1.

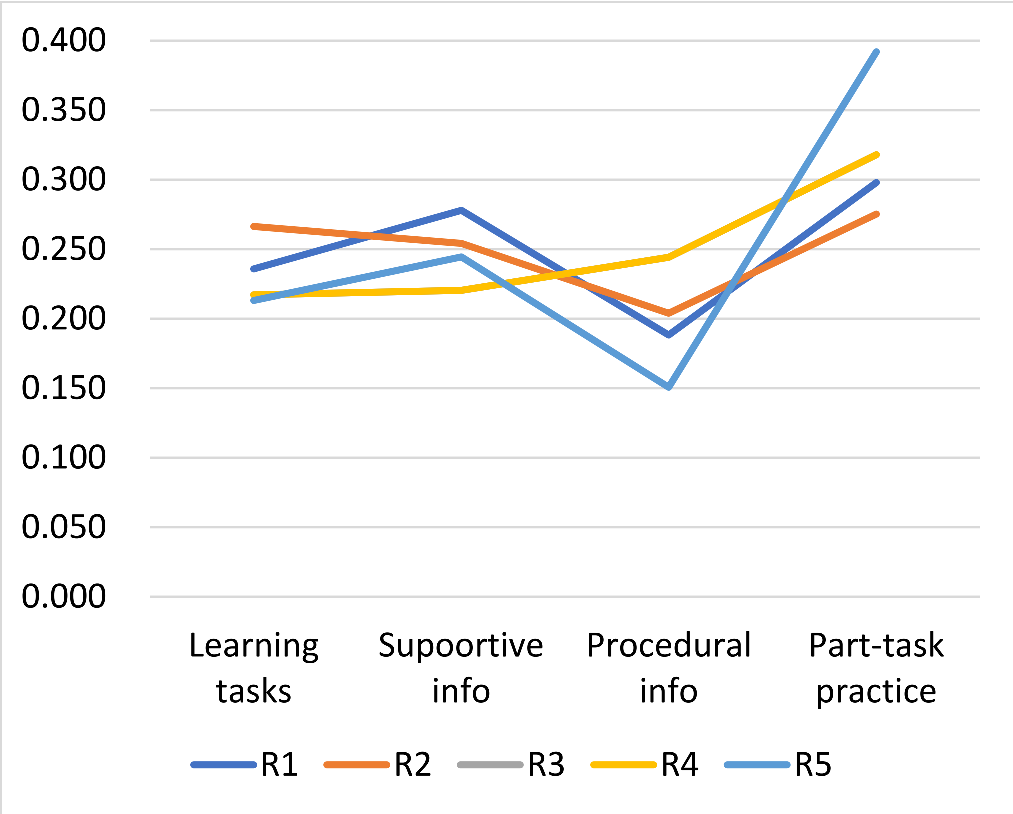


Fig. 3-13b. Decision weights for four components of instructional design in exercise case 2.

Figure 3-13a and b show the weight patterns across the four instructional design components. There were no clear differences between weight patterns assigned by the two commanders and three exercise designers for each exercise. The respondents thought procedural information was important for Exercise 1 but not for Exercise 2. For Exercise 2, part-task practices were thought to be particularly important. Thus, the important components of instructional design changed according to the exercise.

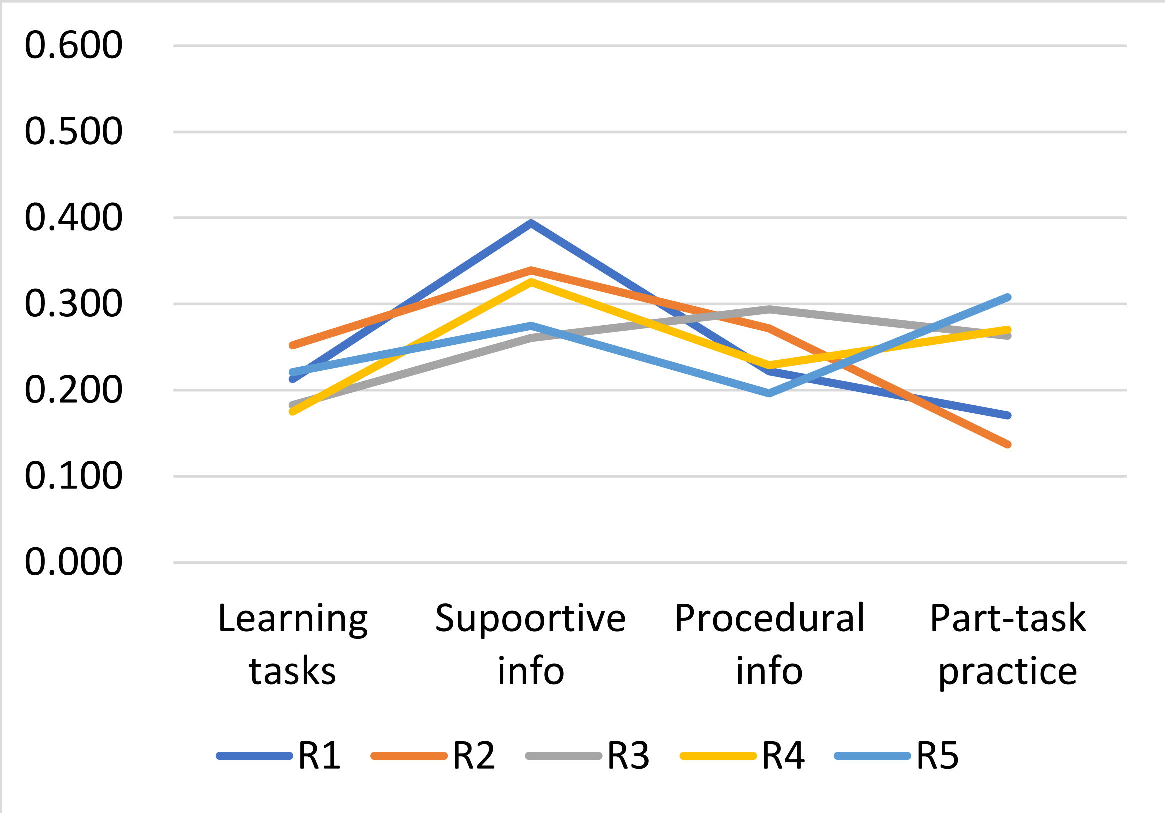


Fig. 3-14a. Decision weights across instructional design components for element of Command and control in the exercise case 1

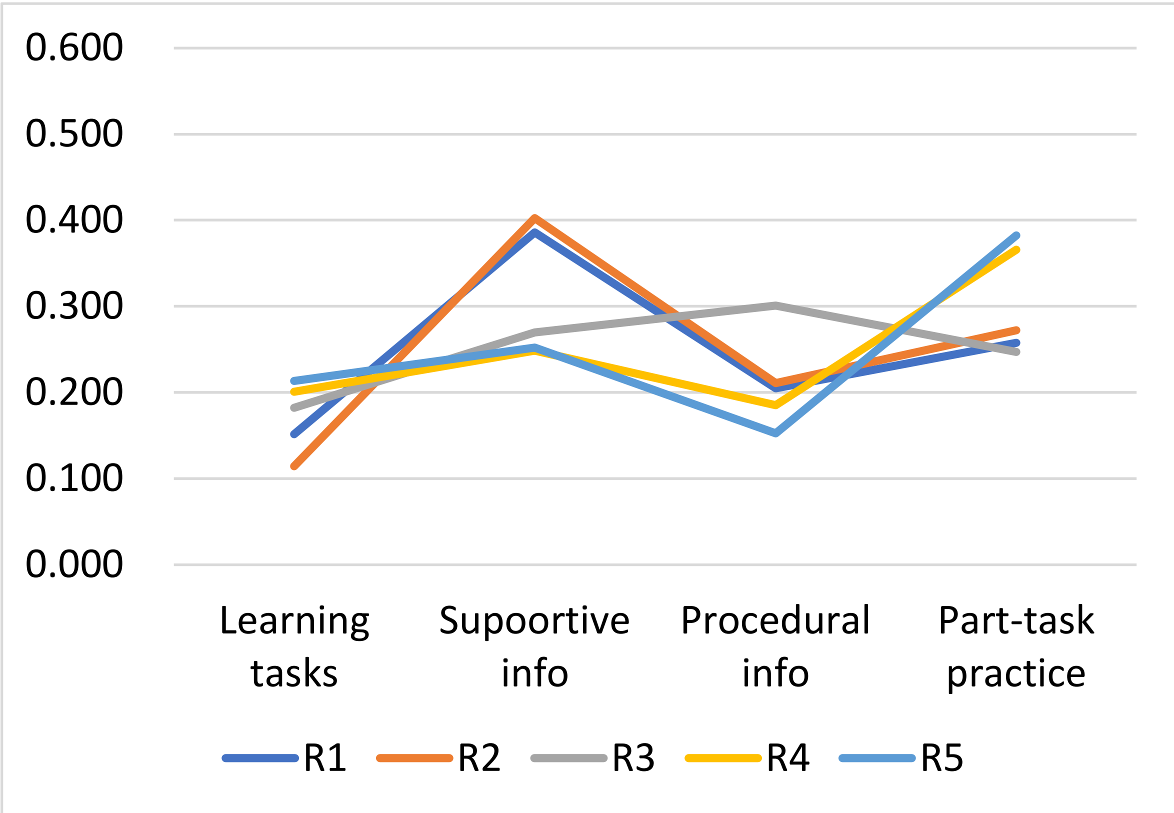


Fig. 3-14b. Decision weights across instructional design components for element of Command and control in the exercise case 2

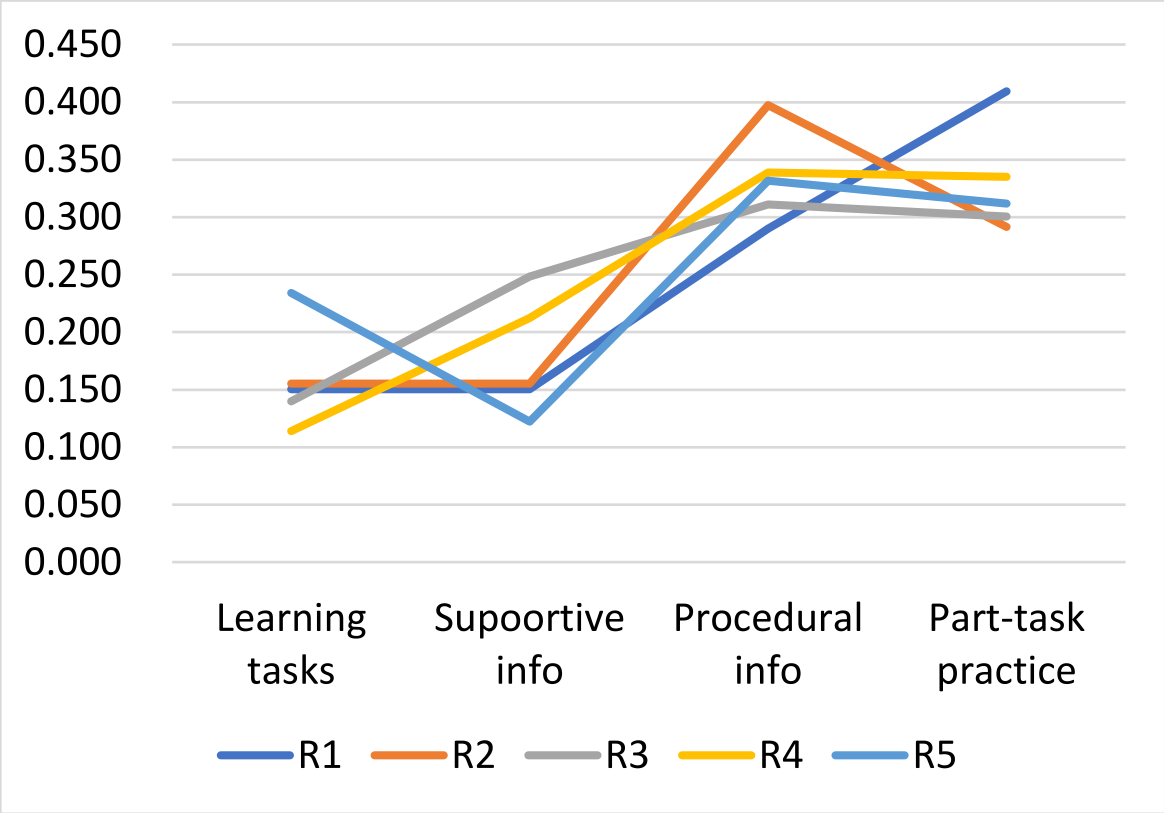


Fig. 3-15a. Decision weights across instructional design components for element of Logistics in the exercise case 1

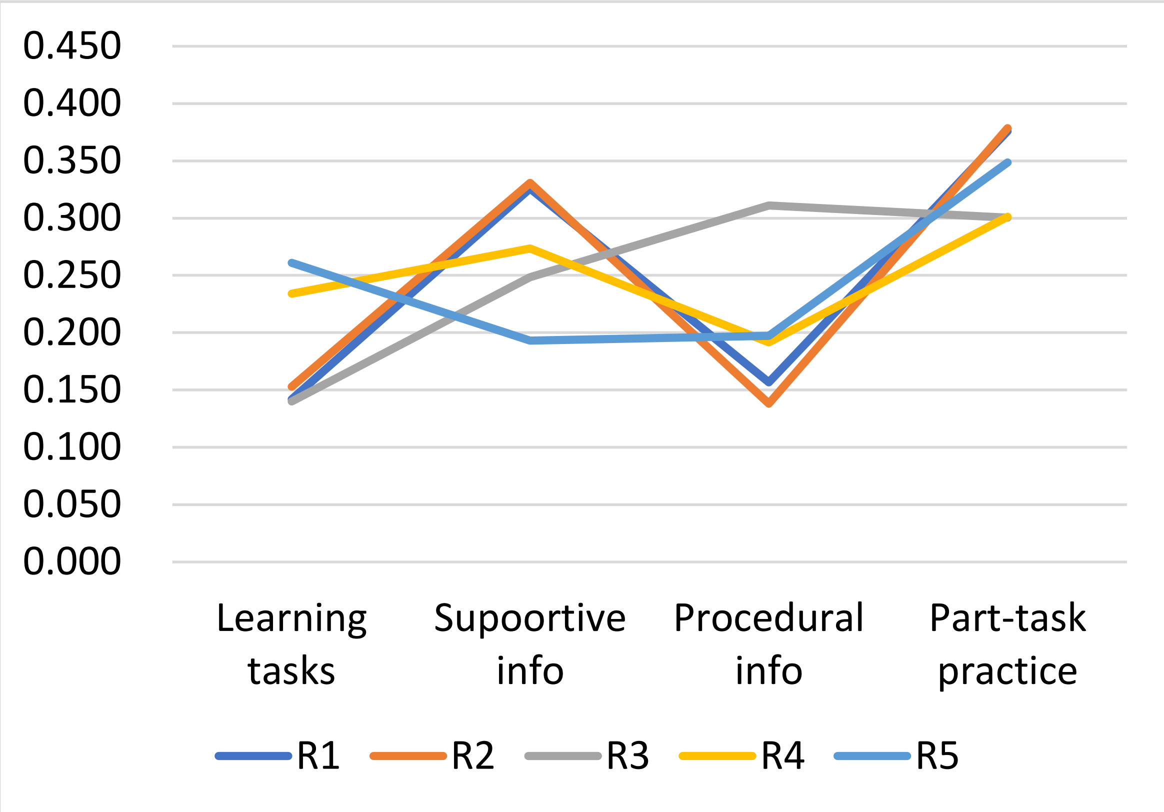


Fig. 3-15b. Decision weights across instructional design components for element of Logistics in the exercise case 2.

We focused on two elements of emergency management, namely, command and control and logistics, and visualized the weight patterns across the four instructional design components (Figure 3.14a and b, Figure 3.15a and b). We observed weight pattern differences between the two exercises for each emergency management element. Therefore, the best method for improving each element of emergency management depends on the type of emergency. These figures showed that two commanders assigned similar weights across the instructional design components in all four panels. The responses of the three exercise designers were more diverse than those of commanders, particularly for Exercise 2.

3.3.2. Cluster analysis

Visual inspection of the graphs in the previous subsections showed distinctive differences in responses between commanders and exercise designers. We conducted hierarchical clustering to consider all the weights shown in Fig. 4 and examined whether this difference existed among the exercise participants. First, we serialized the weight table into a vector of weights for each participant during each exercise. We then applied a hierarchical clustering method to each exercise. The resulting dendrogram is shown in Fig. 3-16.

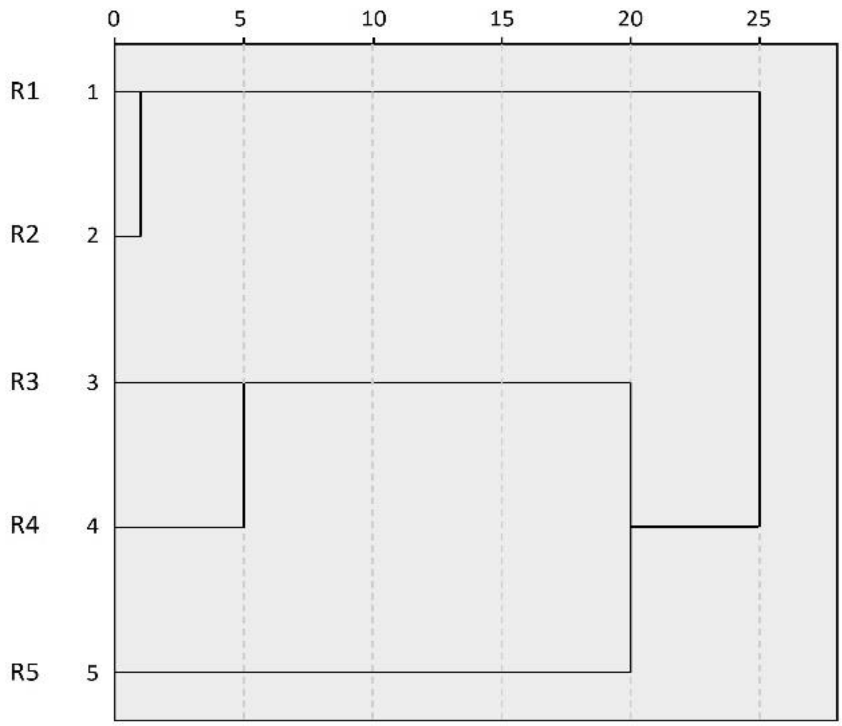


Fig. 3-16a. Cluster analysis of responses regarding exercise case 1.

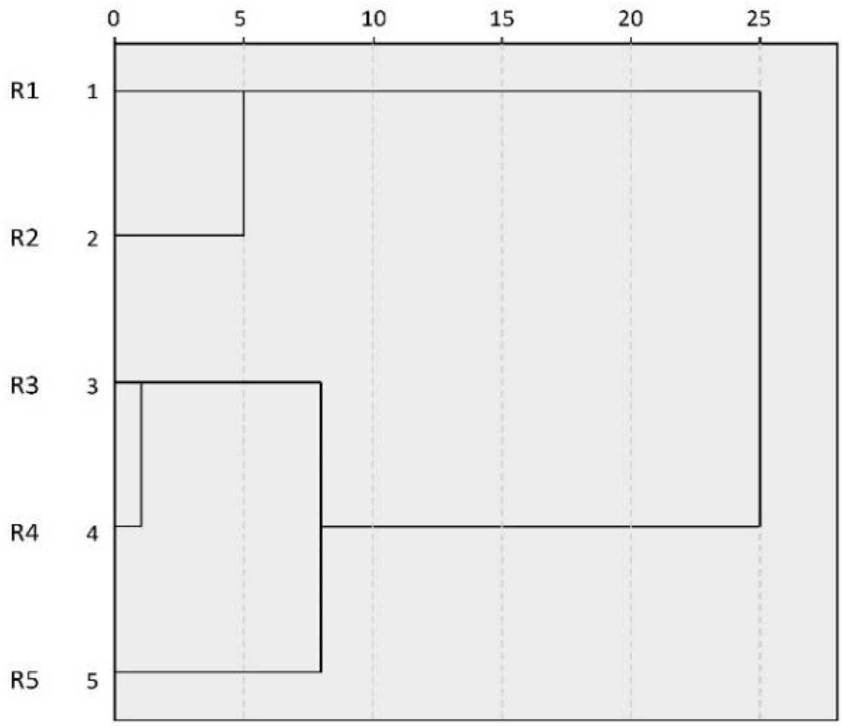


Fig. 3-16b. Cluster analysis of responses regarding exercise case 2.

The two dendrograms in figure 3-16 a and b clearly show the similarity in assigned weights between commanders R1 and R2, because the lines from them converge at an early stage. The dendrograms also show that the weight patterns are different between the two commanders and the three exercise designers, because the lines from these two groups do not converge until the last stage. Thus, the cluster analysis results confirmed that the two commanders thought differently than the three exercise designers did.

3.4. Discussion

First, we examined the average weights. Tables 3-11 and 3-12 present the weights averaged across the five respondents for Exercises 1 and 2, respectively. There were similarities in the weight patterns of the emergency management elements between the two exercises. Table 3-13 summarizes these similarities. Among the sub-elements, functional response capacity (E21) had the largest weight in both exercises.

The priority order of the four components of the instructional design differed between the two exercises. For Exercise 1, the priority order was part-task practice > procedural information > learning task > supportive information. However, for Exercise 2, the priority order was part-task practice > supportive information > learning task > procedural information.

We conducted follow-up interviews with the respondents to determine the cause of these patterns. They noted some differences between the two exercises. Exercise 1 was conducted in a newly constructed residential area, and the members of the initial response team were newly trained and not yet skilled in many tasks. Exercise 2 was performed in a traditional market where the participants were sellers and not very focused on the assigned tasks because they cared more about the negative effects on their merchandise. The differences in the capabilities and intentions of the exercise participants were related to the differences in the priority order of the four instructional design components. The average weights can be used to understand the exercises characteristics.

Table 3-12a. Average weights for Exercise 1

				Learning tasks	Supportive info	Procedural info	Part-task practice
Command and control	0.177	**E11**	0.038	0.007	0.009	0.012	0.010
		E12	0.060	0.011	0.018	0.015	0.016
		E13	0.079	0.017	0.027	0.017	0.017
Manpower	0.315	**E21**	0.235	0.087	0.044	0.057	0.048
		E22	0.080	0.015	0.021	0.021	0.023
Means	0.196			0.046	0.041	0.047	0.061
Logistics	0.311			0.047	0.053	0.105	0.106
Total				0.231	0.213	0.274	0.282

Table 3-12b. Average weights for Exercise 2

				Learning tasks	Supportive info	Procedural info	Part-task practice
Command and control	0.205	**E11**	0.052	0.010	0.010	0.012	0.021
		E12	0.071	0.013	0.020	0.013	0.024
		E13	0.082	0.015	0.027	0.019	0.021
Manpower	0.348	**E21**	0.239	0.082	0.038	0.053	0.066
		E22	0.109	0.022	0.021	0.023	0.043
Means	0.207			0.042	0.056	0.046	0.062
Logistics	0.240			0.043	0.068	0.045	0.083
Total				0.228	0.241	0.212	0.320

Table 3-13. Similarities in the priority order of emergency management elements between the two exercises

Category	Priority order
Four elements	Manpower > Logistics > Means > Command and control
Command and control sub-elements	Communication and information capacity (E13) > Basic skills and situation understanding (E12) > Executive capacity (E11)
Manpower sub-elements	Functional response capacity (E21) > Communication capacity (E22)

However, as we have seen in the previous section, the weight patterns were divided into two assemblages: (i) R1 and R2 (commanders), (ii) R3, R4, and R5 (exercise designers). Thus, we could observe a clear distinction in the role of respondent, which is a problem because sharing the same objectives is necessary for effective emergency management (DHS 2020, Saaty 1980). Our method of combining AHP and 4C/ID can identify these gaps among the exercise participants. We then can share information on the gaps with exercise participants and discuss how to share the same exercise objectives.

Table 3-14 summarizes the merits of our method relative to the conventional methods for designing emergency exercises in Vietnam.

Table 3-14. Comparison of exercise design and evaluation methods

Conventional method in Vietnam		**Our method**	
Method	Problems	4C/ID	AHP
- Qualitative consultation with experts	- Cannot identify methods for improvement in a structure manner - Cannot depict differences in ideas among participants	- Can highlight key components of instructional design	- Can identify relative weights across emergency management elements and instructional design components - Allows visual mapping of differences among exercise participants

3.5. Summary

3.5.1. Conclusion

This study proposed a new method for designing emergency exercises in a structure manner using AHP and 4C/ID combined with the Vietnamese emergency management framework of the “four-on-the-spot” motto. We tested this method and confirmed that it could be used to determine exercise objectives and select implementation methods in the absence of predesigned detailed emergency standards. This method was tested with two fire and rescue exercises in Hai Phong and provided useful results to the designers of the exercise programs. The research analysis revealed that the priority orders of the four components of instructional design were different, although the priority orders of the four elements of emergency management were the same between the two exercises. They then can utilize this result to optimize the design content and choose the most appropriate type of exercise to improve the capacity of organizations. This model enables continuous improvements through PDCA cycles (Plan - Do - Check - Act) including design upgrades. The application of the AHP model is highly feasible for analyzing expert responses. The AHP model is flexible and easily customizable to other types of exercises. Thus, the integration of the conventional qualitative approach with our quantitative approach will enable practitioners to identify the emergency elements to be improved, thereby creating opportunities for the continuous improvement of exercise programs. Evaluation of the effectiveness of emergency management protocols is important for organizations and communities that wish to strengthen their emergency response capacity.

We successfully visualized the differences in the understanding of exercise objectives and the necessary implementation methods among exercise participants. We found a clear distinction between the exercise commanders and designers. Thus, our method can contribute to strengthening the exercise design in different situations. The introduced method does not require pre-specified emergency management standards and can be implemented in both developed and developing countries.

3.5.2 Practical implications

By discovering the priorities in instructional design needs for the two cases, this study can provide planners with useful information to develop follow-up exercises for them. The Cat Bi Apartment Complex has been operating well and management staff have considered referencing this new knowledge for emergency response exercises. However, a sad incident happened to Tam Bac Market. A fire covered the entire premises of this market in early 2023 and burned it down. Up to now, the investigation is still underway, and the Hai Phong city government has decided not to restore commercial activities but instead create a public park.

In addition, we introduced this conceptual model to the Fire and Rescue Division of Hai Phong city, and they also appreciated it. The difference in experts' perception of the need for exercise design is a critical issue and needs to be clarified so that they can improve for many other tasks.

The conceptual model of this study is also expected to contribute to the exercise programs of organizations in general and emergency services in particular. At the same time, we also continue to look for other exercise programs to take advantage of the opportunity to test the effectiveness of this conceptual model.

3.5.3. Limitations and future work

The sub-criteria under the four emergency management elements are not decisive. Depending on the exercise, the sub-criteria can be adjusted for an appropriate evaluation.

The COVID-19 pandemic has hampered many exercises in Vietnam, and we have lost opportunities to test our methods in further diverse conditions. This method is new and hence, needs to be tested for other types of exercises.

4. IMPROVEMENT IN EXERCISE EVALUATION: A CASE STUDY IN JAPAN

4.1. Introduction

4.1.1. Issues of organized responses in disaster medicine in Japan

Municipal governments play a key role in reducing disaster risk in all phases of the emergency management cycle. Thus, enhancing the capabilities of municipal governments is necessary to reduce disaster risks (Kato et al., 2022), (UNISDR, 2017). However, the allowed autonomy levels of municipal governments differ according to the national standardization level of emergency management across countries. As mentioned in chapter 2, Japan uses a local government approach to prepare and operate the core of its emergency responses. Japanese municipalities can autonomously decide their disaster risk reduction framework (Kato et al., 2022). Thus, it is important to construct an effective coordination and cooperation structure for local medical and social service organizations (Hoang et al., 2024).

Japan experiences natural hazards every year, particularly those caused by heavy rain and earthquakes. Medical and social welfare organizations need to respond appropriately to help individuals in need for each time frame, for this, we used the time frame model for disaster medicine created by The Bureau of Social Welfare and Public Health, Tokyo Metropolitan Government (2018), (Yamazoe et al 2022). This model distinguishes between immediate (up to 6 h after a disaster), hyperacute (6–72 h), acute (72 h to 1 week), subacute (1 week to 1 month), chronic (1–3 months), and mid-term (after 3 months) phases. In addition to saving lives in the immediate and hyperacute phases, health deterioration in the acute and later phases has been a critical issue in recent disasters in this country.

In recent decades, various medical and social assistance teams with a range of expertise have been involved in disaster medicine to help survivors with varying individual difficulties in Japan. Maintaining the health of elderly citizens who have survived disasters is becoming more critical as the country continues to age. Damages caused by disasters in general and for the elderly in particular were mentioned at the beginning of chapter 2 of this dissertation. One of the highlighted health issues among elderly evacuees is the decrease in physical activity, and to help tackle this problem, the Japan Disaster Rehabilitation Assistance Teams have been organized (Sannomiya, 2017).

Disaster Psychiatric Assistance Teams are another example of the newly introduced expert teams (Takagi et al 2021).

The report by the Kumamoto Prefectural Government showed that individual houses (39.6%) and evacuation shelters (5.1%) were major places of later-phase deaths other than medical facilities (Kumamoto Prefecture Government, 2018). Medical activities need to cover not only medical facilities but also official and unofficial evacuation shelters and individual houses. This increases the burden on medical support teams. Thus, coordination and cooperation between medical and social service organizations with a variety of expertise are key to effectively maintaining the health of disaster survivors.

The city of Kitakyushu, located in western Japan, is a city with an aging population, wherein more than 30% of its 950,000 citizens are aged ≥65 years old. Although this city has not been affected by large disasters for more than 50 years, several are potentially vulnerable to natural hazards. The city established the Disaster Medical Operation Center (DMOC) framework in 2014 under the initiative of the Kitakyushu Medical Association and other relevant organizations. The DMOC headquarters are initiated under the supervision of the Kitakyushu City Government Emergency Operation Center (EOC) in the event of a significant natural or manmade hazard. The DMOC is tasked as the Health Emergency Operation Center (H-EOC) for the Kitakyushu area, and as an important part of its operation, the DMOC provides the emergency medical team coordination function that was defined by WHO (2021). The DMOC headquarters are located at Kitakyushu City Yahata Hospital, and the DMOC oversees disaster medicine activities in the Kitakyushu area. The DMOC works as a hub for collecting and distributing information concerning medical needs, resources, and commands and dispatches medical staff, including supporters from other regions to hospitals and evacuation shelters where they are needed during a disaster. The main objective of the center is to seamlessly organize medical activities to reduce health impacts from the moment of the disaster until the subacute phase. Because reinforcement and support from the central government and public and private organizations from outside the disaster-affected area are expected one week after a disaster, operation until the end of the acute phase is particularly important for the DMOC. This study aimed to introduce a novel exercise method for enhancing communication effectiveness between the functional groups of the DMOC and various organizations that work with the DMOC.

Table 4-1. Composition structure of DMOC (Kitakyushu City Hospital Organization, 2016)

	Group Leader (Medical Association)	**Sub-Leader**	
		Medical Associations	**City (Liaison)**
Correspondence Adjustment	Managing Director	Director of Accounting	Fire Department
News	Director of Public Relations	Deputy Director of Public Relations	
Finances	Director of Accounting	Managing Director	Department of Health and Human Services
Assets	Director of Medical Safety	Director of Regional Health Care	Department of Health and Human Services
Assistance	Director of Regional Health Care	Director of Medical Safety	Department of Health and Human Services

4.1.2. Functional exercises

During disasters, hospitals and medical groups implement extension tasks based on daily activities. Enhancing coordination across organizations contributes to removing communication barriers (To et al., 2019). Moreover, as major incidents in emergency medical services do not occur frequently, organizations and staff need to practice procedures and skills before these events to improve preparedness (Skryabina et al., 2017). As proxies for actual emergencies, drills and exercises can raise awareness, stimulate improvements in planning and training, and provide opportunities to examine how different public health system components respond to challenges (Savoia et al., 2010).

The standard training program mentioned in HSEEP by the US Department of Homeland Security includes seven types of exercises across two categories. Discussion-based exercises include seminars, workshops, tabletop activities and games. Operation-based exercises include drill, functional, and full-scale exercises (DHS 2020). Among these, functional exercises are most suitable for improving interagency coordination, clarifying roles and responsibilities, and identifying problems in emergency management plans (Militello et al., 2007).

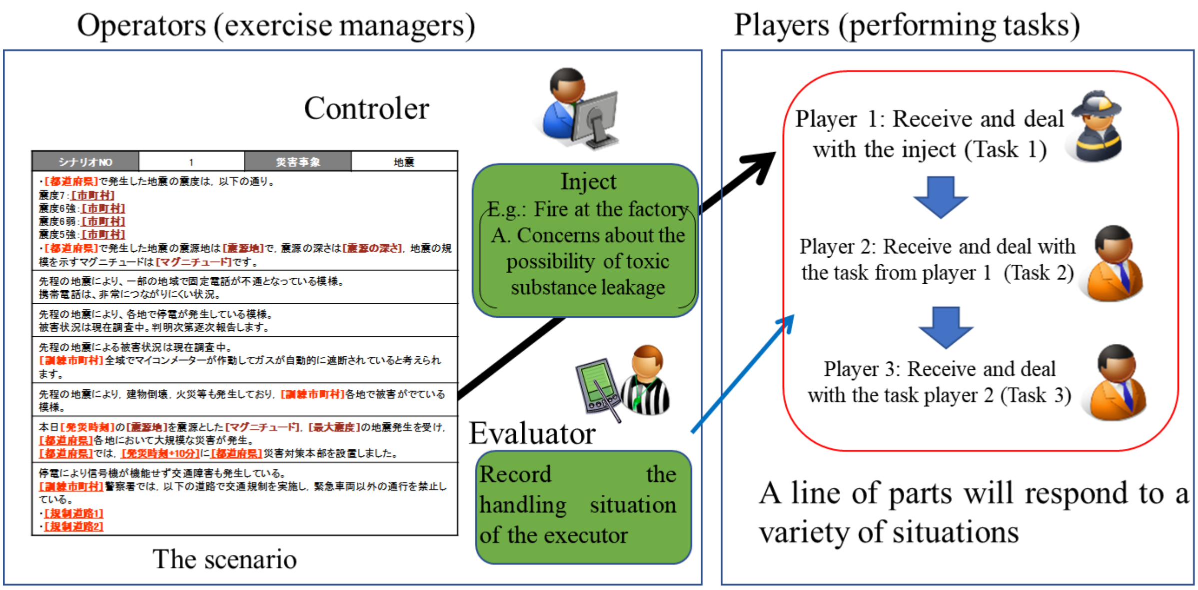


Fig. 4-1. A simple model of a functional exercise

Functional exercises do not involve the deployment of resources. Instead of deploying assets and personnel, functional exercises employ a high degree of simulation to drive decision-making by agency command staff (Obaid et at, 2017). In a functional exercise, a series of simulated emergency events, or "exercise injects," are provided to exercise participants, or "players," and together, they find solutions to the problems specified in these injects (Phelps, 2011). One of the main benefits of a functional exercise is to see how participants respond to reality-based injects (Johnson et al 2009). Moreover, this type of exercise helps to evaluate the current capabilities of medical stakeholders in emergencies that are difficult to observe in detail during an actual disaster (Savoia, 2014).

Several functional exercises have been developed for emergency medical operations. The Emergo Train System is a well-known real-time simulation exercise for immediate and hyperacute situations involving both natural and human-made hazards. Our exercise can be applied not only to the hyperacute phase but also to the later phases.

4.1.3. Evaluation of functional exercise results

According to a review of disaster preparedness exercise evaluation, academic research on this issue is limited (Beerens et al., 2016). Thus, it is necessary to consider both practical and academic documents to understand the existing ideas regarding exercise evaluation. The Exercise Evaluation chapter of the HSEEP doctrine highlights a comparison between “what was supposed to happen based on current plans, policies, and procedures” and realized exercise players’ actions (DHS, 2020). Identifying the gaps between planned and actual actions helps to identify problems with current plans and other emergency management documents. Some academic studies have focused on the specific aspects of emergency management that can affect the effectiveness of disaster response activities. For example, Laurila-Pant et al. (2023) analyzed how shared situational awareness develops among exercise players. This study focuses on the evaluation of emergency operation plans.

Various methods have been used to collect data to evaluate functional exercises. We agree on the importance of synthesizing both qualitative and quantitative information to understand players’ actions and the reasons for those actions from multiple perspectives, such as studies of Taninobu and Kohriyama (2011) about task-process chain and To et al. (2019) which developed systematic time-tracking evaluation frameworks that can be applied to general forms of functional exercises. This method first applies the work breakdown structure (WBS) to find the “tasks” to be carried out by each player group to respond to exercise injects. Many tasks consist of receiving information requests from another group, processing the information or requests, and sending results to another group. Player groups must appropriately complete a series of tasks to answer the exercise questions. This series of decisions based on information can be described as a process of direction and coordination involving multiple organizations. Thus, the chain of expected tasks and responsible player groups was specified for each exercise inject before the exercise. The actual responses for each task performed by the player groups were compared to the expected task responses. The differences between the expected and actual task responses as well as the time required to complete the tasks were considered when evaluating the effectiveness of the emergency plans. However, these methods do not fully utilize information on player response times to evaluate the effectiveness of emergency plans. This time-tracking evaluation method, with a task-processing chain framework, was adopted in this study.

4.1.4. Chapter objectives

This chapter aims to improve the joint emergency operation capabilities of various medical and welfare service groups through functional exercises using a systematic time-tracking method. In this functional exercise, the players complete various communication and decision-making tasks. This study has two objectives.

1. To measure communication and task processing performance and to compare different types of groups and emergency response phases.

2. To identify the causes of unfinished tasks and find solutions for improving emergency operations. We intended to identify differences in the players' communication responses within the DMOC groups as well as between the DMOC and other groups. We also focused on differences across individual groups with similar medical roles.

Most of the information in this chapter is due to Hoang et al. (2024)

4.2. Methods

4.2.1. The DMOC Exercise

We used the data recorded during the two-hour DMOC exercise on July 20, 2019. Kitakyushu City Yahata Hospital provided a place for the exercise. The exercise examined the responses to a citywide storm disaster and was divided into two main phases corresponding to hyperacute (6–72 h) and acute (72 h to 1 week) situations, called Phase 1 and Phase 2, respectively. A total of ninety players and thirteen staff members participated in the exercise program. Table 1 presents the main groups and their IDs. DMOC had "Coordination," "Shelter," "Goods and Relief," and "On-site/disaster base" groups and arranged communication with corresponding organizations. The "On-site/disaster bases" mean field hospitals in the disaster area. Local medical associations are groups of organizations that brought together hospitals, clinics, and health service facilities for both the public and private sectors of the administrative wards in Kitakyushu City, including Moji, Kokura, Yahata, Tobata, and Wakamatsu. Special-purpose medical teams are organizations and professional services related to pharmacology, nursing, etc., in Kitakyushu City and Fukuoka Prefecture.

Table 4-2. Player groups

Group types	Player groups	Code
DMOC	DMOC Coordination Group	SS01
	DMOC Shelter Group	SS04
	DMOC Goods and Relief Group	SS05
	DMOC On-site/Disaster Base Group	SS08
Local medical association	Moji Ward Medical Association	SS31
	Kokura Medical Association	SS32
	Tobata Ward Medical Association	SS33
	Yahata Medical Association	SS34
	Wakamatsu Ward Medical Association	SS35
Special purpose medical teams	Pharmacists Association	SS17
	Home nursing station	SS18
	Dialysis Physicians Association	SS36
	Dentist Association	SS37
	Japan Disaster Rehabilitation Assistance Team (JRAT)	SS38
	Fukuoka Prefecture Nurse Association	SS39

Fig. 4-2. An activity in the DMOC exercise 2019.

Source: Kitakyushu City Yahata Hospital

4.2.2. Time tracking procedure

A systematic time-tracking evaluation method was employed to record and evaluate players' responses to exercise injects. For each inject, exercise designers prepared a chain of expected tasks, and exercise evaluators recorded whether the player groups completed the expected tasks. The evaluators observed the team members' actions, listened to their conversations, and used Infogram Inc.'s Exercise Evaluation System to record the player groups' responses and the time spent on each task. In the latter part of this study, we use the group IDs and task types listed in Tables 4-1 and 4-2.

The original exercise plan had thirty-five injects with 129 expected tasks, and forty-two injects with 135 expected tasks in Phases 1 and 2, respectively. Three tasks associated with two injects in Phase 1 and one task with one inject in Phase 2 were removed from this analysis due to a lack of time records, possibly because of a measurement failure. These expected tasks were categorized as shown in Table 2. However, not all expected tasks could be performed; as such the analysis will focus on the tasks selected by players to respond, called "started tasks." The execution time of each task was recorded using Infogram Inc.'s Exercise Evaluation System and was measured from the moment the player group received information from the controller or from the preceding player group in the task-processing chain. Those that took more than 20 minutes were considered incomplete tasks. When a preceding group in a task-processing chain does not complete its responsible task, the following groups in the chain cannot start processing their expected tasks. These were labeled non-started tasks. A threshold of 20 min is the provisional deadline. The actual processing time should vary depending on the urgency and difficulty of the task. However, we currently do not have sufficient information to customize the boundary time for different task types. The 20-minute threshold may be too relaxed because the total legitimate processing time for a task-processing chain involving three consecutive tasks can accumulate up to one hour. Although the provisional time threshold was necessary to demonstrate the capability of our time-tracking evaluation method, we agree that there is room for improvement in the threshold time specification.

In the task-processing chain that spans multiple player groups, the first group deals with Stage 1 tasks, and the second and the third groups deal with Stage 2 and Stage 3 tasks, respectively. Although longer task-processing chains were possible, we were able to follow the sequence up to Stage 3 for technical reasons. Figure 4-3 shows an example of the task-processing chain and the time measurement results for Inject 57 in Phase 1. In the first stage, the Yahata Medical Association (SS34) was provided with the inject and was expected to send a request to the DMOC shelter group (SS04) about daily life support needs. All the five expected tasks were completed. Note that the responses of the three groups at the right end of the task-processing chain were beyond the scope of evaluation in this example. In the example shown in Figure 4-3, all tasks were performed within 20 min and are connected by bold lines.

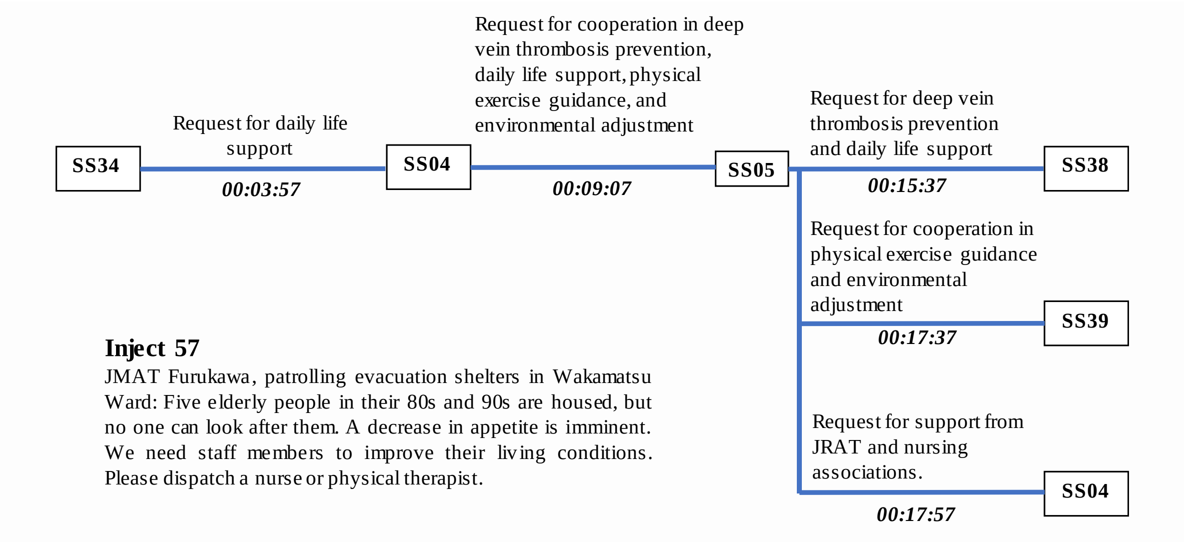


Fig. 4-3. Task processing-chain of Inject 57 with the actual execution time of completed tasks

Table 4-3. Expected tasks by type

Categories	Objectives	Task types	Code	Number of tasks	
				Phase 1	**Phase 2**
Operation of disaster control headquarters	Operation and management of the headquarters	Grasping damage conditions	001	3	14
		Establishment of the headquarters	003	25	0
		Closure of the headquarters	005	0	1
	Request for assistance	Support collaboration with other organizations	016	0	5
Evacuation response	Operation and management of shelters	Shelter health management	037	5	28
	Response to emergency and relief supplies	Establishment of supply structures	041	0	14
		Supply arrangements	044	19	32
Disaster response	On-site support	Establishment of an on-site task force, etc., and determination of the necessity of support	050	13	13
		On-site determination of activity policy, place of activity, personnel, etc.	052	0	2
	Securing a place for emergency transfer	Management of transporter and destination	056	54	19

Public facility management support	Response of public facilities under jurisdiction	Grasping and reporting the damage status of facilities under each jurisdiction	058	1	0
Support for survivors	Health care for residents	Determination of health management implementation system and method	077	6	3
	Operation and management of the quarantine system	Determination of epidemic prevention implementation system and method	087	0	3
Total	-	-	-	126	134

4.3. Results

4.3.1. Overall performance

Because some of the injects were provided with alternative task-processing chains when detailed procedures were not defined in the emergency plan, many expected tasks were not conducted by the players because they did not choose the alternative chain. Also, failure to complete a task prevented the initiation of subsequent tasks within the same task sequence. Thus, ninety-seven tasks (out of 126 tasks in Phase 1) and 110 tasks (out of 134 tasks in Phase 2) were started, and the number of completed tasks in the two phases was 60 and 75, respectively, as described in Table 4-3.

Table 4-4. Inject and task completion by exercise phases

	Completed injects/total injects	Completed task/started tasks
Phase 1	30/33	60/97
Phase 2	39/41	75/110

Figure 4-4 shows the status of task completion. If the first stage task of an inject was not completed, the second and third stage tasks did not begin.

Similarly, a failure in a second-stage task causes the subsequent third-stage tasks not to initiate. These are also counted as an uncompleted inject. As shown in the figure, in Phase 1, completed tasks were found in Stage 1 (47 completed out of fifty-nine started tasks), whereas uncompleted tasks were largely found in Stage 2 (22 of 34 started tasks). A comparable situation also occurred in Phase 2, showing a decreasing trend in the number of completed tasks as the stages progressed.

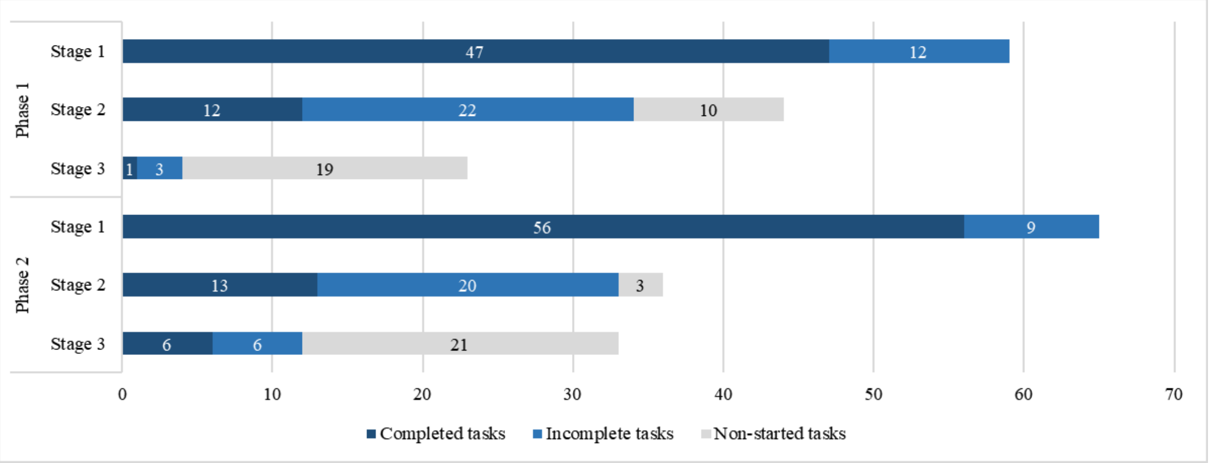


Fig. 4-4. Number of tasks by stage

Figure 4-5 shows the status of completed tasks by type, including average measured execution times and completion percentages, which were calculated by the ratio between the number of completed tasks divided by the number of expected tasks as listed in Table 2. For example, task type 003 was one of the most performed tasks in Phase 1, with eighteen completed among twenty-five expected tasks but required a relatively small average execution time compared to the others. Task type 077 appeared rarely with six expected tasks. Among them, two were completed but had the longest average execution time of 934.5 seconds. This suggests that player groups chose to communicate as simply as possible to deal with the many expected tasks in Phase 1 as their strategy. In Phase 2, the average execution times were distributed evenly across task types, although their frequency of occurrence remained uneven. Task type 044 was executed the most frequently in Phase 2, with seventeen tasks completed, whereas task types 077 and 087 had only one task. Note that some task types did not exist in each phase, including Types 005, 016, 041, 052, and 087 in Phase 1 and Types 003, and 058 in Phase 2. None of Type 001 in Phase 1 or Type 005 in Phase 2 tasks were started; thus, these types are absent in this figure.

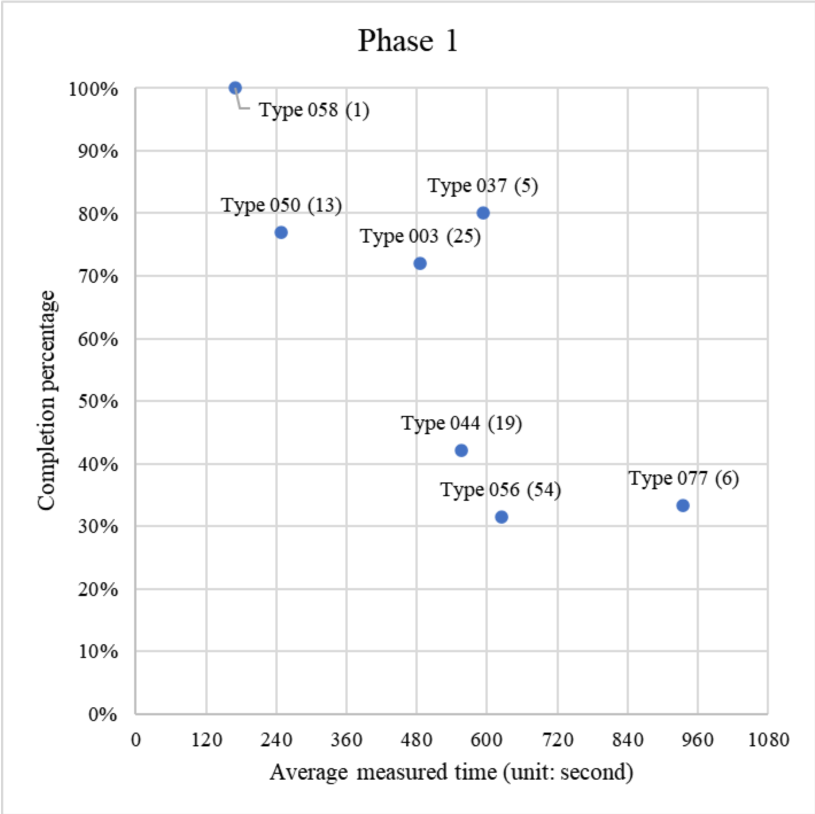


Fig. 4-5a. Average execution time and completion percentage by task type in Phase 1 (Number of expected tasks in parenthesis)

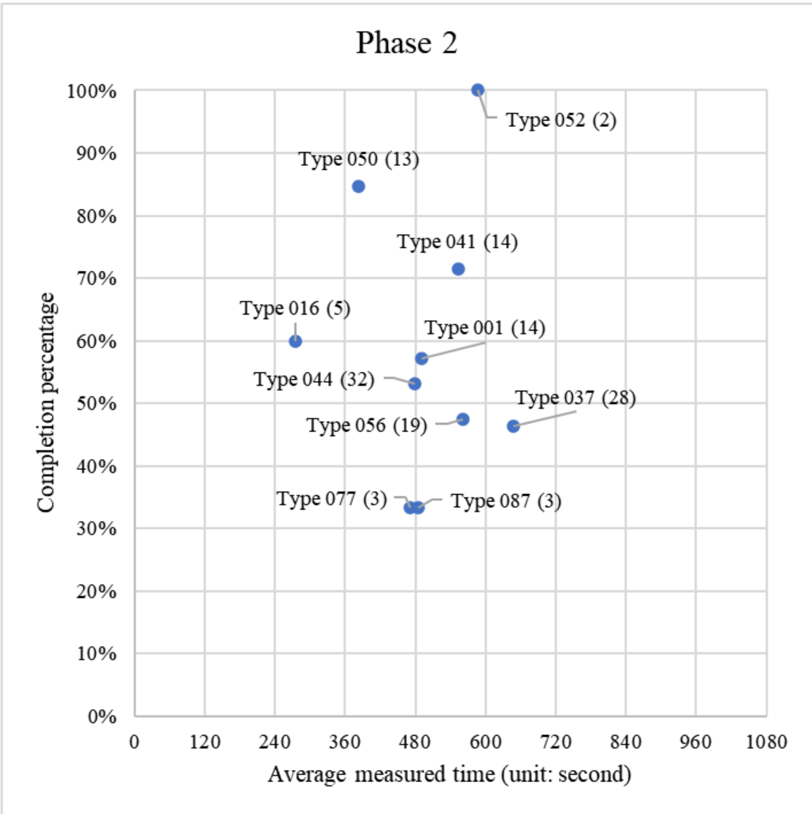


Fig. 4-5b. Average execution time and completion percentage by task type in Phase 2 (Number of expected tasks in parenthesis)

Several tasks were not executed, resulting in a series of non-started tasks in the latter part of the same task-processing chain. Figure 4-6 depicts Inject 27 of Phase 1 with three Type 001 tasks. Player SS01 did not complete the two tasks within 20 min of receiving the inject. The dashed line in Stage 2 represents a non-started task.

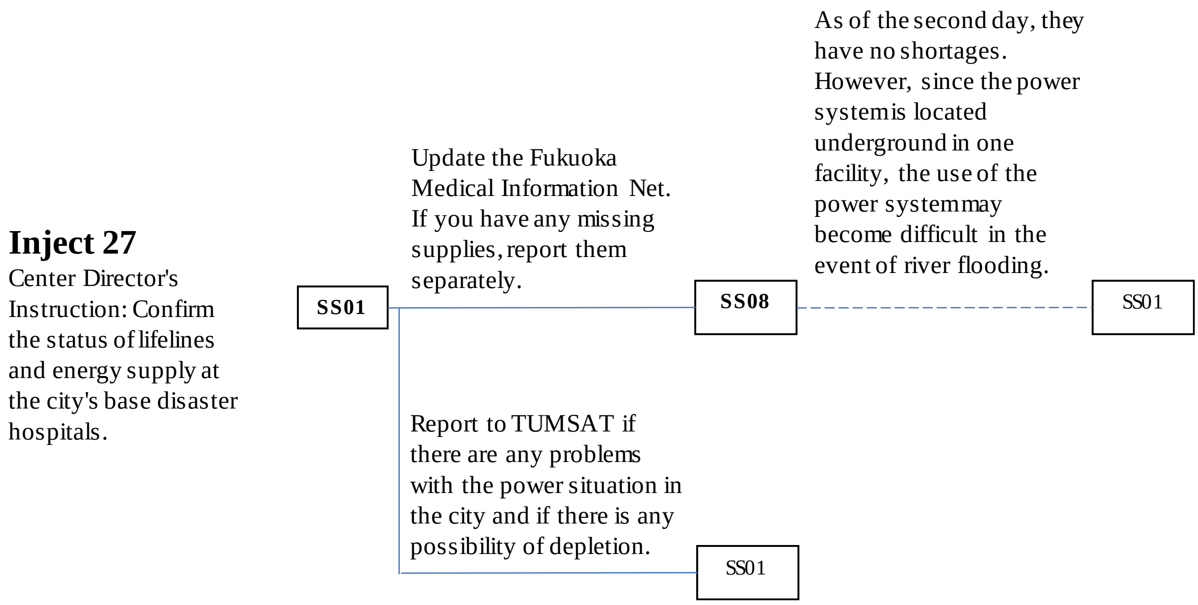


Fig. 4-6. Task processing-chain of Inject 27 with two incomplete and one non-started Type 001 tasks

4.3.2. Characterizing individual player groups

Figure 4-7 shows that in Phase 1, SS01, SS08, and SS04 began many of the expected tasks. All players were in DMOC, and the other players were assigned fewer tasks than in SS01. The number of completed tasks is proportional to the initial number of started tasks. The slope of the fitted blue line shows that approximately 67% of the started tasks were completed, on average, by the player groups. The performance of SS04 was significantly lower than the average. In Phase 2, the leading roles were assumed to be SS05 and SS04. The remaining participants performed a limited number of tasks. The fitted straight line shows that on average, approximately 56% of the started tasks were completed. This number was smaller than that in Phase 1. Again, SS04 failed to achieve the average performance level.

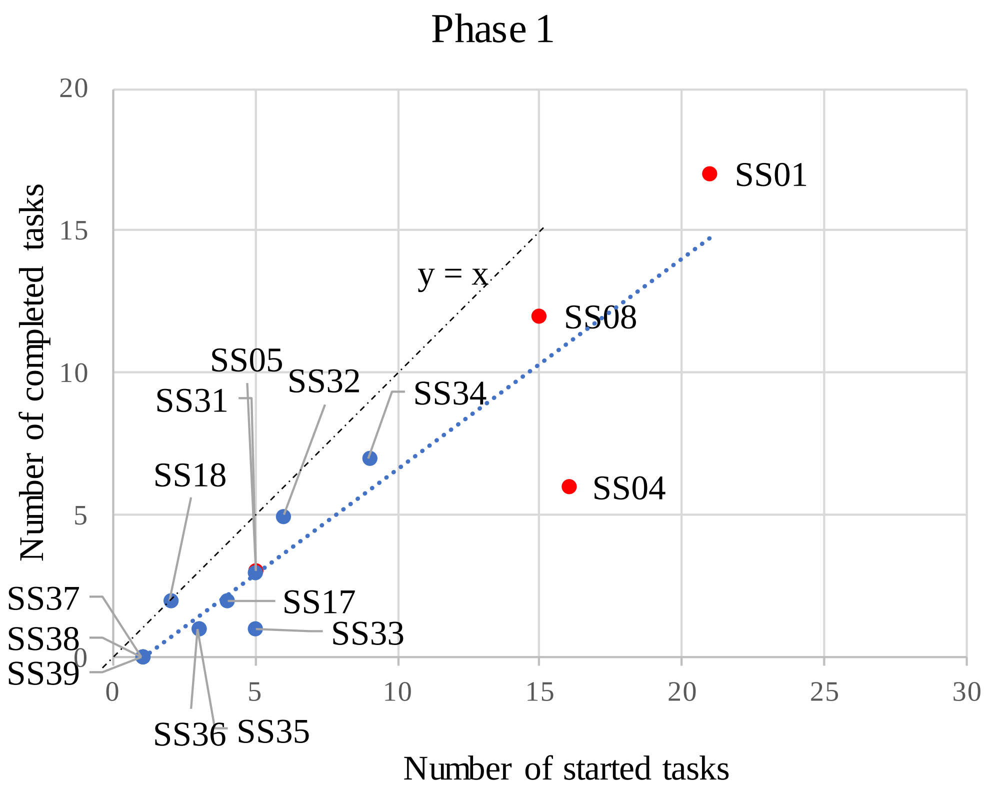


Fig. 4-7a. Task completion ratios by player group in Phase 1

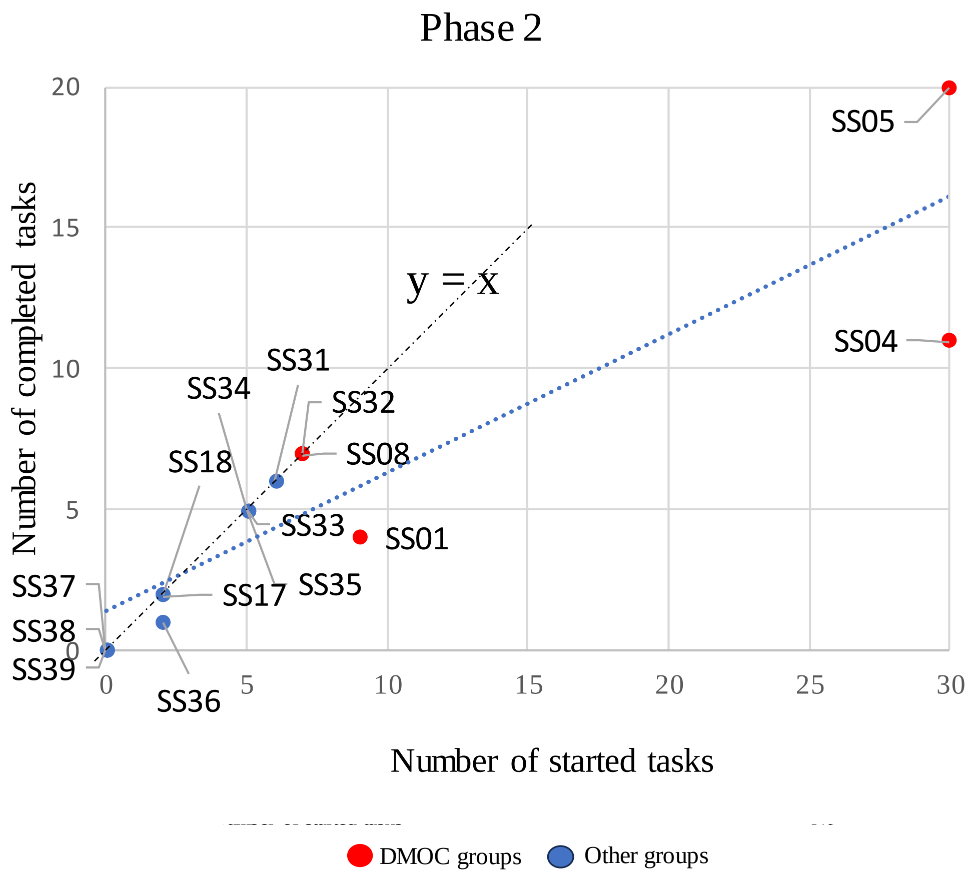


Fig. 4-7b. Task completion ratios by player group in Phase 2

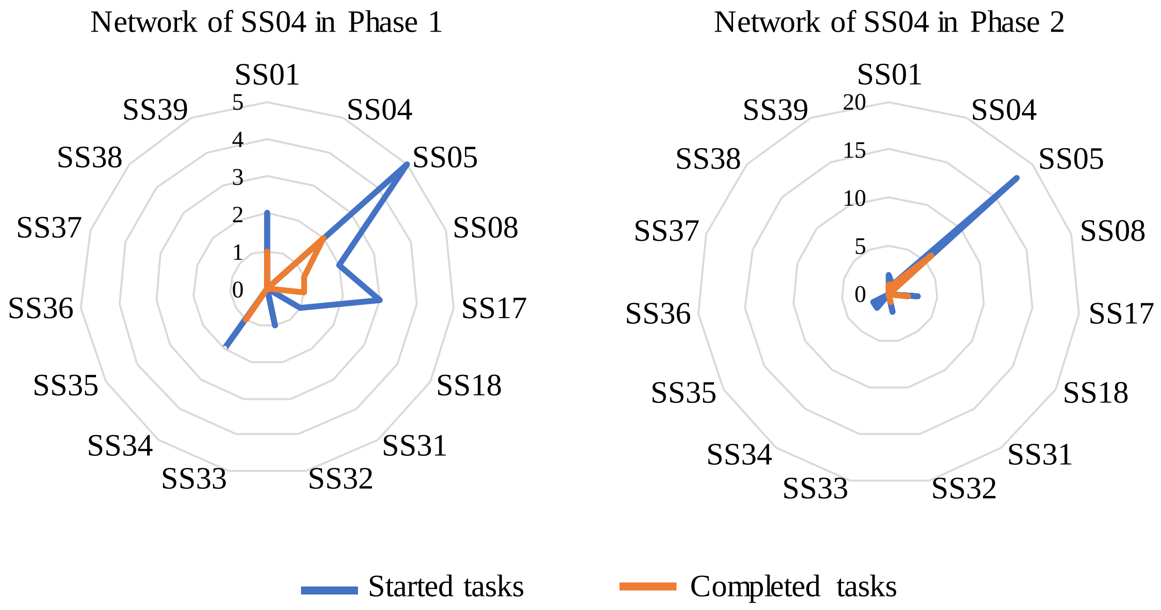


Fig. 4-8. Communication pairs of SS04

Figure 4-8 summarizes the communication pairs of SS04. The blue series shows the number of started tasks, and the orange series represents the number of completed tasks. The number of completed tasks was significantly lower than expected. SS04 had strong connections with SS05 in both phases. The incomplete tasks of SS04 occurred in communication with SS05 and SS17 in Phase 1 and in communication with SS05 in Phase 2.

Tables 4-4 and 4-5 summarize the completion ratios according to task type for each player group and the number of tasks started, respectively. The table shows the weaknesses of the players according to task type. The lower the completion rate, the higher the need to improve the player's ability. In Phase 1, many players were unable to complete the Type 003 task. Among the local medical associations, SS34 performed better than the other medical associations for this task type. However, they did not perform well on the Type 056 task. In Phase 2, all medical associations completed all tasks well. SS04 should have improved their ability to perform the Type 077 task (determination of health management) because they did not complete this task in either phase.

Table 4-5. Completion rate by task type in Phase 1

Player		SS01	SS04	SS05	SS08	SS17	SS18	SS31	SS32	SS33	SS34	SS35	SS36	SS37	SS38	SS39
Task Type[a]	001	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	003	100%	-	-	100%	100%	-	0%	0%	0%	100%	0%	100%	0%	0%	0%
		14	-	-	1	1	-	1	1	1	1	1	1	1	1	1
	037	-	100%	67%	-	-	-	-	-	-	-	-	-	-	-	-
		-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
	044	-	25%	-	-	33%	-	-	100%	-	75%	-	-	-	-	-
		-	4	-	-	3	-	-	3	-	4	-	-	-	-	-
	050	100%	33%	100%	100%	-	-	-	-	-	100%	-	-	-	-	-
		1	3	1	4	-	-	-	-	-	3	-	-	-	-	-
	056	33%	50%	0%	70%	-	-	75%	100%	25%	0%	50%	0%	-	-	-
		3	4	1	10	-	-	4	2	4	1	2	2	-	-	-
	058	100%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	077	-	0%	-	-	-	100%	-	-	-	-	-	-	-	-	-
		-	3	-	-	-	2	-	-	-	-	-	-	-	-	-

a. The second row of each task type shows the number of task

Table 4-6. Completion rate by task type in Phase 2

Player		SS01	SS04	SS05	SS08	SS17	SS18	SS31	SS32	SS33	SS34	SS35	SS36	SS37	SS38	SS39
Task Type[a]	001	57%	0%	0%	100%	100%	-	-	-	-	-	-	-	-	-	-
		7	1	1	3	1	-	-	-	-	-	-	-	-	-	-
	005	0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	016		67%	-	-	-	-	-	-	-	100%	-	-	-	-	-
			3	-	-	-	-	-	-	-	1	-	-	-	-	-
	037	0%	43%	50%	-	-	100%	100%	100%	100%	-	100%	-	-	-	-
		1	7	4	-	-	1	1	1	3	-	2	-	-	-	-
	041	-	0%	83%	-	-	-	-	-	-	-	-	-	-	-	-
		-	1	12	-	-	-	-	-	-	-	-	-	-	-	-
	044	-	36%	60%	-	100%	-	100%	100%	-	100%	100%	-	-	-	-
		-	11	5	-	1	-	2	4	-	1	2	-	-	-	-
	050	-	50%	100%	-	-	-	100%		100%	100%	-	-	-	-	-
		-	2	4	-	-	-	2		1	3	-	-	-	-	-
	052	-	-	-	100%	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	056	-	33%	25%	100%	-	100%	100%	100%	-	-	100%	50%	-	-	-
		-	3	4	2	-	1	1	1	-	-	1	2	-	-	-
	077	-	0%	-	-	-	-	-	-	100%	-	-	-	-	-	-
		-	1	-	-	-	-	-	-	1	-	-	-	-	-	-
	087	-	100%	-	-	-	-	-	100%	-	-	-	-	-	-	-
		-	1	-	-	-	-	-	1	-	-	-	-	-	-	-

a. The second row of each task type shows the number of tasks

4.3.3. Players' communication responses

4.3.3.1. Comparison between DMOC and other groups

We examined the results for the four types of communication pairs. These included communication within DMOC groups, communication from player groups other than DMOC to DMOC groups, communication from DMOC groups to other groups, and communication between other groups. Table 4-6 summarizes the results.

Fisher's exact test was used to examine whether the number of task completions among the initial tasks differed across the four player pairs. There was no statistically significant difference among the four types in Phase 1 ($p = 0.47$), whereas there was a significant difference in Phase 2 ($p < 0.01$). In Phase 2, the completion rates were lower in communication among the DMOC groups or from other groups to DMOC groups, compared to communication from DMOC to other groups or within other groups. The reason for this can be attributed to SS04's and SS05's number of tasks in Phase 2 for a remarkably high proportion of the total number of started tasks (60 out of 110), and the communication between these two groups accounted for most of the communication of the DMOC groups. Figures 4-5 and 4-7 support this hypothesis.

Table 4-7. Performances by communication pair types

	Phase 1				**Phase 2**			
	Within DMOC	**DMOC to others**	**Others to DMOC**	**Within others**	**Within DMOC**	**DMOC to others**	**Others to DMOC**	**Within others**
Number of tasks (No. of started tasks)	52 (40)	32 (28)	26 (17)	19 (12)	66 (56)	28 (28)	29 (20)	12 (6)
Completion rate ***(completed task/started task)***	65.00%	50.00%	70.59%	66.67%	53.57%	96.43%	60.00%	100.00%
Completion rate equality (Fisher's exact test)	p = 0.47				p < 0.01			
Average execution time of completed tasks (seconds)	507.88	707.79	419.92	319.50	528.00	487.89	642.67	254.17

4.3.3.2. Communication between DMOC groups and local medical associations

Tables 4-7 and 4-8 focus on communication between the DMOC and local medical associations. The exercise monitoring system recorded the players' execution times. Although this exercise did not have an evaluation criterion for the execution time, it showed the effectiveness of communication between player pairs. For example, SS34 exhibited a significantly shorter execution time for communicating with SS04 than the other local medical association groups in both phases.

Table 4-8. Average execution times *(unit: seconds)* and number of completed tasks by the DMOC and local medical associations in Phase 1

		Sent to								
		SS01	**SS04**	**SS05**	**SS08**	**SS31**	**SS32**	**SS33**	**SS34**	**SS35**
Sent from	**SS01**	239.8 4	-	-	376 3	385 1	98 1	221 1	393 1	375 1
	SS04	1167 1	-	754.5 2	835 1	-	-	-	177 1	-
	SS05	-	601.5 2	354 1	-	-	-	-	-	-
	SS08	174 3	-	-	614.2 9	-	-	-	-	-
	SS31	-	830 1	-	-	924 1	-	-	-	-
	SS32	-	697.3 4	-	-	-	398 1	-	-	-
	SS33	-	-	-	-	-	-	-	-	-
	SS34	628 1	289.3 3	-	-	-	-	-	149 1	
	SS35	-	704 1	-	-	-	-	-	-	-

Table 4-9. Average execution times *(unit: seconds)* and number of completed tasks by the DMOC and local medical associations in Phase 2

		Sent to								
		SS01	SS04	SS05	SS08	SS31	SS32	SS33	SS34	SS35
Sent from	SS01	-	-	56	982.3	-	-	-	-	-
		-	-	1	3	-	-	-	-	-
	SS04	1597	178	557	-	-	193	-	-	-
		1	1	6	-	-	1	-	-	-
	SS05	266	569.5	89.7	622	772	789	889	740	813
		1	6	3	1	1	1	1	1	1
	SS08	132.7	-	870	626	-	-	-	-	-
		3	-	1	3	-	-	-	-	-
	SS31	-	272.3	-	-	570	-	-	-	-
		-	4	-	-	1	-	-	-	-
	SS32	-	791.7	-	-	-	175	-	-	-
		-	6	-	-	-	1	-	-	-
	SS33	-	531.5	-	-	-	-	447	-	-
		-	4	-	-	-	-	1	-	-
	SS34	-	225.3	-	-	-	-	-	-	-
		-	4	-	-	-	-	-	-	-
	SS35	-	432	-	-	-	-	-	-	128
		-	4	-	-	-	-	-	-	1

This exercise enabled comparisons across local medical associations by providing injects similar to the player groups. Figure 4-9 shows the expected and completed task processing chains for Injects 23 and 31. Similar exercise injects were provided to local associations SS35 and SS31 who were expected to communicate with the DMOC's SS04. However, SS35 completed the task in 11 min 44 s, whereas SS31 did not complete the task at all.

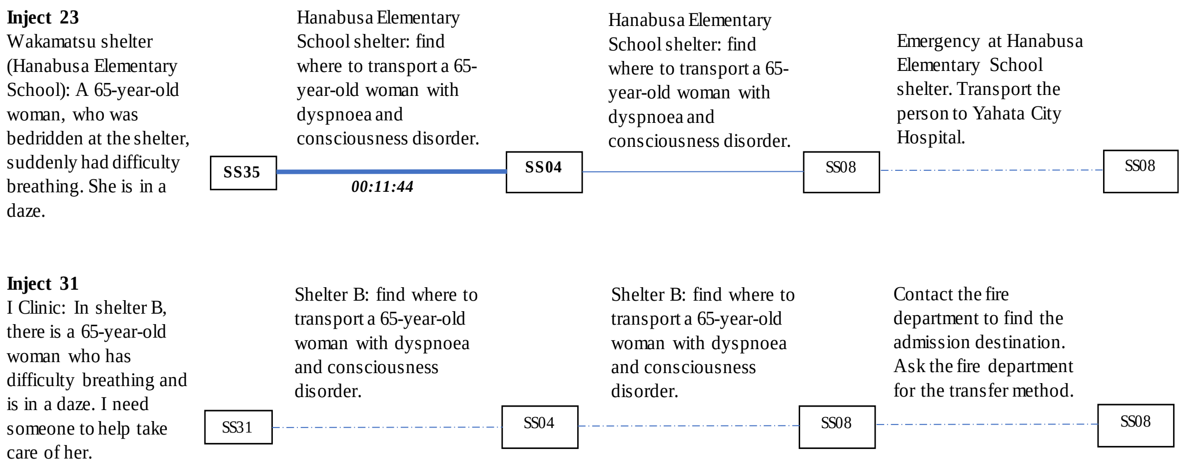


Fig. 4-9. Comparable task-processing chains of Injects 23 and 31 that requested local medical associations to communicate with DMOC

Figure 4-10 shows the expected and completed task-processing chains for Injects 5 and 28. The procedure for responding to this inject was not specified in the emergency operation plan; therefore, the exercise designer prepared possible alternatives. Players' responses showed that both SS 33 and 31 selected to contact SS36 or the Dialysis Physicians Association directly rather than indirectly via the DMOC.

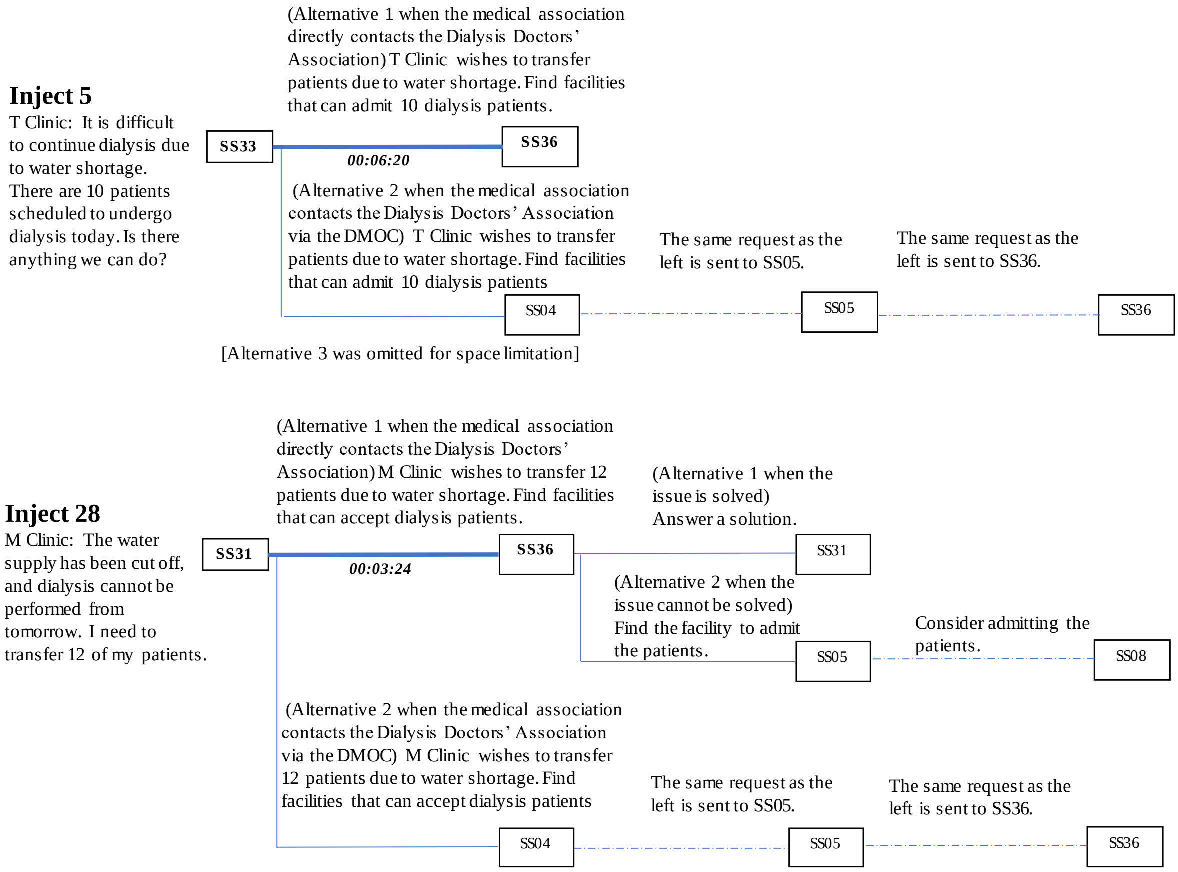


Fig. 4-10. Comparable task-processing chains of Injects 5 and 28 that requested local medical associations to communicate with the Dialysis Doctors' Association

In Phase 2, Injects 73 and 74 requested a doctor or pharmacist to visit an evacuation shelter. SS34 and SS31 completed the two expected tasks with similar execution times, as shown in Figure 4-11. SS34 was a local medical association that had participated multiple times in earlier DMOC functional exercises, whereas it was the first time for SS31 to participate in functional exercises. However, this difference in exercise experience did not affect the results.

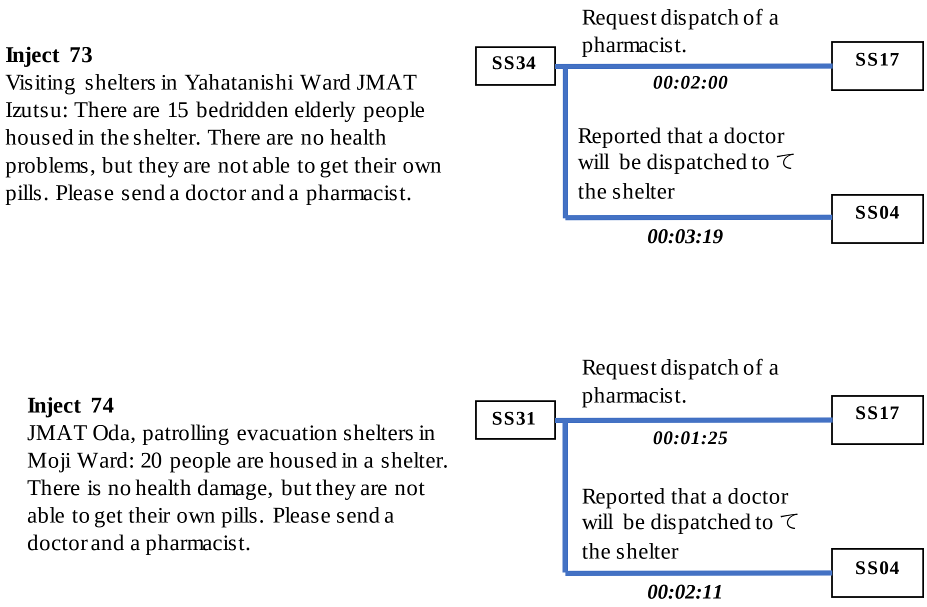


Fig. 4-11. Comparable task-processing chains of Injects 73 and 74 that requested local medical associations to communicate with the DMOC and Pharmacists Association

4.4. Discussion

In this exercise, players' roles were uneven, and the DMOC group played a significant role in terms of the number of tasks. In particular, the SS04 and SS05 player groups not only had an extraordinarily strong network of connections but were also in charge of communicating with medical associations and other organizations. Maintaining a constant flow of communication between players became difficult as the enormous number of tasks overwhelmed them and caused many tasks to go unexecuted or to be started but not completed within the provisional deadline of 20 min.

The results revealed a relationship between the incomplete tasks and their types. The players' ability to perform tasks also depends on the type of task, and they can rely on statistics to improve it; for example, SS04 needs to improve the ability to respond to different task types: 001 (grasping damage conditions), 041 (establishment of supply structures), and 077 (determination of health management implementation system and method). Task Type 056 (management of transporter and destination) in Phase 1, and Type 044 (supply arrangements) in Phase 2 are the most frequent incomplete tasks indicating the important points to be improved.

Coordination experience should also be considered important, as demonstrated through the exercise results of SS34 (Yahata Medical

Association); they performed faster communications to SS04, and their completion rate of Type 003 tasks in Phase 1 was significantly higher than the rest of the medical associations, although they still needed to improve on many other types of tasks.

The execution times of the different task types are detailed in the results. To make organized task processing more effective, exercise designers or even players can identify the types of tasks that must be performed faster. This adjustment has beneficial consequences for exercise.

4.5. Summary

4.5.1. Conclusions

Using the time-tracking evaluation method with a task-processing chain framework, this study visualized connection networks and their performance involving diverse player groups. Through this analysis, the potential problems in organized emergency responses by both the DMOC and other groups were identified. This study presents the execution time for each task type for each player group. We need to interpret the time consumption results carefully because of the differences in urgency and difficulty among the examined tasks and our provisional deadline of 20 min to judge the completion of tasks. Thus, we believe that time-consumption information should be used to make hot-wash and debriefing discussions more fruitful. For example, prolonged time consumption for easy tasks may indicate the overloading of responsible groups, suggesting the necessity for a revision of the current emergency operation plan and the requirement for reinforcement. This topic should be critically discussed among exercise participants and other emergency responders.

The proposed method does not require pre-specified emergency management standards and can be implemented for testing not only medical emergency operation plans but also emergency operation plans for various situations. Owing to the nature of incrementally tracking the execution of task processing chains, the proposed method may not be suitable for evaluating table-top exercises; however, it should work well with full-scale exercises.

4.5.2 Practical implications

DMOC exercises are still conducted annually except for periods affected by the COVID-19 pandemic. The analytical contributions of this study to the time tracking method were recognized by DMOC managers. Analyzing the results as well as the strengths and weaknesses of groups of players is of important value to improve their abilities in the exercise program and especially when a real emergency occurs.

These analyzes are expected to be of interest to emergency exercise designers and considered for application to their programs. The general development of exercise programs has certain implications for the safety of communities or organizations.

4.5.3. Limitations

However, these methods do not fully utilize information on player response times to evaluate the effectiveness of emergency plans. In this case study, the workload of each player group in an exercise may differ from that of a real emergency. We lacked information on the capacities and characteristics of the members of each group. Task and time monitoring were conducted at the player group level and not at the individual level. Thus, combining the data collected through this study with those obtained from conventional evaluation methods, such as interviewing exercise players, should provide a clearer picture of what was done during the exercise and how it differed from what was supposed to be done.

Several issues must be addressed in this study. Although the time-tracking software provided by Infogram Inc. records the time spent conducting each task, task completion must be manually marked by exercise evaluators by observing the activities of multiple exercise players in each group. This induces measurement errors due to the variation in evaluators' responses. The evaluation model must be refined to enhance its accuracy and reliability. Incorporating the strengths of survivors and asking them to support medical activities, when possible, may further improve the effectiveness of emergency plans. This course of thinking needs to be explored in future research.

5. CONCLUSION

5.1. Summary of key issues

Chapter 1 of the dissertation gives an overview of the research issues, including general circumstances, problem statement, research objectives, definition of terms and research structure. With two research questions surrounding the topic of methods for designing and evaluating exercise programs for emergency response, the dissertation outlines four major objectives to solve the problem. This chapter also briefly describes the structure of the dissertation, in which the results are concentrated in Chapter 2 to address the first two objectives and Chapters 3 and 4 address the last two objectives.

In chapter 2 of the dissertation, before the research issue on exercise programs for professional emergency response, we addressed the first two research objectives, including accessing the theoretical frameworks and determine the current situation of the emergency response exercise program. With the first objective, this includes understanding and analyzing existing theoretical frameworks, from basic principles to methods and models used to design and implement exercise programs. The second objective requires evaluating how these programs are currently implemented, identifying best practices, and pointing out areas for improvement. In chapter 2, many previous studies, government documents, and international standards for emergency response exercise programs will be thoroughly reviewed. We also compared the diversity and convergence in theories across different organizations and countries, to better understand overall. An analysis of the shortcomings in the practical application of different formats in design and evaluation was carried out. This includes identifying challenges and limitations in applying existing methods and models, thereby finding weaknesses that need to be overcome to improve the design and evaluation capacity of programs exercise. Through this analysis, the research made an important contribution to the development and refinement of emergency response exercise programs, ensuring they remain effective in meeting practical needs and are ready to deal with complex emergency situations.

In the chapter 3, This study proved the ability of mathematical and instructional methods into designing and evaluating exercises by proposed a model in a structure manner using AHP and 4C/ID combined with the Vietnamese emergency management framework of the “four-on-the-spot” motto. This novel conceptual method was tested with two fire and rescue exercises in Viet Nam and provided useful results to the designers of the exercise programs. We tested this method and confirmed that it could be used to determine exercise objectives and select implementation methods in the absence of predesigned detailed emergency standards. This model enables continuous improvements through PDCA cycles (Plan - Do - Check - Act) including design upgrades. The application of the AHP model is highly feasible for analyzing expert responses. The integration of the conventional qualitative approach with our quantitative approach will enable practitioners to identify the emergency elements to be improved, thereby creating opportunities for the continuous improvement of exercise programs.

Participants were able to visualize the differences in their understandings of exercise objectives and the necessary implementation methods. Using our method, exercise designs can be strengthened in a variety of situations. As a result of identifying the most important instructional design needs for the two cases, this study provides planners with useful information for creating follow-up exercises. In both developed and developing countries, the introduced method can be implemented without pre-specified emergency management standards.

Using the time-tracking evaluation method and a task-processing chain framework, Chapter 4 of the dissertation visualized connection networks and their performance involving diverse player groups. This analysis identified potential problems with organized emergency responses by the DMOC and other groups. In this study, we presented the execution time for each task type for each player group and interpreted the time consumption results carefully. Time-consumption information should be used to make hot-wash and debriefing discussions more fruitful and should be critically discussed among exercise participants and other emergency responders.

Analyzing the results as well as the strengths and weaknesses of groups of players is of important value to improve their abilities in the exercise program and especially when a real emergency occurs. The proposed method does not require pre-specified emergency management standards and can be implemented for testing not only medical emergency operation plans but also emergency operation plans for various situations. The analytical contributions of this study should work well with full-scale exercises in general and with the time tracking method of DMOC in particular.

5.2. An example of application

Currently, solutions to prevent drowning in Vietnam in particular and developing countries in general have not mentioned the functional exercise program model for local government organizations, schools, and residential areas, where there is a danger of drowning. Therefore, establishing a conceptual model for this should be considered. By incorporating tools such as AHP and 4C/ID to design and evaluate exercises, exercise programs can be accessible to multiple stakeholders in the hazard area. Creating feasible scenarios and continuously analyzing improvements using AHP, measuring time and analyzing the characteristics of stakeholders, the community's emergency response capacity when a drowning incident occurs can be gradually overcome.

To let us can understand how this research results are applied to actual problems, a simple scenario of exercise for reducing child water accidents in Vietnam is performed like this: On 24 August 2024, a flash flood occurred along the A River basin, caused by heavy rain for many days, overflow from upstream. At that time, a group of 6 children aged 8 to 14 were playing on the banks of the A River in Commune Y of Province Z, 15km from the nearest medical facility and 32km from the nearest fire service rescue team. The flood swept away 4 children, the remaining 2 managed to cling to the cliff but were injured and needed emergency treatment. A farmer heard the two children's cries for help and called the emergency hotline 114.

This exercise will be implemented as follows:

a) Identification of stakeholders:

Table 5-1. Potential stakeholders for reducing child water accidents

		Code
Main forces in charge of rescue and operation	Emergency hotline 114 operators	114
	Fire Service Rescue Team	FR1
	River Police Force	RP2
	Commune Y Emergency Medical Station	EMS
	Commune Y Chairperson	CYC
	Commune Y’s citizen office	CYO

Support for materials, equipment, communication	Commune Y's primary and secondary schools	CYS
	Provincial hospital	PRH
	River boat radio center	BRC

b) Specification of exercise objectives and identification of elements to be considered in exercises

Exercise objectives:

- Search and rescue of victims swept away by flash floods.

- First aid, transport and treatment of victims.

- Warning to neighboring localities in the Y River basin to prevent damage from flash floods

c) Interview the stakeholders

Key questions for the scenario include:

- Which agency or organization is primarily responsible for search and rescue? Who is in command?

- How will the forces communicate?

What resources are available to conduct search and rescue? What additional resources and personnel need to be mobilized?

- Which department is responsible for communications and warnings? How is it carried out?

d) AHP – 4C/ID model establishment and survey

Based on the main questions and possible answers, the main criteria and sub-criteria can be listed as follows:

Table 5-2. Potential criteria for the AHP - 4C/ID survey

Main Criteria	Sub-Criteria
(E1) Command of search and rescue	(E11) Basic skills and the situation understanding
	(E12) The executive capacity
	(E13) Communication and information capacity

(E2) Manpower	(E21) Functional response capacity
	(E22) Communication capacity
(E3) Means	(E31) Means of search and rescue
	(E32) Mean of first aid and treatment
(E4) Logistics and resource support	(E41) Support of search and rescue
	(E42) Support of first aid and treatment

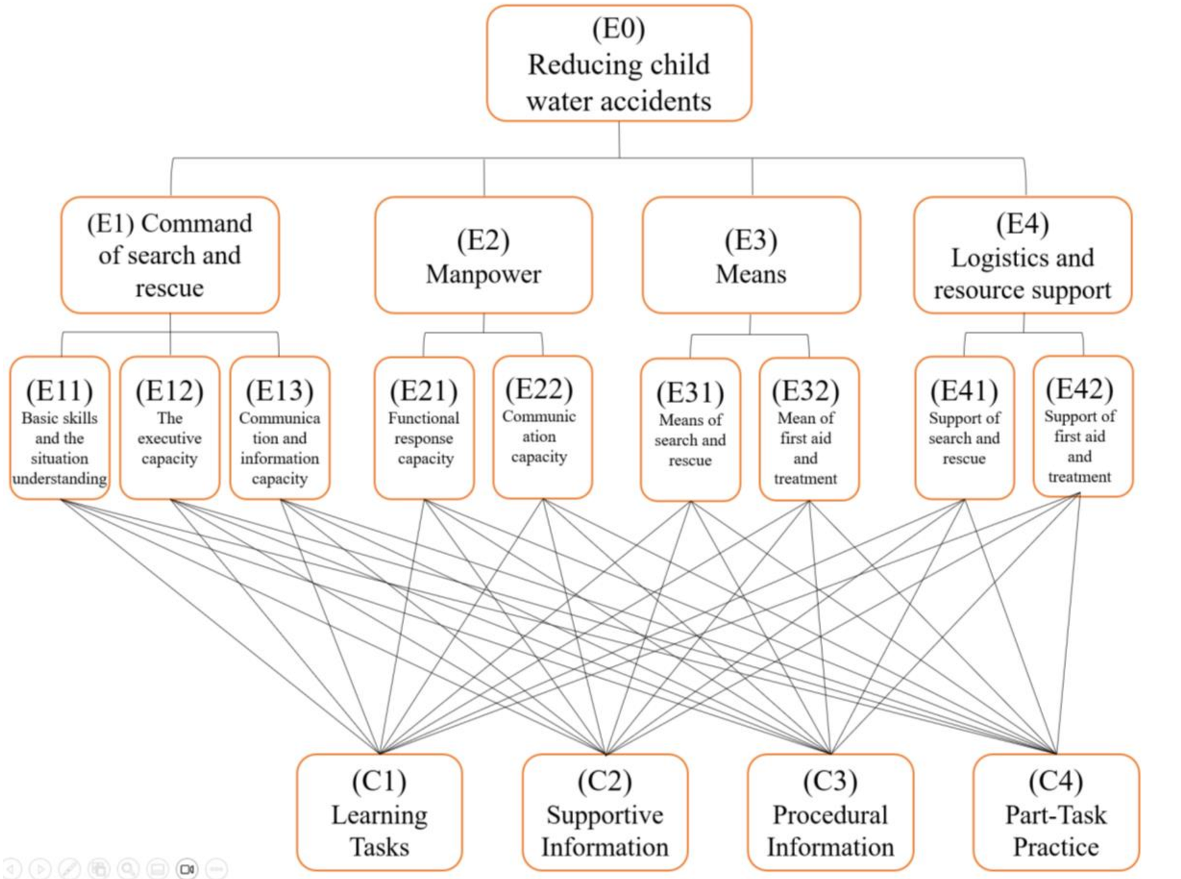


Fig. 5-1. The AHP modeled for reducing child water accident's scenario

By this diagram, we can do the AHP-style survey with the stakeholders and estimate element weights.

e) Exercise design

Based on the analysis of the results of the stakeholder survey, we can choose the appropriate types of exercises for each subject. For example, for stakeholders who need to improve their Learning tasks, we will apply tabletop exercises, and the group that needs to improve their Part Task Pact will apply drills, etc.

f) Example injects

A functional exercise with timing is assumed for the above scenario. Several injects and task sequences are set up to illustrate this exercise.

Inject 1x: People on the southeast bank of the A River, milestone number 15, discovered a victim floating in the flood and reported that to the Emergency hotline 114 operators (114). In this situation, the commander in charge of search and rescue from Fire Service Rescue Team (FR1) was expected to order to the River Police Force (RP2) to dispatch speedboats to that area, request the lighting vehicles and manpower support from local government, order the Commune Y Emergency Medical Station (EMS) to deploy ambulances to be ready for treatment.

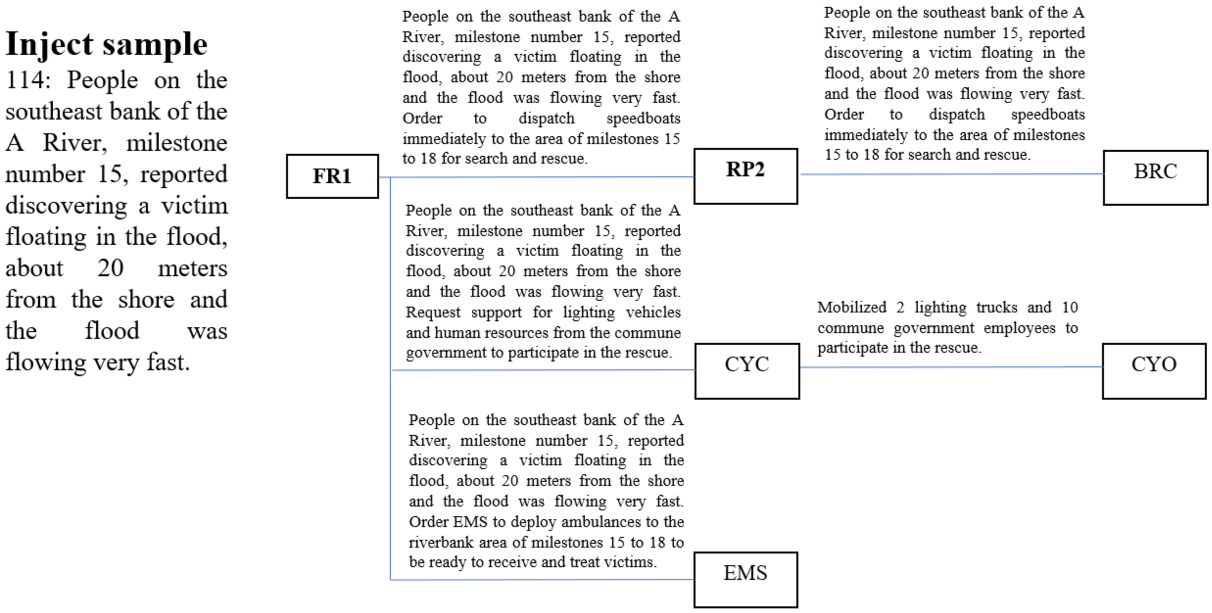


Fig. 5-2. An inject sample of dispatching for search and rescue

Inject 1y: The ambulance informed that the 8-year-old victim received first aid and clinical diagnosis, and was found to have severe respiratory damage and needed special medical support. In this situation, the Commune Y Emergency Medical Station (EMS) need to request the provincial hospital to immediately prepare respiratory support equipment and appropriate treatment agents for the 8-year-old patient, request the commune government to support the direction for the ambulance to transport the patient to the provincial hospital.

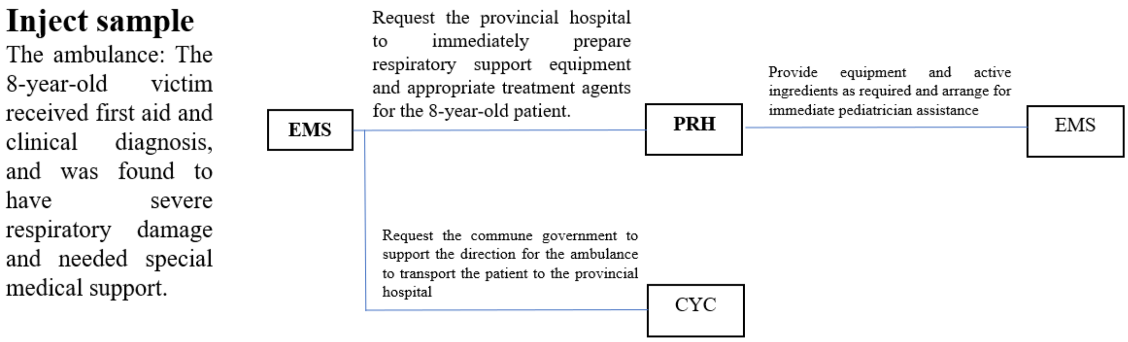


Fig. 5-3. An inject sample of special treatment requirement.

5.3. Further studies

From the results of the case studies, developing methods for designing and evaluating exercises is a common need in many countries and organizations. In this context, adherence to the principles underlying the exercise program is essential for effective emergency management. Designing assignments using mathematical methods such as AHP and teaching methods such as the 4C/ID, as well as time-tracking, feasible and useful. These methods not only help optimize learning and assessment but can also be widely considered and applied to a variety of formats and contexts.

AHP helps in making decisions by analyzing and comparing important factors, thereby determining weights and priorities for these factors. This is very useful in designing complex exercises that require careful consideration of many different aspects. Meanwhile, the 4C/ID method helps build courses based on four main components: learning tasks, supporting skills, learning information, and part-task practice. This method fits to developing complex skills through breaking them into smaller, more manageable parts.

Time-tracking also plays an important role for functional exercises to take place as planned and scheduled. This not only helps to better manage time and resources, but also facilitates tracking progress and evaluating the effectiveness of each stage in the learning and practice process.

In short, the combination of advanced mathematical and teaching methods, coupled with strict time management, provides a comprehensive and flexible approach to design and evaluation. These methods not only meet the needs of countries and organizations but are also adaptable to many different contexts and situations, contributing to improving the quality of education and training, especially in preparation for emergency situations.

For the above reasons, the final part of this dissertation proposes an advanced model for Design and Evaluation of Exercise Programs for Professional Emergency Response, abbreviated as DEEPPER (based on the first letters of the phrase). This model includes two main elements: a design method group and an evaluation method group.

The design method group focuses on building and developing effective exercises that are consistent with training objectives and the actual requirements of emergency situations. Applying the AHP allows designers to analyze and identify crucial factors, thereby prioritizing and planning exercises systematically and scientifically learn. Besides, the 4C/ID helps develop core and auxiliary skills, from technical skills to learning principles and teaching strategies, ensuring ensure that learners can acquire knowledge and skills comprehensively and deeply.

The group of evaluation methods focuses on measuring and analyzing the effectiveness of designed and implemented exercises. Using timestamp measurement tools not only helps track learner progress and performance, but also provides the data needed to evaluate the effectiveness of exercises. This data will be the basis for continuously adjusting and improving training programs, ensuring that they always meet real-life requirements and situations.

The DEEPPER model does not stop applying foundational methods such as AHP, 4C/ID or timestamp measurement, but also brings the possibility of developing and expanding many other methods and tools. For example, integrating information and communication technology, using simulation software, or applying advanced data analysis methods can increase the efficiency and practicality of the model. Furthermore, the DEEPPER model can be customized to suit the specific characteristics and requirements of each country, organization or field, thereby creating the most optimal and effective training programs for the workforce of professional emergency response quality.

This conceptual model exhibits advantages such as: quantitative, flexible and suitable for many exercise formats and implementation situations. The integration of design with sequential evaluation demonstrates the potential for continuous improvement in this model.

The first advantage of DEEPPER is its quantitative nature, thanks to the use of mathematical methods such as AHP to systematically and accurately identify and measure important factors.

The versatility of DEEPPER is also a notable advantage as it can be applied to a variety of exercise formats, including discussion exercises to operational exercises. The ability to adapt to many different situations and requirements makes the model useful in emergency management in general and exercise programs in particular in practice.

DEEPPER integrates the design process with the evaluation process in a sequential and continuous way. Through each assessment cycle, the data collected will provide comprehensive information to adjust and improve the quality of subsequent exercises, ensuring that they always meet the latest requirements and feedback reflects the actual situation.

Currently, this conceptual model is still new and needs to be tested on many different types of exercises to further strengthen arguments about feasibility. Applying the DEEPPER model on diverse types of exercises will help test and verify the effectiveness and feasibility of the model in different contexts. These experiments not only help refine the model but also provide opportunities to explore and further develop new methods and tools, thereby improving the quality and effectiveness of exercise programs. Through continuous testing and adjustment, the DEEPPER model promises to become a useful supplement, meeting the increasingly complex and complex needs of countries, organizations and forces around the world in emergency response.

APPENDICES

Appendix 1: The AHP-modeled questionnaire

SURVEY QUESTIONNAIRE

on quantitative of instructional design of a fire response exercise

Name: ……………………………………… ………………Work position: ………………………………………………….

Case 1: The fire and rescue exercise at Cat Bi Apartment Complex, Hai An district, Hai Phong city (Dec 23, 2020)

Please enter the corresponding scores for pairwise comparison in this case.

Option	**correlated quantitative scores**																	**Option**
	More important ←								**equal** →								**More important**	
pairwise comparison of key factors																		
1. Command and control	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	2. Manpower

1. Command and control	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	3. Means
1. Command and control	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	4. Logistics and resource support
2. Manpower	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	3. Means
2. Manpower	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	4. Logistics and resource support
3. Means	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	4. Logistics and resource support
Comparison between Sub factors of "Command and control"																		
1.1. Basic skills and the situation understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	1.2. The executive capacity
1.1. Basic skills and the situation understanding	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	1.3. Communication and information capacity
1.2. The executive capacity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	1.3. Communication and information capacity
Sub factor 1.1. Basic skills and the situation understanding																		

Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Sub factor 1.2. The executive capacity																		
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice

Sub factor 1.3. Communication and information capacity																		
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Comparison between Sub factors of "Manpower"																		
2.1. Functional response capacity	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	2.2. Communication capacity
Sub factor 2.1. Functional response capacity																		
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information

Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Sub factor 2.2. Communication capacity																		
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Key factors 3: Means																		
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice

Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Key factors 4: Logistics and resource support																		
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Supportive Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Learning Task	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Procedural Information
Supportive Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice
Procedural Information	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Part-Task Practice

Appendix 2: Full list of the Behavioral subcategories of DMOC Exercise (established by DMOC Exercise Organizer Team)

Classification	Objectives	Tasks	Behavioral subcategories
Overview of Disaster Control Headquarters	Operation And Management of The System	System Understanding the situation	001
		System Prediction of the situation	002
		Establishing the system	003
		Change the system	004
		Closure of the system	005
		Mobilization order	006
		Confirmation of the safety of employees	007
		Publicize the damage situation	008
		System Press conference	009
		Establish and operate the local disaster control headquarters	010
	Request For Assistance	Request for dispatch of the Self-Defense Forces	011
		Request for dispatch of emergency firefighting support team	012
		Request for dispatch of emergency rescue team	013
		Support: Request for dispatch of experts	014
		Support: Inter-city support request	015
		Support Cooperation with other organizations	016
	Volunteer Support	Establishing a system for receiving volunteers	017
		Determine location and content of volunteer activities	018
	Securing The Means of Communication	Communication Confirmation of communication status and damage status	019
		Secure alternative means of communication (in case of disaster)	020

		Communication Maintenance and management	021
Evacuation response	Issuance Of an Evacuation Advisory	Request and judgment of evacuation advisory, etc.	022
		Determination of areas to be evacuated	023
		Calculation of the number of people in the evacuation zone	024
		Selection of evacuation centers	025
		Determination of evacuation routes	026
		Publicize evacuation advisory, etc.	027
		Consideration of changing evacuation centers (wide-area evacuation)	028
	Establishment Of Shelters	Determination and dispatch of evacuation center management staff	029
		Organize local public relations teams (manpower, vehicles) at evacuation centers	030
		Organize evacuation guidance teams (personnel, vehicles) at evacuation centers	031
		Consent of facility manager at evacuation center	032
		Confirmation of opening of evacuation shelters	033
	Operation And Management of Shelters	Evacuation centers: Assessing personnel, reporting	034
		Secure supplies for evacuation centers	035
		Evacuation center management system	036
		Evacuation center Health management	037
		Evacuation center Safety management	038
		Evacuation shelters Ensuring privacy	039
		Evacuation shelters Consideration for those who need assistance in times of disaster	040
		Organization of supplies	041

	Response To Emergency and Relief Supplies	Sorting of supplies and securing of storage space	042
		Confirmation of required number of supplies	043
		Arrangement of supplies	044
		Sorting of supplies	045
		Distribution of supplies	046
		Inventory management	047
		Response to donations	048
Disaster Response	On-Site Support	On-site situation assessment	049
		Determination of on-site countermeasure headquarters structure and necessity of support	050
		Establishment of on-site disaster control headquarters and on-site liaison and coordination center	051
		On-site Determination of action policies, locations, units to be deployed, personnel, etc.	052
		On-site securing of materials and equipment	053
		Preliminary report of damage and activity status on site	054
	Securing A Place for Housing	Preparation and selection of hospitals for receiving patients	055
		Identify and manage transporters and destinations	056
		Operation and management of first-aid stations and teams	057
Public facility management support	Response Of Public Facilities Under Jurisdiction	Facilities Assess and report on damage to facilities under each jurisdiction	058
		Facility Implementation of emergency measures and other damage mitigation measures	059
		Facility Ensure safety of facility users and guide evacuation	060
		Facility Decision on facility use policy (open or closed)	061
		Facility Contact with relevant organizations	062

		Facility Implementation of emergency measures for facility use	063
		Facility Secure materials and equipment	064
		Facility Planning and implementation of alternative measures	065
		Facility Implementation of public relations	066
Support for Victims	Application Of the Disaster Relief Act	Rescue method Assessing the disaster situation	067
		Predict and determine the application of the Rescue Law	068
		Application to the prefecture	069
		Response after application of the Rescue Law (communication, coordination, calculation)	070
	Application Of the Livelihood Support System for Disaster Victims	Assessing the extent of damage and establishing the need for support	071
		Determination of applicability of Life Support	072
		Application to the prefecture for livelihood support	073
		Livelihood support Establishment of system for issuing disaster victim certificates, securing locations	074
		Livelihood support Dissemination to residents	075
	Health Care for Residents	Health management Determination of scope of coverage	076
		Health management Determination of implementation system and methods	077
		Health management Securing of materials and equipment	078
		Health management Progress management of implementation status	079
		Health management Dissemination to residents	080
	Handling The Body	Determination of the scope of health care	081
		Decide on the implementation system and methods	082
		Securing materials and equipment	083
		Progress management of the implementation status	084

		Dissemination to residents	085
	Operation And Management of Quarantine System	Determination of the scope of quarantine	086
		Determination of quarantine implementation system and method	087
		Quarantine Secure materials and equipment	088
		Quarantine Progress management of the implementation status	089
		Quarantine Dissemination to residents	090
	Operation And Management of The Waste Treatment System	Determination of the scope of garbage	091
		Determination of implementation system, method, and necessity of support	092
		Secure materials and equipment	093
		Progress management of implementation status	094
		Dissemination to residents	095
	Toilet Measures	Toilet Determination of target area	096
		Toilet Determination of implementation system, method and necessity of support	097
		Toilet Securing Materials and Equipment	098
		Toilet Progress Management of Implementation	099
		Toilet Dissemination to Residents	100
	Water Supply Support	Water Determination of Target Area	101
		Water Determination of implementation system, method, and necessity of support	102
		Water Secure materials and equipment	103
		Water Progress management of implementation status	104
		Water Dissemination to residents	105

REFERENCES

1. Beerens RJJ, Tehler H (2016). Scoping the field of disaster exercise evaluation: A literature overview and analysis. Int. J. Disaster Risk Reduction. 19, 413-446.

2. Bhushan N, Rai K (2004). Strategic decision making: Applying the analytic hierarchy process. London; New York: Springer.

3. Brooks AL, Brahman S, Kapralos, Jain LC (Eds.) (2021) Recent Advances in Technologies for Inclusive Well-Being, Chapter 5 Four-Component Instructional Design Applied to a Game for Emergency Medicine. Berlin: Springer. http://dx.doi.org/10.1007/978-3-030-59608-8_5.

4. Bureau of Social Welfare and Public Health, Tokyo Metropolitan Government. Guidelines for disaster medical relief activities.

5. Cabinet Office (2019) About indirect disaster deaths. https://www.bousai.go.jp/taisaku/kyuujo/pdf/r01kaigi/siryo8.pdf, (in Japanese)

6. Clark RE, Feldon D, Van Merriënboer JJG, Yates K, Early S (2008). Cognitive task analysis. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, & M. P. Driscoll (Eds.), Handbook of research.

7. Committee on Indirect Disaster Deaths, Reconstruction Agency (2012). Report on indirect disaster deaths of the Great East Japan Earthquake disaster. https://www.reconstruction.go.jp/topics/240821_higashinihondaishinsainiokerushinsaikanrenshinikansuruhoukoku.pdf (in Japanese)

8. Cook DA, Hamstra SJ, Brydges R, Zendejas B, Szostek JH, Wang AT, Erwin PJ, Hatala R (2013). Comparative effectiveness of instructional design features in simulation-based education: Systematic review and meta-analysis. Medical Teacher, 35, e867-898.

9. Department of Homeland Security (2020). Homeland Security Exercise and Evaluation Program (HSEEP), Washington D.C.: Department of Homeland Security.

10. EM-DAT (2020). EMDAT: the emergency events database—Université catholique de Louvain (UCL)— CRED,D. Guha-Sapir. www.emdat.be, Brussels, Belgium

11. Emergo Train System, https://www.emergotrain.com/ [accessed 6 Sep 2023].

12. Federal Emergency Management Agency (2017) National Incident Management System (3rd ed.). Washington D.C.: FEMA. https://www.fema.gov/emergency-managers/nims (Accessed on Aug 30, 2022)

13. Federal Emergency Management Agency (2018) Introduction to the Incident Command System, ICS 100. https://training.fema.gov/is/courseoverview.aspx?code=is-100.c&lang=en

14. Fire and Rescue Police Department, Viet Nam (2020). Press release on operational status of 2019, 2021, 2021. Retrieved from http://canhsatpccc.gov.vn/ArticlesDetail/tabid/193/cateid/1172/id/9676/language/vi-VN/ArticlesList/tabid/192/cateid/1172/language/vi-VN/default.aspx

15. Flach JM, Steele-Johnson D, Shalin V, Hamilton GC (2017). Coordination and control in emergency response, in A. B. Badiru and L. Racz (eds.) Handbook of Emergency Response: A Human Factors and Systems Engineering Approach. CRC Press, Boca Raton, FL, USA, pp. 531–546.

16. Gebbie KM, Velas J, Association of Teachers of Preventive Medicine, Centers for Disease Control and Prevention, Columbia University, School of Nursing, Center for Health Policy (2006). Public health emergency exercise toolkit; planning, designing, conducting, and evaluating local public health emergency exercises. https://stacks.cdc.gov/view/cdc/11403,

17. Gulum P, Ayyildiz E, Taskin Gumus AT (2021). A two level interval valued neutrosophic AHP integrated TOPSIS methodology for post-earthquake fire risk assessment: An application for Istanbul. International Journal of Disaster Risk Reduction, 61, 102330. https://doi.org/10.1016/j.ijdrr.2021.102330.

18. Gundran CPD, Lam HY, Tuazon ACA, Cleofas JV, Garcia FB, Puli TEM, Magdales MSI (2022). Enhancing mass casualty disaster management competencies through an integrated disaster simulation training program. Int. J. Disaster Risk Reduction, 78, 103124.

19. Hai Phong city government portal (2020). Overview on Hai Phong city. Retrieved from https://haiphong.gov.vn/tong-quan-ve-hai-phong/Tong-quan-ve-thanh-pho-Hai-Phong-12948.html.

20. Hoang LHG, Kato T (2023). Disaster risk reduction education with flood management in Viet Nam, The 9th International Conferences on Flood Management (oral presentation).

21. Hoang LHG, Kato T (2023). Use of Analytical Hierarchical Process and Four-Component Instructional Design for Improving Emergency

Response Exercises. International Journal of Disaster Risk Reduction, 87, 103583. 2023. https://doi.org/10.1016/j.ijdrr.2023.103583.

22. Hoang LHG, Kato T, Taninobu M, Ito S (2024). Evaluating communication capability across diverse groups for disaster medicine: A time-tracking method for functional exercises", International Journal of Disaster Risk Reduction, Volume 109, 104590, 2024. https://doi.org/10.1016/j.ijdrr.2024.104590.

23. Hoscan O, Cetinyokus S (2021). Determination of emergency assembly point for industrial accidents with AHP analysis. Journal of Loss Prevention in the Process Industries, 69, 104386.

24. IPCC (2014) Climate change 2014—impacts, adaptation and vulnerability: part A: global and sectoral aspects: working group II contribution to the IPCC 5th assessment report: volume 1: global and sectoral aspects, vol 1. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781107 415379.

25. ISO (2018). ISO 22300:2018 Security and resilience — Vocabulary

26. ISO (2018). ISO 22320:2018, Security and resilience: Emergency management: Guidelines for incident management, ISO.

27. Johnson YJ, Herrmann JA, Wallace RL, Troutt HF, Myint MS (2009). Development and Implementation of a Functional Exercise to Assess Public Health Agency Response to Foodborne Bioterrorism. J. Homel. Secur. Emerg. Manag., 6, 49. https://doi.org/10.2202/1547-7355.1570.

28. Joint Advocacy Network Initiative (2011). Four on-the-spot Motto in disaster management Key contents and actual application.

29. Kato T, Aso H, Matsumoto K, Kimoto T, Shiraishi A, Umeki H, Tanaka K, Matsumoto Y, Inada K, Hinami K (2014). A quantitative evaluation method for coordinated disaster management in functional exercises for a local government. Journal of Social Safety Science, 24, 43–52 (in Japanese).

30. Kato T, Wang JJ, Tsai NY (2022). Elements of standard operating procedures and flexibility issues in emergency management: A Japan-Taiwan comparison. International Journal of Disaster Risk Reduction, 71, 102813, 1-14. https://doi.org/10.1016/j.ijdrr.2022.102813.

31. Khalil MK, Elkhider IA (2016). Applying learning theories and instructional design models for effective instruction. Advances in Physiology Education, 40, 147-156. https://doi.org/10.1152/advan.00138.2015.

32. Kitakyushu City Hospital Organization (2016) Kitakyushu City Hospital Organization Medical Relief Plan (in Japanese).

33. Kumamoto Prefecture Government (2018). An overview of earthquake-related deaths, (in Japanese).

34. Laurila-Pant M, Pihlajamäki M, Lanki A, Lehikoinen A (2023). A protocol for analysing the role of shared situational awareness and decision-making in cooperative disaster simulations. Int. J. Disaster Risk Reduction, 86, 103544. https://doi.org/10.1016/j.ijdrr.2023.103544.

35. Louws ML, Van Veen K, Meirink JA, Van Driel JH (2017). Teachers' professional learning goals in relation to teaching experience. European Journal of Teacher Education, 40(4), 487–504.

36. Luong M, Nguyen D (2022). Vietnam's Hai Phong: An industrial gateway and port city, https://www.vietnam-briefing.com/news/vietnams-hai-phong-industrial-gateway-and-port-city.html/

37. McEntire DA (2007). Disciplines, disasters, and emergency management: The convergence and divergence of concepts, issues and trends from the research literature. Charles C Thomas Publisher.

38. Militello LG, Patterson ES, Bowman L, Wears R (2007). Information flow during crisis management: Challenges to coordination in the emergency operations center. Cogn. Technol. Work, 9, 25–31. https://doi.org/10.1007/s10111-006-0059-3.

39. Ministry of Culture, Sports and Tourism, Vietnam (2021). Decision no. 3246/QD-BVHTTDL on the improvement of The Program on Safe swimming to prevent child drowning in term of 2021-2030.

40. Nivolianitou Z, Synodinou B, Manca D (2015). Flood disaster management with the use of AHP. International Journal of Multicriteria Decision Making, 5(1-2), 152-164. https://dx.doi.org/10.1504/IJMCDM.2015.067943

41. Obaid JM, Bailey G, Wheeler H, Meyers L, Medcalf SJ, Hansen KF, Sanger KK, Lowe JJ (2017). Utilization of Functional Exercises to Build Regional Emergency Preparedness among Rural Health Organizations in the US. https://doi.org/10.1017/S1049023X16001527

42. Ortiz-Barrios M, Gul M, Yucesan M, Alfaro-Sarmiento I, Navarro-Jiménez E, Jiménez-Delgado G (2022). A fuzzy hybrid decision-making framework for increasing the hospital disaster preparedness: The Colombian

case. International Journal of Disaster Risk Reduction, 72, 102831. https://doi.org/10.1016/j.ijdrr.2022.102831

43. Panchal S, Shrivastava AK (2022). Landslide hazard assessment using analytic hierarchy process (AHP): A case study of National Highway 5 in India. Ain Shams Engineering Journal, 13, 101626. https://doi.org/10.1016/j.asej.2021.10.021

44. PANO (2020) ASEAN military medical forces join online COVID-19 response exercise, People's Army Newspaper, License number: 52/GP-CBC 10-6-2021

45. Perry RW, Lindell MK (2007). Emergency planning. Hoboken, NJ: Wiley.

46. Phelps R (2011) Emergency Management Exercises: From Response to Recovery: Everything You Need to Know to Design a Great Exercise; Chandi Media: San Francisco, CA, USA; pp. 10–18, ISBN 0-9831143-0-7.

47. Russo F, Rindone C (2014) Urban exposure: Training activities and risk reduction. WIT Trans. Ecol. Environ. 191, 991–1001. https://doi.org/10.2495/SC140842.

48. Saaty TL (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. New York: McGraw-Hill.

49. Saaty TL (2000). Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process. Pittsburgh: RWS Publications.

50. Saaty TL (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 1(1), 83-98. https://doi.org/10.1504/IJSSCI.2008.017590

51. Saaty TL (2008). Decision making with the analytic hierarchy process. International Journal of Services Sciences, 7(1), 83-98.

52. Saaty TL (2012). Decision making for leaders: The analytic hierarchy process for decisions in a complex world (Third Revised Edition ed.). Pittsburgh: RWS Publications.

53. Sannomiya K (2017). Supporting elder and/or disabled disaster survivors by rehabilitation experts: JRAT activity in Kumamoto Earthquake. Rehabil. Eng., 32(2), 85-86. (in Japanese). https://doi.org/10.24691/resja.32.2_85.

54. Savoia E, Agboola F, Biddinger P (2014). A Conceptual Framework to Measure Systems' Performance during Emergency Preparedness Exercises.

Int. J. Environ. Res. Public. Health, 11, 9712–9722. https://doi.org/10.3390/ijerph110909712.

55. Savoia E, Biddinger PD, Burstein J, Stoto MA (2010). Inter-Agency Communication and Operations Capabilities during a Hospital Functional Exercise: Reliability and Validity of a Measurement Tool. Prehospital and Disaster Medicine, 25(1), 52-58. https://doi.org/10.1017/S1049023X00007664.

56. Skryabina E, Reedy G, Amlot R, Jaye P, Riley P (2017). What is the value of health emergency preparedness exercises? A scoping review study. Int. J. Disaster Risk Reduction., 21, 274–283. https://doi.org/10.1016/j.ijdrr.2016.12.010.

57. Soma K (2003). How to involve stakeholders in fisheries management: A country case study in Trinidad and Tobago. Marine Policy, 27(1), 47-58. https://doi.org/10.1016/S0308-597X(02)00050-7

58. Socialist Republic of Vietnam (2007). Decision No. 172/2007/QD-TTg to approve the National Strategy on natural disaster prevention, response, and mitigation to 2020.

59. Socialist Republic of Vietnam (2002). Decree on the State of Emergency, No. 71/2002/ND-CP.

60. Socialist Republic of Vietnam (2012). Decision on issuance of national action plan on climate change period 2012-2020, No 1474/2012/QD-TTg.

61. Socialist Republic of Vietnam (2013). Law on Fire Prevention and Fighting, No. 40/2013/QH13.

62. Socialist Republic of Vietnam (2013). Law on Natural Disaster Prevention and Control, No 33/2013/QH13.

63. Socialist Republic of Vietnam (2014). Decision on detailed regulations on natural disaster risk levels, No. 44/2014/QD-TTg.

64. Socialist Republic of Vietnam (2014). Decision to approve the Master plan on incident and disaster response and search and rescue activities through 2020, No. 1041/QD-TTg.

65. Socialist Republic of Vietnam (2014). Decree on detailing and guiding a number of articles of the Law on Natural Disaster Prevention and Control, No 66/2014/ND-CP.

66. Socialist Republic of Vietnam (2017). Decree on regulating the response to emergencies, natural disasters, and search and rescue, No. 30/2017/ND-CP.

67. Takagi Y, Takahashi S, Fukuo Y, Arai T, Tachikawa H (2021). Acute-stage mental health symptoms by natural disaster type: Consultations of disaster psychiatric assistance teams (DPATs) in Japan. Int. J. Env. Res. Public Health., 18(23), 12409. https://doi.org/10.3390/ijerph182312409.

68. Ta L, Hong C (2022). 6 children drown to death in Vietnam every day, VnEpress, License number: 71/GP-CBC.

69. Taninobu M, Kohriyama K (2011). Developing a quantitative evaluation method for blind style functional exercises (in Japanese), in Functional Exercise Research Group (ed.) Introduction to Functional Exercises, Naigai Syuppan, pp. 218-219.

70. Teknomo K (2006). Analytic hierarchy process (AHP) tutorial. Revoledu. Com, 1-20.

71. To NT (2019). Enhancing communication among emergency responders by developing exercise programs in Vietnam, Doctoral dissertation, University of Kitakyushu.

72. To NT, Kato T (2018). Characteristics and development of policy and institutional structures of emergency response in Vietnam. International Journal of Disaster Risk Reduction, 31, 729-741.
https://doi.org/10.1016/j.ijdrr.2018.07.016

73. To NT, Kato T, Imai M, Taninobu M, Kohriyama K, Ito S (2019). Developing a time-based evaluation method for functional exercises of emergency medical operations. Safety, 5(3), 49, 1–16.

74. To NT, Kato T, Imai M, Taninobu M, Kohriyama K, Ito S (2019). Developing a time-based evaluation method for functional exercises of emergency medical operations. Safety, 5(3), 49, 1-16. https://doi.org/10.3390/safety5030049.

75. Tong TTM, Nguyen DTH, Park TY (2022). The Practice of Education for Disaster Risk Reduction in Vietnam: Lessons Learned from a Decade of Implementation 2010–2020. In Interlocal Adaptations to Climate Change in East and Southeast Asia (pp. 101-112). Springer, Cham.

76. Turner BA (1995). The role of flexibility and improvisation in emergency response. Natural risk and civil protection, 463-475.

77. United Nations International Strategy for Disaster Reduction (2017). Local Government Powers for Disaster Risk Reduction: A Study on Local-Level Authority and Capacity for Resilience. UNISDR, Geneva.

78. Van Merriënboer JJG (2019). The Four-Component Instructional Design Model: An Overview of its Main Design Principles, Maastricht. The Netherlands: Maastricht University.

79. Van Merriënboer JJG, Kirschner PA (2018). Ten steps to complex learning: A systematic approach to four-component instructional design (3rd ed.). London: Routledge.

80. Viet Nam Government (2020). Decree no. 136/2020/ND-CP Detailed regulations on several articles and measures to implement the Law on Fire Prevention and Fighting. https://thuvienphapluat.vn/van-ban/Tai-nguyen-Moi-truong/Nghi-dinh-136-2020-ND-CP-huong-dan-Luat-Phong-chay-va-chua-chay-458292.aspx (Accessed on Dec 10, 2022).

81. Vietnam Disaster management authority (2019 – 2021). Statistics of damage caused by natural disasters. Retrieved from http://phongchongthientai.mard.gov.vn/Pages/Thong-ke-thiet-hai.aspx

82. Vietnam General Statistics Office (2022). Population data. https://www.gso.gov.vn/en/population/.

83. Vukmir RB (2006). Survival from prehospital cardiac arrest is critically dependent upon response time. Resuscitation 2006, 69, 229–234. https://doi.org/10.1016/j.resuscitation.2005.08.014.

84. World Bank (2010). Weathering the storm: options for disaster risk financing in Vietnam—Viet Nam. The World Bank report no. 70394. The World Bank. https://reliefweb.int/report/viet-nam/weathering-storm-options-disaster-risk-financing-vietnam.

85. World Bank (2014). Turn down the heat: confronting the new climate normal. The World Bank. https://openknowledge.worldbank.org/handle/10986/20595.

86. World Bank (2021). Vietnam overview. Retrieved from https://www.worldbank.org/en/country/vietnam/overview

87. World Health Organization, Regional Office for Europe (2011). Hospital emergency response checklist, Copenhagen. Denmark: WHO Regional Office for Europe. https://www.who.int/docs/default-source/documents/publications/hospital-emergency-response-checklist.pdf.

88. World Health Organization (2021). Emergency Medical Teams Coordination Handbook. https://resourcecenter.undac.org/wp-content/uploads/2021/01/Library.Emergency-Medical-Teams-Coordination-Handbook.pdf.

89. World Health Organization (2021). World drowning prevention day 2021. https://www.who.int/campaigns/world-drowning-prevention-day/2021.

90. World Health Organization, Regional Office for South-East Asia (2021). Regional Status Report on Drowning in South-East Asia, New Delhi. Licence: CC BY-NC-SA 3.0 IGO.

91. Yadollahi, M., Rosli, M.Z. (2011) Development of the Analytical Hierarchy Process (AHP) method for rehabilitation project ranking before disasters. WIT Transactions on The Built Environment, 209220. https://doi.org/10.2495/DMAN110191

92. Yamazoe J, Naito H (2022). Roles of dental care in disaster medicine in Japan, Current Oral Health Reports, 9:111-118, 2022. https://doi.org/10.1007/s40496-022-00314-z.

93. Zhou F, Botzen W (2021). Firm Level Evidence of Disaster Impacts on Growth in Vietnam. Environmental and Resource Economics (2021) 79:277–322 https://doi.org/10.1007/s10640-021-00562-0.

THE END.