

A Study on the Feasibility Examination for Utilizing New Technology in the Nuclear Emergency Response Training Program

Seokki Cha^{ab*}, Hyo Rak Lee^a, Young Woo Jin^a, Changkyung Kim^b, Minsu Cho^{a**}

^aKIRAMS (Korea Institute of Radiological and Medical Science), 75 Nowon-ro, Nowon-gu, Seoul, Rep. of Korea

^bSTP (Science & Technology Policy) Dept., Hanyang Univ., Wangsimni-ro, Seoungdong-gu, Seoul, Rep. of Korea

*First author: skc@kirams.re.kr

1. INTRODUCTION

Nuclear technology provides energy to humans with high efficiency and can be considered as an environmentally friendly energy resource that enables low carbon emissions. [1] In addition, radiation science applied from nuclear technology has been very useful in various fields such as agriculture, medicine, non-destructive analysis, and geologic logging, which has prospered human life. [2] Nevertheless, in the event of accidents caused by these technologies, psychological and social disturbances can be widely caused by radiological human influences due to the specificity of radiation that cannot be detected by the five senses. [3] For this reason, the government of Republic of Korea is planning and implementing a nuclear emergency training program based on the 'ACT ON PHYSICAL PROTECTION AND RADIOLOGICAL EMERGENCY' to improve the level of proficiency of nuclear emergency response agents. Recently, by utilizing new A/VR technologies in various disaster and safety areas, the agent have been strengthening their proficiency in responding to accidents. According to the 'Marine Accident Investigators International Forum' (MAIIF) survey of the maritime and ship sectors, there were 93 deaths and 96 injuries in 101 accidents during 1998-2009 when a vessel entered a confined space under special circumstances. Therefore, the 'International Maritime Organization' (IMO) revised the 'Guidance for Enclosure Entry and Rule 19 of Chapter 3 of the SOLAS 1974 Convention' to periodically enforce enclosed space entry training for ships under special circumstances. Such improvement of proficiency may require practical and repetitive learning and training without restriction of places. Therefore, 'Korea Institute of Maritime & Fisheries' and 'Korea Research Institute of Ship & Ocean Engineering' have proved the effectiveness of upgrading the vessel's confined space entry proficiency under special circumstances by using the new technology in the training program. [4] Also new technology has recently been used in fire response to reproduce situations that are difficult to describe. In the field of railway, the necessity of using the A/VR education and training system has been attracting attention in order to prevent accidents caused by human errors and under-proficiency of railway driver. [5] These studies consider the use of new A/VR technology to improve the proficiency of specific behaviors under special circumstances. So, this study argues the necessity of using A/VR technology in the field of nuclear emergency response training program.

2. MATERIAL AND METHOD

2.1 Classification of Training Program into 15 Sessions

Nuclear emergency response training program is conducted

in accordance with article 37 of the 'ACT ON PHYSICAL PROTECTION AND RADIOLOGICAL EMERGENCY'. Local governments and nuclear operators covering all or part of the emergency preparedness zone are obliged to implement nuclear emergency response training programs in accordance with the 'ACT ON PHYSICAL PROTECTION AND RADIOLOGICAL EMERGENCY'. According to article 35 of the enforcement decree of the 'ACT ON PHYSICAL PROTECTION AND RADIOLOGICAL EMERGENCY', training for the participation of designated agencies and nuclear operators in jurisdictions should be conducted at least once every two years and at least once a year for intensive training in specific areas requiring cooperation in the event of a disaster. This training program aims to improve the proficiency of agent in response to nuclear emergency. The training contents implemented in the current nuclear emergency response training programs could be categorized into 15 sessions as shown in Table 1. This is the result of classifying the training contents according to the specific behavioral performance characteristics under special circumstances.

Table 1. Training Program Sessions

Session	Contents
1	Propagation of Emergency Situations
2	Understanding the Response Manual of Nuclear Emergency Response
3	Table-Top Training for Commanding Ability
4	Use of Communication Devices
5	Use of Personal Protective Equipment
6	First-Aid the Injury in the Accident Site
7	Radiation Detection and Dosimetry
8	Management of Emergency Supplies
9	Maintenance and Use of Dispatch Vehicle
10	Installation and Use of Negative Pressure Tent
11	Radioactive Decontamination
12	Installation and Use of Deployment Tent
13	Utilization of Emergency Response Equipment
14	Radiation Emergency Medical Treatment
15	Stand to Extreme Circumstances

Session 1 is the training content for the first agents who recognize the emergency information to accurately disseminate related information to other agents. Session 2 is intended to familiarize users with manuals developed to respond to nuclear emergency. It is also content for improving the understanding of the governmental nuclear emergency response system. Session 3 is the table-top training content for establishing interdisciplinary cooperation systems. This aims to minimize the spread of effects of nuclear emergency. Session 4 is the training content to improve the proficiency of using emergency communication devices in the event of complex nuclear emergency disaster. Session 5 is training content to practice the use of protective equipment for radiation protection during nuclear emergency. Session 6 is the practical training content for medical first aid for radiation casualties. Session 7 is the theoretical education and practical training contents for improving radiation detection understanding in case of nuclear emergency. Session 8 is the practical training content of peacetime inspection training to maintain the availability of supplies to response nuclear emergency. Session 9 is the practical training content that improves the proficiency of maintenance and utilization of the vehicle for rapid dispatch to the accident site in the event of nuclear emergency. Session 10 is the practical training content to improve the skill of installing and utilizing negative pressure facilities to prevent the spread of radioactive contamination. Session 11 is the practical training content to remove and dispose of radioactive material contamination under nuclear emergency. Session 12 is a proficiency training content for the installation and use of deployable tents at the nuclear emergency site. Session 13 is training content to improve the proficiency of using emergency response equipment in the field. Session 14 is a training content for implementing emergency medical care for radiation casualties under special circumstances. Session 15 is a training content conducted in winter to improve proficiency of nuclear emergency response performance under extreme weather conditions.

2.2 Proficiency Distribution Analysis Methodology by R Program

R was first offered in 1993 as a free version of S-PLUS by Ross Ihaka and Robert Gentleman from the University of Auckland, New Zealand. R has almost absorbed users of the existing S-PLUS (S language). Despite being open source, R has high performance computing speed and data processing capability. The R program is still available free of charge in open source and can be used to perform statistical tasks, data mining and data visualization. In particular, there is an advantage that it is possible to utilize R functions indefinitely through computer programming based on the understanding of the language of R. In recent years, R programs have been used in various fields because a community that develops and shares packages for free with extended R program functions. The 'ggplot2' package is a visualization package developed by Hadley Wickham that specializes in data visualization among various R program packages created by the active community. It is also known as the most commonly used package in R. The 'ggplot2' package is a package created by applying the

'Grammar of Graphics' methodology to R's grid graph system. Thus, 'gg', which means 'Grammar of Graphics', combines R's basic graph function, 'plot' and '2' which means the second version, as result of that is called 'ggplot2'. [6] In this study, data mapping using the 'ggplot2' package of R program was conducted to examine the current proficiency distribution of nuclear emergency response agents.

2.3 Benefit and Cost Analysis

B/C (Benefit and Cost) analysis refers to a comparative analysis of the benefits against the cost of public funds. If the B/C analysis shows that the benefits to the entire population are greater than the costs, the cost of public funds of the invested government may be considered positive validity. [7] Therefore, the economic results can be analyzed by calculating the cost-benefit ratio method for future benefits and values. This can be summarized as follows.

$$B/C = \frac{\sum_{t=0}^n \frac{B_t}{(1+i)^t}}{\sum_{t=0}^n \frac{C_t}{(1+i)^t}}$$

Bt : Benefit of t Year
Ct : Cost of t Year
i : Social Discount Rate

If the B/C index is greater than 1, it can be regarded as a benefit from technology development. In addition, as a result of the economic evaluation, if the B/C value is greater than 1, a larger benefit or profitability is considered. The social discount meaning 'i' in the equation can vary depending on the social background of each country. In Republic of Korea, the social discount rate is 4.5% based on the government guidelines.

3. RESULTS

3.1 Result of Proficiency Distribution Analysis

In Sessions 3, 11 and 14, proficiency distribution of agents in nuclear emergency response was relatively low. The reason for this result is that Sessions 3, 11, and 14 are difficult to reproduce in the real world of peace. Session 11 is difficult to reproduce because of the specificity of radiation. Session 14 is difficult to reproduce because of medical practice under special circumstance of nuclear emergency. The visualization of these data with R programming is shown in fig 1.

3.2 Results of Cost-Benefit Analysis

The B/C ratio was estimated as 2 by applying the cost-benefit analysis equation. Therefore, the economic feasibility of using A/VR technology system was positive.

4. DISCUSSTION & CONCLUSION

Proficiency of Agents was low in sessions that were hard to reproduce in the real world of peace time due to radiation specificities. By using new technology, it is possible to realistically reproduce the nuclear emergency situation in the real world. Also this will enable the minimization of place constraints, practical learning as well as repetitive learning and so on. Therefore, it will be possible to advance the proficiency of nuclear emergency response agents that require background knowledge of various fields.

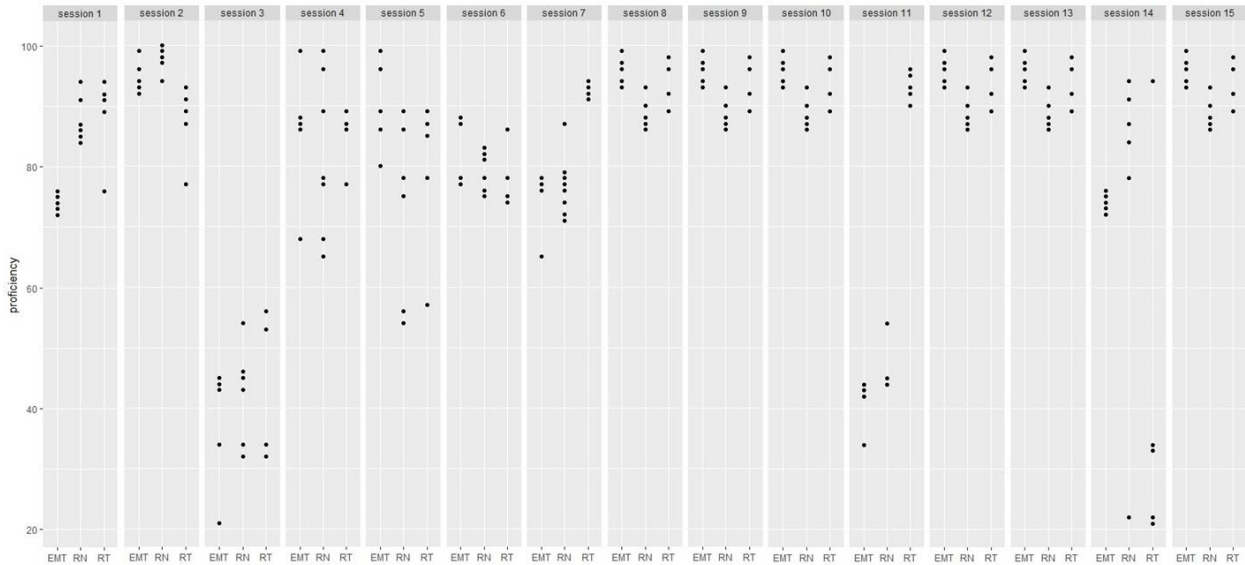


Fig 1. Data Mapping Visualization from R Program

ACKNOWLEDGEMENT

This study was supported by a grant of the Korea Institute of Radiological and Medical Sciences (KIRAMS), funded by Ministry of Science and ICT, Republic of Korea (1711045572/50445-2019)

REFERENCES

- [1] OECD NEA, The Role of Nuclear Energy in a Low-Carbon Energy Future (France) ISBN: 978-92-64-99189-7, 2012.
- [2] IAEA, Radiation Processing: Environmental Applications (Vienna) ISBN: 92-0-1-100507-5, 2007.
- [3] Charles A. Salter, Psychological Effects of Nuclear and Radiological Warfare, Military Medicine, Vol. 166, Supplement 2, pp 2-17, 2001.
- [4] Chong-Ju Chae, Jin-Woo Lee, Jin-Ki Jung, Young -Joong Ahn, Effect of Virtual Reality Training for the Enclosed Space Entry, Journal of the Korean Society of Marine Environment & Safety, Vol. 24 No. 2, pp 232-237, 2018.
- [5] Seokyoung Yoon, A Study on the Improvement of Safety Education System for Railway Drive Task Employees, Dissertation, Department of Railway Safety Graduate School of Seoul National University of Science and Technology, 2018.
- [6] Nicholas E Hamilton, Michael Ferry, ggtern: Ternary Diagrams Using ggplot2, Journal of Statistical Software; Dec, 87 cn3, pp 1-17, 2018.
- [7] Doo Ul Kim, Introduction to Cost Benefit Analysis: Basic Principles and Practices, Korea legislation Research Institute, 2017.