Title	留学生の災害時の対応スキル向上を目的としたビデオベース学習支援システムの開発
Author(s)	Sagorika, Safinoor
Citation	
Issue Date	2021-12
Type	Thesis or Dissertation
Text version	ETD
URL	http://hdl.handle.net/10119/17601
Rights	
Description	Supervisor:長谷川　忍，先端科学技術研究科，博士

Design and Development of Video Aided Retention Support System for Enhancing Disaster Survival Skills Among International Students

Safinoor SAGORIKA

Japan Advanced Institute of Science and Technology (JAIST)

Doctoral Dissertation

Design and Development of Video Aided Retention Support System for Enhancing Disaster Survival Skills Among International Students

Safinoor SAGORIKA

Supervisor: Professor Dr. Shinobu HASEGAWA

Graduate School of Advanced Science and Technology
Japan Advanced Institute of Science and Technology (JAIST)
[Information Science]
December 2021

Abstract

Response to natural disasters and how to save lives and resources became a vital issue around many countries in the world. Among them, Japan is one step forward in terms of disaster education and training. Academic institutions in Japan regularly provide disaster survival skills training to reduce vulnerability and to create disaster awareness among the students. A large number of international students come to Japan every year to pursue higher education and research a diverse discipline. In many cases, these international students do not have enough knowledge and training on how to survive in a disaster situation while living in Japan. The available literature shows a significant gap in the field of disaster survival skills (DSS) between Japanese and international students. There are diverse types of content used in DSS education and training. Among them, video content received broad interest from the students and instructors in a self-directed video-based learning environment. However, in Japan, DSS video content specially designed for international students is limited. Besides, unstructured long video contents consume learning time and concentration of the students resulting in poor engagement and learning outcome from video content. In addition, scattered and unstructured short videos available in different sources force students to lose their way of learning as well as miss some important content. Moreover, tracking, and analyzing students' learning behavior inside video parts including the attention and retention process to support them during learning are missing in traditional video-based learning.

To overcome these issues, the objective of the research is to design, develop, implement, and evaluate the Video Aided Retention Tool (VART) system to support international students in enhancing their disaster survival skills through self-directed video-based learning. In pursuing the objectives, this research focused on one Major Research Question (MRQ): How to develop an adaptive self-directed video-based learning support system for enhancing DSS among international students? and five Subsidiary Research Questions (SRQs) as SRQ1: Which type of content structuring systems are appropriate for the DSS video content? SRQ2: What type of domain, students', e-teaching strategy models are required for video-based DSS training? SRQ3: What is the process of integrating different models with the VART system? SRQ4: How to implement the system among international students for providing DSS training? and SRQ5: How to assess students 'learning outcomes and provide necessary feedback and recommendation in video-based training and learning process?

The research follows the five phases of the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model from the beginning to the end of the task as a framework for the VART system in the proposed platform. In the analysis phase, the research did a good number of literature reviews to realize the current situation of disaster training and learning in Japan. Besides, the research did a questionnaire survey and collected primary data from 133 international students at the Japan Advanced Institute of Science and Technology (JAIST) to realize the actual situation of DSS knowledge and experiences. In the design phase, the research provides the design structure/architecture of the four conceptual models for VART. The models are i) domain model, ii) students' model, iii) e-teaching strategy model, and finally iv) a conceptual model with the integration of VART for supporting the DSS learning. In the development phase, the research developed three content structuring systems: i) non-support (N) traditional long video, ii) structured (S) long video with virtual fragmentation, and local indexed, and iii) branching (B) scenario lessons with short videos to determine the appropriate content structure of VART. In the implementation phase, the researchers conducted an experiment to identify the appropriate content structuring system and understand the effectiveness of the proposed method. In the evaluation phase, the research compared the changing impact of the learning outcome among the learners before and after implementation, summarized and modified the functions where necessary, and proposed the new system for implementation in the disaster survival education domain.

To identify the appropriate content structuring system, the research conducted an experiment among the 36 international students in JAIST to track students' watching and learning behaviors, including the attention and retention process. Results show that branching (B) scenario lessons are the most preferred by the participants (50%) in the video-based learning system followed by the structured (S) video (45%). Very few participants (5%) only preferred non-supported (N) video structure. In addition, the Normality test result shows that video 02 structured video (S) score and video 03 branching video (B) scores are non-normal distribution, while video 01 non-support video (N) score and pre-test score are a normal distribution. The Friedman test indicates that the statistical significance among the three videos is <.001, which is below 0.05. So, it is statistically proven that the three videos have significant differences. In the Bonferroni correction, we found statistical significances <.001 less than .017 between videos 01 and 02, and between videos 01 and 03. So, there are also statistically significant differences between the video 01 scores with videos 02 and 03 scores. The result shows positive effects on videos 02 & 03, and the score results are also higher than video 01. Besides, the learning behavior and learning outcome also have a significant effect on the videos 02 and 03 comparing video 01.

In addition, to realize the structural relationship among the students' previous knowledge on DSS, duration, repetition, clicks, and score from a video-based learning environment, the research applied Structural Equation Model (SEM) using SmartPLS for videos 02 and 03. The SEM-Partial Least Square (PLS) bootstrapping model fit analysis indicates that the d_ULS and d_G (Saturated and Estimated model) value of videos 02 and 03 are in the supported range of SEM-PLS model fit. The Normed Fit Index (NFI) for both types of video content are well supported (acceptable value between 0 and 1), which is 0.609 and 0.694 for structural and branching videos, respectively. The research also found that the number of repetitions of Learning Objects (LOs) has a significant impact on the group as well as the individual learning process. Hence, the research suggests that the domain model should be formulated based on users' watching history data. The LOs which received a greater number of views, the system might recommend such LOs both for the individual or group of students. Similarly, students' models are also formed based on the learning behavior, attention, and retention process of each student. Accordingly, the research provided mathematical algorithms to provide necessary recommendations both for the group students and individual students.

The research created the platform, developed content under different content structures, added essential support functions to the videos, and allowed students to access the platform and learn from the video domain. With the assistance of VART, the domain model displays the important contents, important video parts with the indexes, and students watch some videos as retention and the system gets the learners' model based on watching history data. The VART then assists the e-teaching strategy model in receiving and combining data from the students' model and the domain model and knowing the learner's attention and retention process. Based on the watching and learning behavior data, the system determined instant feedback and recommendation to the students.

The VART system overcomes most of the issues faced by international students in DSS learning. In addition, the VART system can support meeting the teaching-learning goal of students, as well as the educators/instructors. Besides, the summative assessment indicates a significant improvement in students' learning behavior and learning outcome. The content visualization map and learners' learning path visualization map developed in this research is helpful to both the learners and the educators/instructors to realize the learning scenario and assist students in adjusting to the content structure dynamically. The proposed VART system might help overcome the existing limitations in video-based DSS learning, and support students acquire the necessary DSS skills in a self-directed learning manner.

Keywords: Content Structuring System, Disaster Survival Skill (DSS), Video Aided Retention Tool (VART), H5P, Video-based Learning, Self-directed Learning, Learning Support System, International Students

Achievements

Publications

Several manuscripts have been published during my doctoral research. Therefore, some contents, information, figures, and tables in this dissertation might have previously appeared in the following publications.

International Journal Articles:

1. S. Sagorika and S. Hasegawa, "Design of Video Aided Retention Tool for the Health Care Professionals in Self-directed Video-based Learning," *Turkish Online Journal of Distance Education*, vol. 21, no. Special Issue-IODL, pp. 121–134, 2020.

2. S. Sagorika and S. Hasegawa, "Development and Identification of Content Structuring System for Video-based Disaster Survival Skill Training Among the International Students" Journal of *Educational Technology Research and Development.* (On submission)

3. S. Sagorika and S. Hasegawa, "Development of Data-driven Learning Path Visualization Map and Recommendation System in Video-based Disaster Survival Skill Training" Journal of *Research and Practice in Technology Enhanced Learning*. (On submission)

International Conference Proceedings:

Manuscripts Related to Major Research

4. S. Sagorika and S. Hasagawa, "Model of Video Aided Retention Tool for Enhancing Disaster Survival Skills on Earthquake among International Students," in *28th International Conference on Computers in Education*, 2020, vol. II, p. 215-225, November 2020, Tokyo, Japan.

5. S. Sagorika and S. Hasegawa, "Video Aided Retention Tool for Enhancing Decision-Making Skills Among Health Care Professionals.," in International Open and Distance Learning Conference Proceedings Book, 2019, p. 305-312. IODL-2019, Eskişehir, Turkey.

6. S. Sagorika and S. Hasegawa, "Designing a Soft-skill Cultivation Platform for Health Care Professionals (HCPs)," in *The 13th International Conference on Knowledge, Information and Creativity Support Systems (KICSS 2018)*, p. 212-217, 2018. Pattaya, Thailand: Artificial Intelligence Association of Thailand.

Manuscripts Related to Minor Research

7. S. Sagorika, S. Kawanishi, and S. Hasegawa, "Adopting Orphan Migrants in Japanese Elderly Care Services: A Diversified Model for Ishikawa Prefecture", in the *6th Asian Conference on Aging & Gerontology 2020 (AGen2020)* Conference Proceedings, p.13-18, 2020. The International Academic Forum (IAFOR) 2020, Tokyo, Japan.

Awards

i. Ministry of Education Culture Sports and Technology (MEXT/Monbukagakusho Scholarship), Japan 2017-2021 for doctoral research.
ii. Educational Internship Project in Malaysia, 2018, JAIST, Japan.
iii. JAIST Research Grant, 2019 for attending IODL-2019 conference, Eskişehir, Turkey.

Table of Contents

List of Tables

List of Figures

Definition of Terminology

1. Learning Objects (LOs)

The LOs are small learning units or video parts of the fine granularity, which has their own meaning and learning goals [1]. It also improves reusability and enhances the quality of the learning resources. So, it must be created adaptive to achieve high acceptability by the learners and engage them in their learning process [2]. For example, in the proposed domain model, each video part or LO has a meaningful index, timestamp, and ranking, so that it can save the time and concentration of the students to locate their desired parts to learn and provide more adaptation and engagement with the learning objects.

2. Disaster Survival Skills (DSS)

Definition of DSS Disaster Survival Skills (DSS) are both the psychological, and physical abilities or techniques of a person that he/she may use instantly in a dangerous situation to save himself/herself and others [3][4]. In other words, disaster survival skills are strong cognitive skills as well as practical skills to judge or identify any dangerous situation very quickly and make instant decisions to save life or execute from the dangerous place safely. Therefore, awareness about the situation and making a quick decision have a tremendous effect on acquiring successful and effective disaster survival skills [5]. In this research, DSS refers to learning necessary knowledge, and skills on disaster aiming to enhance students' awareness, behavior, and reaction towards disaster situations [6]. The will to live and must live safely could be a turning point for a disaster survival situation.

Although, DSS is divided mainly into two types of skills i) cognitive skills, and ii) practical skills, learning basic knowledge about the disaster is a prerequisite before learning any skills. Therefore, the research has emphasized learning basic knowledge as well as learning cognitive skills such as cultivating awareness, preparedness actions, situation judgment, and decision-making skills, etc., and physical skills, such as practical actions or demonstrations on the disaster.

Knowledge Learning

Learning knowledge basically refers to theoretical understanding or getting familiarity with something or some events with necessary factual and descriptive information. This process mainly includes reading, watching, listening, sharing experiences, and similar activities [7] [8]. In the proposed disaster knowledge learning, it includes knowing the topics and sub-topics of the content structure, learning from texts represented in the videos, and simply watching some videos on common information and cautions on disasters, and understanding the risks involved in disasters [9].

Cognitive Skill Learning

The cognitive skills include students' knowledge of disaster, awareness, preparedness actions, situation judgment, decision-making skills, and so on. Among them, decision-making is considered one of the important cognitive procedures [10] in acquiring DSS. In decision-making learning, the learner should learn diverse situations to get the criteria of decision making. In the proposed content selection method, a variety of real-life scenarios, and situational videos are included to provide experiences-based situations to teach them decision-making skills. At the same time, knowledge-based videos are important to increase their awareness and preparedness knowledge on the disaster which also contribute to making decisions during a disaster situation. Therefore, to improve student's cognitive skills including decision-making skills, watching a variety of knowledge-based, real-life scenarios, and situational videos are essential. In fact, when they watch a knowledge-based video for the first time, they might acquire some basic disaster survival knowledge from the video. But they cannot be sure that they can apply the knowledge to make decisions in the actual disaster situation. But if they watch the video many times, they might remember some important parts. Or if they watch some actual situational, or factual videos first, and then watch the knowledge-based video, in that case, they get to know how to apply such knowledge in an actual situation. This is how their knowledge converts into skills. In the case of learning cognitive skills, making repetition of the video parts is not mandatory but, if learners wish to make repetition while learning from the contents, it depends on their learning need, and behavior.

Practical Skill Learning

Practical skills are considered physical actions or demonstration activities. For example, how to provide CPR, how to use an AED, or how to learn the steps to operate a fire extinguisher properly, etc. In this case, the proposed system has used a variety of necessary earthquake drills, and practical videos so that students can acquire the necessary skills. For example, how to provide CPR when someone collapses. In physical skills learning, watching the video or specific parts of a video several times has a good effect on knowing how to do or learn the skills following step by step methods. Therefore, making repetitions of important video parts, and learning the necessary actions or functions step by step is important in this case.

3. Video Aided Retention Support System (VARS)

The Video Aided Retention Support System (VARS) indicates the entire learning support system designed and developed to provide video-based Disaster Survival Skill (DSS) training among international students. The VARS integrates the Learning Management System (LMS), Video Aided Retention Tool (VART), H5P, programming languages, and other support tools to create the whole system and allows students, instructors, and concerned users to use the domain and other facilities on the same platform.

4. Video Aided Retention Tool (VART)

The proposed VART system combines video fractioning, indexing, tracking, analyzing, and filtering tools to integrate the domain model, students' model, and e-teaching strategy model to assist in self-directed video-based learning. The system organizes and makes fractions of each long video into different important parts, puts indexes for each fraction, and identifies interrelated and prerequisite Learning Objects (LOs). Similarly, it also organizes short videos and structures them based on interrelated and prerequisite relations among the LOs. Furthermore, it tracks each student's ID, content preferences (attention), duration, repetition of the content (retention), most watching parts, etc., during watching. Based on the detailed watching history data, VART analyzes and determines each student’s learning needs and filters and delivers essential video parts sequentially to support the video-based learning process.

Acknowledgement

First and foremost, I bow myself with utmost gratitude to the Entirely Merciful, the Almighty Allah, for planning my name as a doctoral research fellow, and providing me enough patience, and strengths throughout my doctoral research journey. Without the compassion of the Almighty, it would not be possible to make the impossible a "possible adventure".

My heartfelt thanks and intense appreciation go to my respected Professor and Supervisor Dr. Shinobu Hasegawa, area of Learning Technology, Learning Informatics and Educational Technology in JAIST, for his target-oriented, and brilliant support throughout my doctoral journey. He is more than a professor. His continuous supervision, scholarly instructions, profound teaching, genuine contribution, high patience, and generosity made me not only a researcher but also opened my eyes about how to shape myself as a committed researcher and dream to be an educator. He taught me numerous new concepts, the latest ventures, tools and technologies, important parts of statistical analysis, and algorithms, in the field of education and learning technology which I did not know before. I feel fortunate enough and convey my earnest gratefulness to the Almighty to assign his name as my distinguished Supervisor.

I also would like to acknowledge the name of my respected second supervisor and one of the committee members, Associate Professor Dr. Kiyoaki Shirai, for his constructive statements on my thesis and research presentations, and for always being very kind to me in the laboratory. Special gratitude to my esteemed minor research supervisor Professor Dr. Shungo Kawanishi for guiding me and making me feel the Japanese cultures, issues, and the way Japanese people live their lives. My sincere thanks go to the respected judging committee members Professor Dr. Kazunori Kotani, and Professor Dr. Kokolo Ikeda, JAIST, and Associate Professor Dr. Hiroyuki Mitsuhara, Tokushima University, for their time and valuable remarks on my research and thesis paper. I am very grateful to my esteemed master research supervisor Professor Dr. Md. Shiful Islam, University of Dhaka, Bangladesh, an alumnus of JAIST, introducing JAIST as a world-class university and always encouraging me from the beginning.

I must express my thankfulness to the Ministry of Education Culture Sports and Technology, Japan for awarding me with the renowned MEXT Scholarship, which opened the door to enter the community of doctoral researchers. I also acknowledge JAIST as well as my "Hasegawa Lab" for funding me to attend several international conferences in Japan and abroad and to conduct miscellaneous research activities.

I cannot but must mention my wonderful lab members, friends, and contemporary research fellows for their support, and constructive criticism during lab seminars and research activities in everyday life. I must mention the name of my best friend in the lab Mr. Xu Tianshu, whom I also consider as my loving younger brother for his impatient support. He always stood beside me like an honest, and very devoted person from my 1st day in JAIST until graduation. I also would like to mention another good friend Mr. Minh-Tuan Tran for his time and scholarly discussion in my lab life.

Finally, I must remember my most beloved parents Md. Abubakar Siddique and Ms. Sherena Begum for their endless prayers, and unconditional love for me always provide me the spiritual shades of a Banyan tree to nurture my entire life and overcome this challenging journey. I am so grateful to my brothers and sisters and all family members, relatives, known and unknown significant others, who kept me in their daily prayers. My heart always melts on my eldest brother BM. Abenoor Rahman Bin Abubakar and eldest sister Kohinoor Binte Abubakar for their strong support and keeping trust in me without any reason.

I have no language to express my thankfulness to my beloved son Md. Miraj Mahmood and husband Dr. Md. Mukhlesur Rahman. They had been always beside me and experienced my hurdles. I am so grateful to them for their intensive supports, sacrifice, time, and patience for the sake of a loving family.

Safinoor Sagorika
JAIST, Ishikawa Campus
September 30, 2021

Chapter 01: Introduction to the Research

1.1 Introduction

Disaster Survival Skill (DSS) training for students is considered as one of the mandatory criteria to reduce the risks and increase the survival capacity during disasters. Researchers found that a huge number of international students studying in Japanese universities have little or no prior knowledge and skills on how to survive in a disaster [11], especially in an earthquake, tsunami, or sudden fire situation. Students who have a low level of awareness become very nervous during the disaster and unable to take proper actions, and cannot protect themselves sufficiently during an emergency [12] [13] [14] [15]. So, to reduce such vulnerability, providing DSS training to international students is considered a mandatory part of disaster education. However, it is very challenging to conduct an earthquake disaster education or similar training course because this type of disaster cannot be replicated. It is also hard to involve the students emotionally in the traditional learning process or take them to the actually affected sites [13]. Very recently, due to the COVID-19 situation, organizing face-to-face and group training has become quite challenging. As a result, the learning functions have been forced to move online [16]. Contemporarily, watching video streaming from various video-sharing platforms as well as institutional videos on the web has become one of the important parts of the teaching and learning process. However, determining learning outcomes from video content is difficult, especially in self-directed learning. Yuzer, Firat, & Dincer [17] research suggested that there should be learning analytics tools for educators as well as learners for analyzing learning outcomes from a learner's interaction with every medium of content. In this case, video content again received significant attention from the teaching and learning communities.

However, in this situation, a well-designed and target-oriented video and animation-based DSS training platform is very important for international students to increase their awareness and preparedness. This kind of online training might enhance their survival skills to prepare and tackle any catastrophe during an earthquake and similar disasters while staying in Japan.

Accordingly, this research proposes the design and development of the Video Aided Retention Tool or VART system for analyzing video content to assist in the self-directed video-based DSS learning among international students. The proposed VART is a newly introduced and combined tool to create different types of content structuring systems, add interactions inside the video parts, segment more specific parts inside the videos, and put the indexes or tags to represent each specific part or content in a meaningful way. It also can instantly conduct content moderation across a huge amount of data, filter a user's viewing history and preferences quickly and efficiently, represent a learning path visualization map, and provide a necessary recommendation to aid in self-directed video-based learning [18].

1.2 Context of the Research

Response to natural disasters and how to save lives and resources became a vital issue among all groups of people in Japan. Because of her geographical, topographical, and meteorological conditions, the country suffers from various natural disasters like earthquakes, tsunami, typhoons, heavy rainfall, and snowfall, etc. [19] [20]. One of the major disasters in the present decade was the 2011 Tohoku earthquake and tsunami, which caused unlimited damage in Japan [21]. At that time, a dozen colleges and universities were closed on the eastern pacific coast of Japan. Many classrooms, laboratories were damaged, and computer networks were damaged at six universities in Sendai [22]. Households of 526 students were damaged; 28 buildings were unsafe, and 48 buildings were restricted to use at Tohoku University in 2011 [23]. Three were 15,879 deaths, 2,700 missing people, 6,132 injured, including many students in that area, and 128,911 buildings completely collapsed [24]. Very recently, the year 2018 and 2019 was remarkable for a series of natural disasters like floods, earthquakes, storms, and Typhoons, etc. which caused many deaths and a huge economic loss [25] [26].

In this globalized age, students have the enormous opportunity to move from one country to another for pursuing higher education, acquiring knowledge, and conducting research on a diverse discipline. Japan is one of the top preferred countries for obtaining quality education among global students and scholars. As per the statistics provided by the Japan Student Services Organization (JASSO), about 312,000 international students enrolled in Japanese schools in 2019 [27]. These increasing numbers of international students basically do not have enough knowledge and training on how to survive in a disaster situation, especially during an earthquake, tsunami and a sudden fire, an unknown infectious virus, or a criminal attack while living in Japan. So, they may need to adapt to many social manners as well as different types of emergencies for their survival.

In Japan, disaster education is provided elaborately in primary and secondary schools in their native language. As a result, Japanese students are well trained about how to tackle disasters before they enter universities. However, there is a lack of standardization in Japanese universities' disaster education, and most of the international students come to study at the university level [11] who have different disaster knowledge and skill levels [28]. It is found that a significant number of these students do not have any remarkable previous training or experiences on how to survive in an earthquake, tsunami, fire, or such kind of disaster situation. In addition, many of them feel a low interest in the current DSS education and training method in Japan. They cannot adopt the training due to the communication gaps, language barrier, content variations, different learning and training approaches or methods.

However, researchers found that, in current disaster education and training approaches, concrete disaster training videos and animation-based contents are well known, practical, and received wide acceptance among the teachers/instructors and learners [29] [4] [30] [31] [32]. So, the research considers video and animation-based real-life, practical, and demonstration-based DSS contents as the target domain to provide training among international students. Nevertheless, there are some problems associated with the current video-based training and learning.

1.3 Research Problems

Based on the previous research, this research identified several problems that triggered the designing and developing of VART to assist international students learning DSS from video and animation-based content. The core problems include:

(i) **Content Variation:** There is a diverse type of video and animation content existing in disaster education and training. There are a variety of DSS contents available on the same topic developed by different authors from different viewpoints. However, most of the available DSS training contents have been focused on 'What To Learn' but do not indicate 'How To Learn' based on the competency level of international students.

(ii) **Unstructured Long Videos:** In the case of long disaster training videos, the contents are usually integrated with several topics or learning objects (LOs) and unnecessary parts. If one video has this kind of complicated structure, it is difficult for the system to control the video sequences and the student's watching/learning behaviors. On the other hand, defining target parts from the long video consumes time and much concentration of the students in their busy schedule [33], resulting in poor engagement and learning outcomes from video content.

(iii) **Scattered and Unstructured Short Videos:** Short videos are often scattered and not structured based on inter-relation or pre-requisite relation**.** In this case, students often lose their way as well as miss some important content when learning from such kinds of scattered videos.

(iv) **Learning Behavior:** In the traditional video learning process, it is challenging to know students' preferences, information-seeking behavior, and interactions inside the video parts. Also, filtering expected content and delivering the contents based on students' attention and retention process and learning progress is important. However, most systems do not have a clear description of providing content based on the learner's competency level and learning progress.

Furthermore, there is no technique to follow the cognitive behavior of a learner to know his/her learning process and how to assist the learner in that process [34].

1.4 Objective and Research Questions

To overcome the above issues, the objective of the research is to anlyze, design, develop, implement, and evaluate the VART system to support international students in enhancing their disaster survival skills through self-directed video-based learning.

In pursuing the above objectives, this research has been formulated one Major Research Question (MRQ), and five Subsidiary Research Questions (SRQs) as below:

MRQ: How to develop an adaptive self-directed video-based learning support system for enhancing DSS among international students?

SRQs

SRQ1: What type of content structuring systems are appropriate for the DSS video content?

SRQ2: What type of domain, students', e-teaching strategy models are required for video-based DSS training?

SRQ3: What is the process of integrating different models with the VART system?

SRQ4: How to implement the system among international students for providing DSS training? and

SRQ5: How to assess students 'learning outcomes and provide necessary feedback and recommendation in video-based training and learning process?

1.5 Research Methods

The research follows the five phases of the ADDIE model from the beginning to the end of the task as a framework for the VART in the proposed platform. The ADDIE model is an Instructional Systems Design (ISD) framework that is widely used by many instructional designers and training developers to develop their educational and training programs [36]. This model is also known as the "Cyclic Improvement Process", initially developed for the U.S. Army by the Centre for Educational Technology at Florida State University in 1975 [37] . Nevertheless, the model includes five important phases: analyze, design, development, implementation, and evaluation to guide and achieve the whole task. The following diagram in figure1 is presented based on the ADDIE model, which briefly describes the process or the workflow of the proposed system.

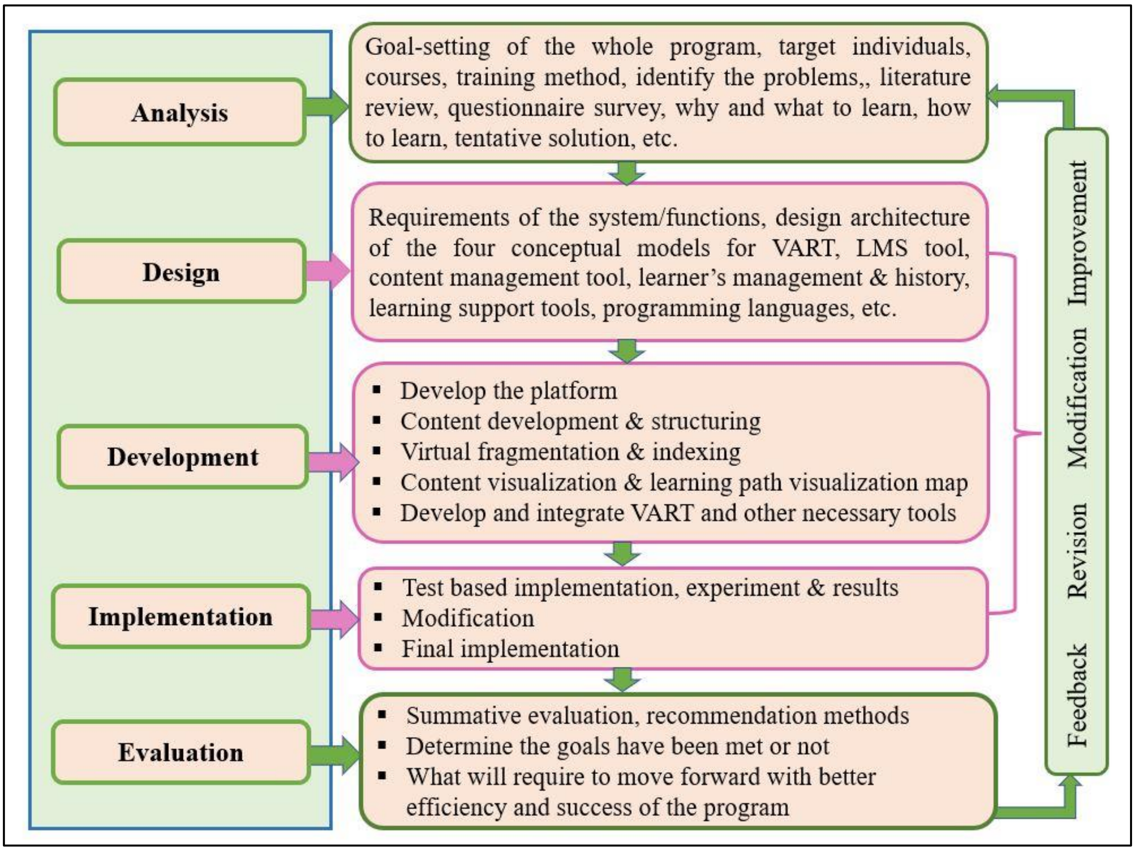

Figure 1: Workflow of the proposed VART system development

1.5.1 Analysis Phase

The analysis phase is considered as the goal-setting stage, pre-assessment matters and identifies the current situation and need. In this phase, the research did a good number of literature reviews to realize the current situation of disaster training and learning in Japan. Further, the research conducted a questionnaire survey among international students at Japan Advanced Institute of Science and Technology (JAIST) to realize the actual situation of DSS knowledge and experiences among them, their feelings on current DSS training, and their remarks for the future DSS training. After that, the research summarized the current situation, identified the need, determined the target course, course content, and learning methods, and the necessary tools to overcome the problems. Based on the circumstances, the researchers divided the whole problems into four main systems/functions and initiated step-by-step actions to solve the problems. These actions start with the design phase.

1.5.2 Design Phase

One of the essential roles in the design phase is to define the requirements of the system/functions to be developed to resolve the problems. The design phase provides the basic architecture to implement the four main functions or four conceptual models into the whole system. However, in the design phase, the research provides the design structure/architecture of the four conceptual models for VART. The models are i) domain model, ii) students' model, iii) e-teaching strategy model, and finally iv) a conceptual model with the integration of VART for supporting the DSS learning on earthquake for international students in Japan.

1.5.3 Development Phase

In the development phase, to realize the models on a computer as a support system, the research formalizes them as mathematics and data structures to develop the actual VART functions. It uses three different types of example videos or movies to realize the models' proposed functions. It also developed three content structuring systems to identify the appropriate content structuring system, such as i) traditional long video structure, ii) long video with virtual fragmentation structured and local indexed, and iii) short videos with branching scenario lessons. In addition, it also created interrelated and prerequisite assets or learning objects to indicate important content parts in the content hierarchy. Moreover, determined LMS tool, content management tool, learning support tools, learner's management, learner's activity management, programming languages, etc., as a development stage of the proposed platform.

1.5.4 Implementation Phase

In the implementation phase, the research considered test-based implementation and identified the positive outcomes from the system as well as shortcomings. In this phase, the researchers also conducted an experiment to identify the appropriate content structuring system and understand the effectiveness of the proposed method. The result showed directions for necessary modifications where it was needed and finally implemented the new integrated platform for assisting international students in self-directed video-based learning. In this phase, the research discussed all the implementation procedures and the outcomes from the implemented new system.

The design, development, and implementation phase followed the action research method to test, modify, and improve the functions concurrently until the whole system works well based on the expected goals and requirements.

1.5.5 Evaluation Phase

After the successful implementation, the research collected system-generated output for the evaluation of the proposed system. It conducted the summative evaluation and answered the research question to determine whether the goals have been met or not and what will require them to move forward with better efficiency and success of the proposed system. The research also compared the changing impact of the learning outcome among the learners before and after implementation. Finally, the findings were summarized and modified the functions where necessary and proposed the new system for implementation in the disaster survival education domain.

1.6 Dissertation Structure

The dissertation is structured in seven chapters. Figure 2 illustrates the overall chapter structure and brief content of each chapter.

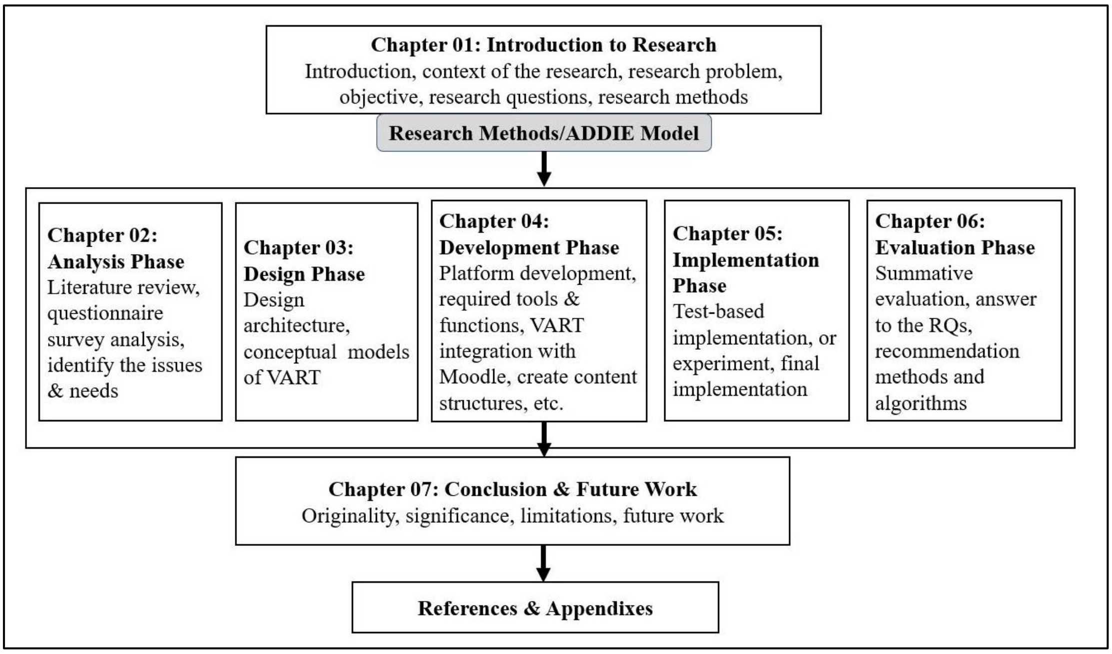

Figure 2: Dissertation structure

Chapter 01 discussed the introduction to the research, context, and importance of the research, research problem, objectives, and research questions followed by a brief description of the methodology followed in the research. At the end of chapter 1, the research illustrates the dissertation structure.

Chapter 02, in the analysis phase the research discussed the literature reviews with a special focus on characteristics of the international students, characteristics of the current content delivery method along with a description of the existing DSS training system in Japan. Besides, chapter 2 also includes preliminary questionnaire survey analysis, results, and findings including issues and needs of the international students and so on.

Chapter 03 illustrates the main design architecture and the essentials models of the proposed system which includes the students' model, the domain model, and the e-teaching strategy model. Besides, the integrated VART function model was also described in this chapter.

Chapter 04 discussed the detailed development of the platform, necessary tools and functions, VART integration with the Moodle LMS, content selection process, content development and structuring system, quiz creation, VART function, and other necessary functions.

Chapter 05 illustrated details about the experiment plan, settings, objective, methods, and other necessary matters related to the experiment, followed by the detailed data analysis and test result of the experiment and description of structural equation model fit. In addition, it also provided the delayed survey feedback of the students at the end of the chapter.

Chapter 06 discussed the assessment process, including summative assessment. Besides, the answers to the research questions were also discussed and provided descriptions on the system-generated content visualization maps, recommendation algorithms, as well as the evaluation of group students, and single students' learning path visualization maps as an important part of the evaluation of the proposed system.

Finally, chapter 07 discussed the originality, the contribution of the research, limitations, and future works as a conclusion of this dissertation.

Chapter 02: Analysis Phase

2.1 Introduction

The foundation of this research is based on the review of related literature and the computation of survey data.

First, based on the discussion on the research problems, objectives, and research questions, the research did a good number of literature reviews divided into three main topics. While reviewing the literature, the research focuses on investigating the i) characteristics of international students in acquiring Disaster Survival Skills (DSS) in Japan. It means how international students feel about the current situation of disaster education/training in Japan, their knowledge and experience levels, difficulties they face during learning, and why they need support in the learning process. After that, it explored the main ii) characteristics of current disaster education/training to know the type of content, content delivery method usage in disaster education. Finally, the iii) characteristics of the disaster education and training strategy in Japan. Based on the result of the literature review, the research will determine three main computational models and a conceptual model for the future DSS training platform.

Secondly, based on the findings from the literature review, the research collected primary data from international students in Japan Advanced Institute of Science and Technology (JAIST), Japan. Following sections demonstrate the findings from literature as well as the result of the survey.

2.2 Literature Review

2.2.1 Characteristics of the International Students

Haburi et al. [14] explored disaster readiness behavior between Japanese and international students and found that Japanese students have a higher level of disaster preparedness knowledge than foreign students. The behavior of international students is also different and not satisfactory in the disaster preparation situation. Therefore, the study suggested that the education method should be conducted in a different way for foreign students. Leleito et al. [11] identified that a big proportion of the international students in Japanese universities have little or no prior experience with disasters. Iwamoto and Ishikawa's survey result shows that around 60% of international students never experienced an earthquake in their home country, and 80% of respondents were very worried during the earthquake in Japan [12]. The research recognizes the differences in 'self-help' ability in an earthquake situation among the international students by comparing their disaster prevention knowledge levels and disaster prevention actions using the disaster prevention awareness scale developed by Shimazaki et al. [39]. The result shows that the students who have a low level of awareness could not secure themselves sufficiently during and immediately after the earthquakes, compared with high awareness level students [13].

The Japanese Ministry of Land, Infrastructure, Transport, and Tourism pointed out some special characteristics of the foreigners such as different levels of disaster knowledge and experience, disaster response behavior is different from Japanese people, language issues, lack of knowledge about local disasters and drills, and lack of communal mindset due to cultural diversities [28] [40] [41]. Kondo and Kawasaki [42] discovered that the language barrier is one of the main gaps which result in a lack of access to disaster prevention resources. Another study found that international students might perform risky actions during disaster incidence since they do not have proper knowledge of preparedness and survival skills. Education on this subject, and contents and support provided in English are highly expected from international students [15]. The students want fast, reliable, easily accessible information with no language barrier [43]. The survey conducted by Nakagawa [18] found that international students have a low interest in disaster prevention drills, and many of them provided their opinions that the training or seminars on disaster are not necessarily specific based on their demand. So, it should be knotted to relevant knowledge and behavior to concrete disaster prevention measures. Bisri and Sakurai suggested that it is important to know the special needs of international students and understand their risk awareness and disaster preparedness levels in order to provide inclusive education and training to them [44]. Table 1 below summarized the key findings of the features and characteristics of international students.

Table 1: Characteristics of international students

Features	Key Findings
Knowledge levels	✓ International students have a much lower DSS knowledge level than Japanese students. ✓ Their learning needs are different from Japanese students. ✓ Also, there are different levels among the international students based on their prior knowledge and experience [14][11] [12].
Barriers	✓ The language barrier, cultural differences, lack of knowledge about local disasters and drills, etc. lead them to lack access to the disaster education resources [28] [40] [41] [42].
Attitudes	✓ Low interest in the existing DSS education and training. ✓ Education and training provided on disasters are not necessarily specific based on their demand [18].
Feelings Why they need support	✓ Very worried during the disaster. ✓ Unable to take proper actions and may perform risky actions. ✓ Students who have a low level of awareness could not be able to protect themselves sufficiently during emergencies. [14] [12] [13][15]
Special Need	✓ Their special needs are fast, reliable, easily accessible contents with no language barrier tied to relevant knowledge on disaster prevention actions [15] [43][18] [44]. ✓ Contents and training provided in English are highly expected from foreign students [15].
Research Gap	✓ Identified students have different knowledge levels but did not propose or show the way how to teach them accordingly. ✓ Recognized special needs, feelings of foreign students and suggested that the education method should be conducted in a different way but did not discuss how to conduct that.

2.2.2 Characteristics of the Current Content Delivery Method

Japanese universities arrange emergency evacuation drills/training once or twice a year to create emergency awareness among students. Besides, there are text-based instructions on the university web pages on 'guidelines for crisis management' or text-based lectures for foreign students on disaster control [45] [46] [47]. But many international students are not fully aware of such drills and instructions delivered by an unknown language [12]. Challenges are associated with the course delivery method because the contents are received from diverse disciplines. In addition, the course contents need to be represented based on the student's different levels of previous knowledge on the disaster in a simple and understandable manner so that they feel the interest to learn from the content [11].

There are also different types of content such as text-based, verbal lectures, audio, videos, games, simulations, etc., that are available for disaster education and training on different sources. Wahyudin & Hasegawa [5] developed a 3D role-playing mobile serious game named MAGNITUDE to train inexperienced disaster volunteers to make proper ethical decisions. Hatakeyama, Nagai, & Murota [48] developed a scenario-based learning support system named Evacuation Scenario Simulator System (ES3) to improve students' judgment capacity in an emergency. Hiroyuki Mitsuhara et al. [49] developed a web-based system using 'Bosai Yattosar' (BY) to design a game-based evacuation drill (GBED) [49]. Toyoda & Kanegae [50] established a connection between problem-based learning (PBL) and gaming simulation (GS) to provide earthquake evacuation practice and training among university students. However, only game-based content cannot fulfill the DSS learning requirements and creating a virtual reality (VR) environment for simulation training is expensive and time-consuming to teach a huge number of international students in public universities.

Research results show that among all other contents, inclusive disaster training videos are very effective and can improve learner's understanding of disaster preparedness [29]. Sejati and colleagues [31] found that the use of multimedia contents, such as the combination of images, text, animation, sound, and videos provide enthusiasm and a deeper understanding of disaster risk education among the students. Therefore, students showed high interest when learning was conducted with multimedia contents. The study identified that learning by watching videos has some strong points that increase students' understanding of disaster; hold their interest and attention, help in the remembering process, show evidence, clarify and support ideas, change attitude, and save time [51]. Researchers also found that video and animation-based contents have a more significant impact on the learning and retention process and increase student's awareness of disaster [30] [31].The student may access the contents anytime, multiple times [52], the learning procedure becomes more stimulating and not dull [32], and supports self-directed and collaborative learning [53].

Tools Used in Video-based Learning

Researchers found that teachers and learners can reflect on their own teaching and learning experience with the support of video annotation or video analysis tools [54]. For example, some video annotation tools, VideoAnt or EVA, allow users to make a list of comments in the video parts. Another tool, called OVA, provides a platform that enables analysis and collaborative discussion on the topics illustrated in the video and allows learners to share comments with each other [55] [56].

Saravanan [57] created a segment-based indexing technique to segment and index the video files. Tian, Yan et al. [58] proposed a novel triple attention network called TriANet that utilizes temporal, spatial, and channel context by using the self-attention method for the fragmentation of the videos. However, this method is mainly applicable for the segmentation of specific images or groups of images of a video, for example, input image of an animal, object, and activity sequences like breakdance hand, leg, and head movement separately or specific dental dataset images, etc.

Researchers introduced hyper videos which afford high interaction between the content and the learners. Hyper videos are basically known as hyperlinked, structured, and non-linear interactive videos that enable learners to interact with the contents through links and navigate video with other related media such as text, images, audios, indexes, etc.[59]. Similarly, research created automated hyper video summaries into a new tool called 'Hyper-Hitchcock'. These hyper video summaries aim to minimize user disorientation from the linked navigation and to reduce the repetition of watching of video [60] which is somewhat different from our proposed approach. Our research encourages and emphasizes the repetition of specific parts of the videos to realize the retention process of the students.

Another research proposed a within-speaker keyword identifying system that creates indexes from lecture videos using audio keywords. It enables students to search required topics in the lecture videos using audio queries talked by the instructor [52]. However, this indexing technique is only based on audio keywords from the video data, but it does not include other elements in the videos such as discussion between students and the instructor and so on.

Very recently, Nazari et al. [61] found that step-by-step video-based learning results in lower cognitive load and fewer procedural errors than continuous video demonstration. Delen, Liew, & Willson [62] examined learners' self-directed learning behaviors in online video-based learning using 'common videos' with micro-level functions in the traditional method and 'enhanced videos' included macro-level with the micro-level functions in the experimental method. The study found that an enhanced video learning environment was accepted as a higher instructional tool than the common videos in terms of learners' learning outcomes.

Researchers also found that multi-media learning tools enhance the retention of information and provide quick and high-quality instruction on the learning topics [63]; video streaming teaching-learning facilities and their acceptance, enhanced the learners of the "do it yourself" approach [64]. However, it is worth mentioning that the learner's attention and retention process are very crucial for the "do it yourself" or self-directed learning environment. The learning process based on only watching the videos may not be effective until learners can remember, reflect, and use it in a real situation [65].

However, learners do not want to know the traditional indexes and structure but are more interested to know the inside contents parts and specific indexes of the videos [66]. It is hard to select the right video content in the contemporary video learning process, based on the learner's knowledge levels, attention, and retention process. Also, defining and fractioning essential parts with meaningful tags from the long video is challenging and time-consuming [33]. Ding et al. [67] stated that accurate segmentation of the video sequences and reducing unnecessary parts from the long video poised difficulties in managing video-based content. In contrast, short videos are highly shareable but often they are scattered and not organized or re-presented based on inter-relation or pre-requisite relations. In addition, replicating natural disasters like earthquakes and providing real feelings through conventional content and content delivery methods is very difficult [68]. In this case, video and animation-based real-life scenarios, situational and demonstration videos might effectively provide DSS training among international students. Table 2 has represented the key findings of the characteristics of the content delivery method.

Table 2: Characteristics of content delivery method

Features	Key Findings
Content type	Text-based, verbal lectures, audios, videos, games, simulations, etc. [36] [37] [38].
Language	Mainly Japanese, some English contents and instructions are also available [5].
Challenges in content delivery	✓ Course delivery method is challenging because the contents are received from diverse disciplines and media [4]. ✓ Contents need to be represented based on the student's different levels in a simple and understandable manner. ✓ How to filter the accurate contents based on learning demand. ✓ There is no mechanism to know the student's post-training learning outcome.
Issues in video-based contents	✓ Defining and segmenting of essential inside parts with meaningful tags in long videos is challenging. ✓ Short videos are often scattered and not well organized based on inter-related and pre-requisite relations. ✓ How to support learners based on their attention and retention process in self-directed video-based learning.

Tools used in video-based learning	✓ There are numerous tools i.e. VideoAnt or EVA, OVA, TriANet, Hypervideos, Hyper-Hitchcock' audio keyword indexing, and many others serve different purposes in video-based learning. ✓ But these tools might be introduced for target groups, and their needs i.e., sports videos, news videos, lecture videos, geographic channels, or medical videos, etc. ✓ DSS videos, target groups, and their needs might have some similarities with other groups but also there are some special requirements.
Research Gap	✓ Existing research identified different challenges. ✓ Some issues were partially solved but did not show how to resolve all the issues in DSS training and learning.

2.2.3 Characteristics of the DSS Educational/ Training Strategy in Japan

In Japan, Nagoya University and Tohoku University started a combined Disaster Risk Reduction Education (DRRE) program for the first time in 2014 to cultivate disaster preparedness skills among international students. The course provided important teaching and learning experiences on disaster for the teachers and students in many positive ways. At the same time, combining several methods, for example, face-to-face, video conferencing, field trips, group projects, and reports were challenging. So, the research suggested combining the pre-recorded video lectures with video conferencing and sort out the duplicate contents in the videos. The final version of the video contents may be compiled and shared with different universities through the web. Finally, the study seeks a proper model and platform for future DRRE to cover a wide range of international students in providing collaborative education throughout Japanese universities [11].

Tobita [69] investigated the natural disaster response of Nagoya University from three aspects: organization, training, and infrastructure point of view. Among them, training, awareness, and education are considered mandatory criteria where creating awareness and repetition of disaster training are very important to reduce destructiveness. Shiroshita [70] suggested that disaster education means the transmission of information or skills from the disaster specialists or teachers to the learners, and it is a matter of co-learning and sharing the sense of disaster among the learners. The APRU-IRIDES multi-hazards campus safety workshop, 2018 in Sendai, proposed that orientation training to the new students and special training on disaster preparedness to the international students should be provided regularly [71][72]. The 2015-2030 Sendai Framework for Disaster Risk Reduction (SFDRR) included the safety of the educational institutes as one of the important global pointers of SFDRR to lessening loss and damage due to disaster. It also emphasized the safety of the whole school, learning environment, disaster management, and DRR education at the same time [73]. Table 3 has summarized the key findings of the characteristics of the DSS education/training strategy in Japan.

Table 3: Characteristics of the DSS education/training strategy

Features	Key Findings
Nature of the education/training	Single university-based, and few joint-universities collaborative education/training [11].
Need	✓ Regular orientation training for the new students. ✓ Special training for international students. ✓ Repetition of disaster training.
Teaching & learning approaches	✓ Transmission of information or skills from the disaster experts or teachers to the learners. ✓ Collaborative learning and sharing the sense of disaster among the learners.
Challenges	✓ Combining several methods in disaster education is challenging.
Future-plan	✓ A proper model and platform for future DRRE to cover a wide range of international students to provide collaborative education in Japanese universities.

Research Gap	✓ Web-based self-directed learning is not mentioned. ✓ How to create a proper model and platform for providing DSS training among international students in an affordable, workable, and convincing manner?

2.2.4 Summary of the Literature Review

The literature review from the above three main topics found that there are limited scholarly publications focused on emergency preparedness related to university students, and how disaster education is developed for newcomer and international students [74], [44]. A very few researches have been conducted to realize the suitable content and content delivery method for effective disaster education based on students' special needs [75]. Very limited research was also found on DSS teaching and training strategy in Japanese Universities.

This lack of previous research support factor itself emphasizes the need for disaster survival skill training among the international students to save them from an emergency. The most important finding is that video content is considered effective and widely used in disaster survival education and training. So, it is assumed that a learner's centered video learning support system needs to fulfill their needs. Therefore, this research initiates DSS training among international students in the universities using selected and effective video and animation-based content with the help of VART to assist in self-directed video-based learning.

2.3 Questionnaire Survey Analysis

In the literature review part, the research has identified international students as targeted learners and analyzed their requirements and problems in the current disaster education. In this part, the research explored the characteristics of international students on how they feel about the current situation of disaster education/training in Japan, their knowledge, experience levels, difficulties they face during learning, and why they need support in the learning process. In addition, this research also presents the type of content and content delivery methods in the current disaster education system and the characteristics of the current disaster education/training strategy in Japan.

2.3.1 Method

Primary data were collected using a questionnaire survey from the international students in Japan Advanced Institute of Science and Technology (JAIST), Japan to investigate Disaster Survival Skill (DSS) education, and training, and identify their needs. The survey also gathered feedback from the international students on how to improve some important issues in DSS training in the university to help students acquire DSS in an effective and practical manner.

The survey questionnaire was designed on google form and sent by e-mail to all international students in JAIST on September 18, 2020. A total of 13 questions composed of 92 variables were designed to obtain the necessary information about international students' current situation on disaster survival skills. The questions included the Likert scale, multiple-choice, single-choice, and also open ending questions. Out of 530 international students, 133 students, or about 25% of international students, responded to the questionnaire. The collected data were analyzed using SPSS and MS Excel. The following section discussed the survey results in detail on different issues related to DSS among international students in JAIST.

2.3.2 Geographical Distribution of the Respondents

The research explored that student from different geographical locations have a different level of understanding of a variety of disasters. For example, students from countries that do not have an earthquake, tsunamis, or typhoon, may not have experiences or understanding of such types of disasters. However, the survey found that the respondents are mainly from Asian countries including, China, Vietnam, Thailand, India, Bangladesh, Indonesia, Egypt, Malaysia, Myanmar, Saudi Arabia, Taiwan, Korea, Laos, Cambodia, etc., and some parts of Africa, Europe, and Central America. Table 4 shows the percentage of participants from different regions of the world. The table represents that most of the participants (94%) belong to the Asian region followed by Africa, Europe, and other regions.

Table 4: Geographic region of the participants

Region	Frequency	Percentage
Africa	3	2 %
Asia	125	94%
Central & South America	2	1%
Europe	2	2%
Middle east	1	1%
Total	**133**	100%

The research assumes that there is a core relationship between the length of stay and knowledge of DSS. Hence, Secondly, the survey tends to know their length of stay in Japan. Table 5 shows their percentages of the length of stay in Japan in different years.

Table 5: Length of stay in Japan

Duration (Year)	Frequency	Percentage
0-1 year	12	9%
1-2 years	43	32.3%
2-3 years	36	27.1%
3-4 years	12	9%
4-5 years	21	15.8%
5 years+	9	6.8%
Total	**133**	100.0

Table 5 illustrates that 32.3% of respondents stay in Japan for about two years, while 27.1% respondents stay 2-3 years. Only 6.8% of participants live more than 5 years.

2.3.3 Status of Past Training

The survey also investigated whether international students have received any disaster survival training in their home country before coming to Japan. Figure 3 below demonstrates the status of past training among international students.

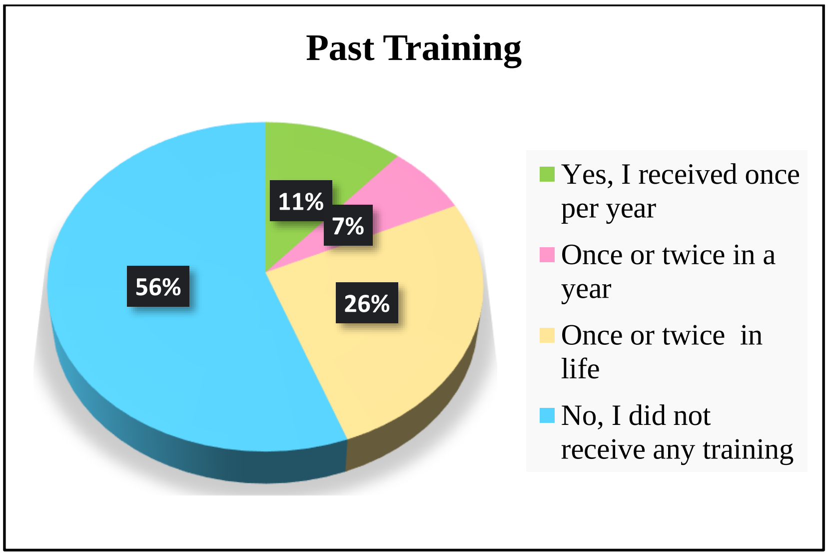

Figure 3: DSS training in home countries

The pie chart in figure 3 shows that 56% of the international students did not receive any DSS training in their home country and around 26% of the students received training once or twice in a life. Once or twice means there is a possibility to forget the training, or the experience might not be effective at present. So, it is assumed that around 82% of students did not receive any remarkable training, or do not have any effective training experience before coming to Japan. This finding is considered one of the important grounds that emphasizes that DSS training is crucial for international students immediately after entering the universities in Japan.

2.3.4 Familiarity with Disasters in Japan

Based on the previous question, the survey inquired about the type of disasters that international students got familiar with after coming to Japan and whether they have received any disaster survival training at their current university in Japan. Figure 4 illustrates the familiarity with disasters in Japan.

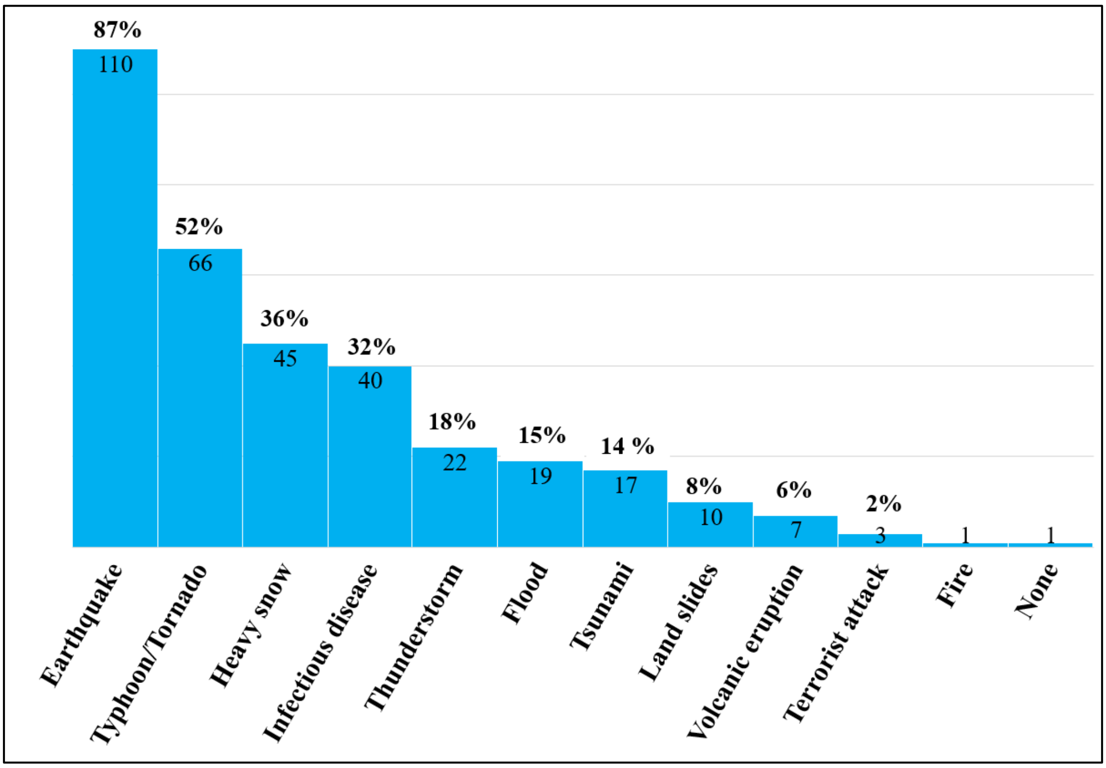

Figure 4: Familiarity with common disasters in Japan

First, in figure 4, we found that most of the students, or 87% were got familiar with the earthquake disaster, followed by typhoons or tornadoes 52%, heavy snow 36%, infectious disease 32%, and some other disasters. In this section, they could select multiple options.

2.3.5 Status of Existing Training System

In figure 5, we found that, out of 132 students, 88 or 67% of the students received the training, and 44 or 33% students did not receive any training from their current university.

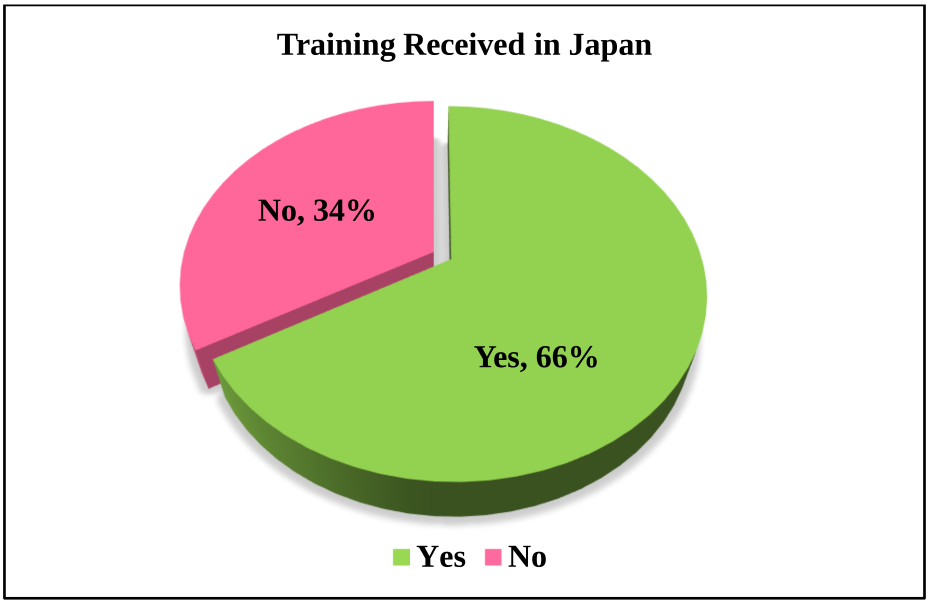

Figure 5: Training received at current university in Japan.

The study also gathered remarks/feedback on existing training from the international students who received training in Japan. The following figure 6 shows the overall remarks regarding existing disaster survival training/ drills from the respondents at their current university in Japan.

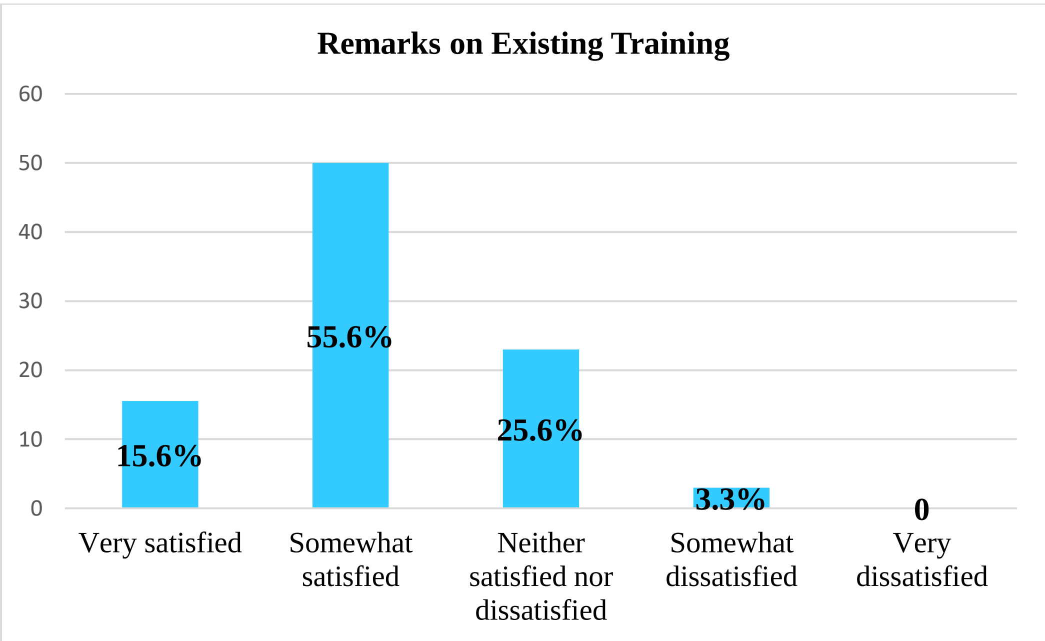

Figure 6: Remarks regarding existing training in Japan

From figure 6, it is found that students who received training, majority of them, i.e., 55.6% said they are somewhat satisfied with the training followed by 25.6% students are neither satisfied nor dissatisfied, and 15.6% students are very satisfied and though only 3.3% students expressed their opinion as dissatisfied with the training.

2.3.6 Difficulties Faced in Existing Training

The survey also enquired whether they have faced any difficulties during their participation in disaster survival training/ drills at the current university. While responding to the questions, students could choose more than one option from the given answers. Figure 7 demonstrates the response from the students.

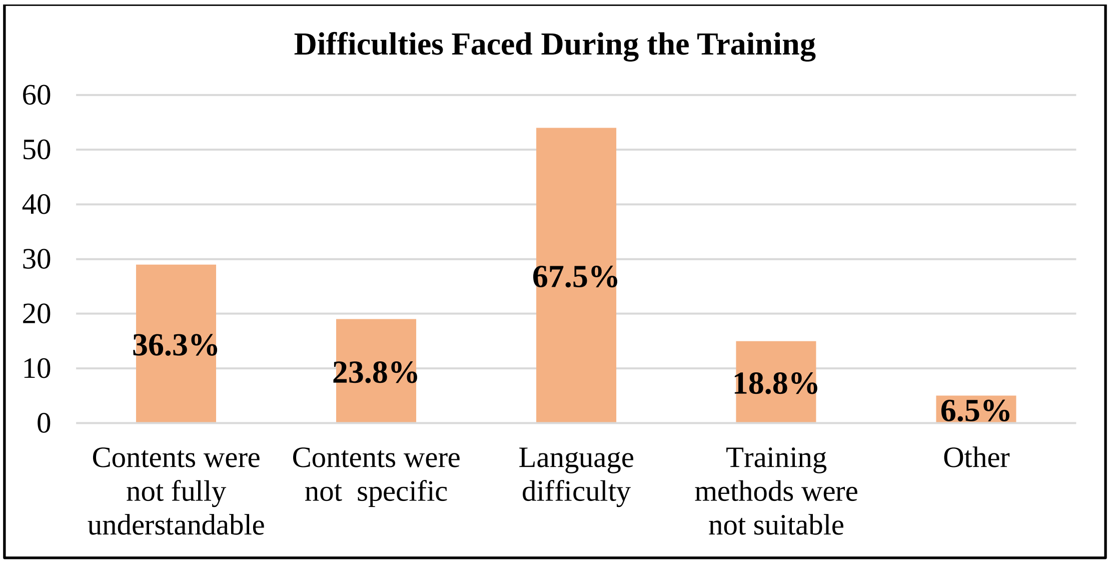

Figure 7: Difficulties faced during the training/drills.

In figure 7 it is observed that out of 80 respondents 54 or 67.5% of the students identified the language barrier as one of the main challenging issues which might lead them not to understand the contents properly. Some other students also identified that the contents were not specific, and the training method was not so suitable for them to acquire necessary skills on disasters, etc.

Reasons for Not Taking the Training

For the students who did not receive any training from their current university in Japan, the survey requested them to mention the reason for not taking the training.

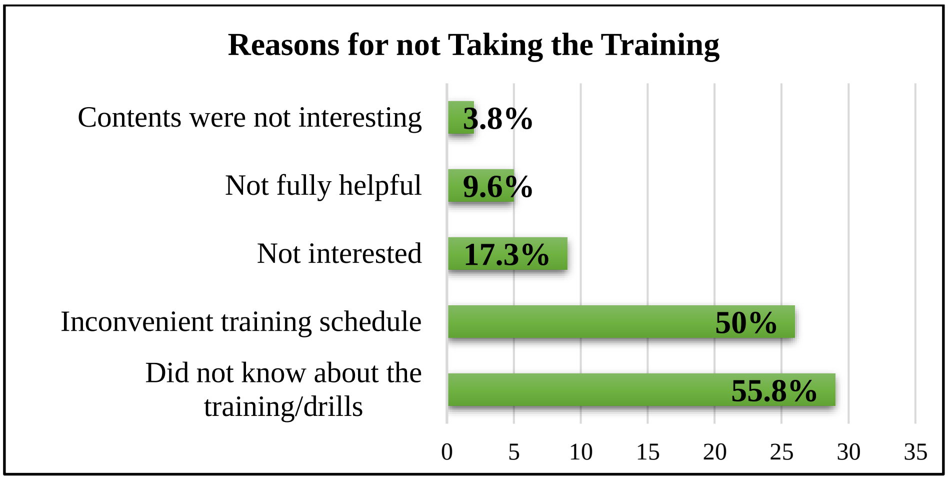

Figure 8: Reasons for not taking the training

Figure 8 indicates that 53 students who did not receive the training, responded to the query. Among them, 29 students or 55.8% mentioned that they were not aware that the training or drills followed by the training schedule was not convenient 26 or 50% and not interested 9 or 17.3%. Other reasons include the training was not fully helpful for them, and the contents were not interesting, and they were not interested in it.

2.3.7 Tools Used for Getting Disaster Updates

The research also inquired about the types of tools and applications students usually use to receive disaster updates, alarms, instructions, training, etc. In this case, the questionnaire provided a list of the latest tools and apps to investigate their choice and capacity. Students had the opportunity to select multiple options for this query. Figure 9 shows that 124 students or more than 93% of students use the smartphone to receive disaster updates, alarms, etc. 70 students or around 53% of students use the JAIST ANPIC system, 21% of students use internet news sites, 12% of students use the Line and only 9% students use smartwatches. Other tools and apps such as Real-World Edutainment (RWE), Game-based evacuation drill (GBED), Yurukeru call app, smartphone-based binocular opaque Head Mounted Display (HMD), Japan shelter guide, smart glasses, Japan-Automated External Defibrillator (AED) map app, have no use or very little use.

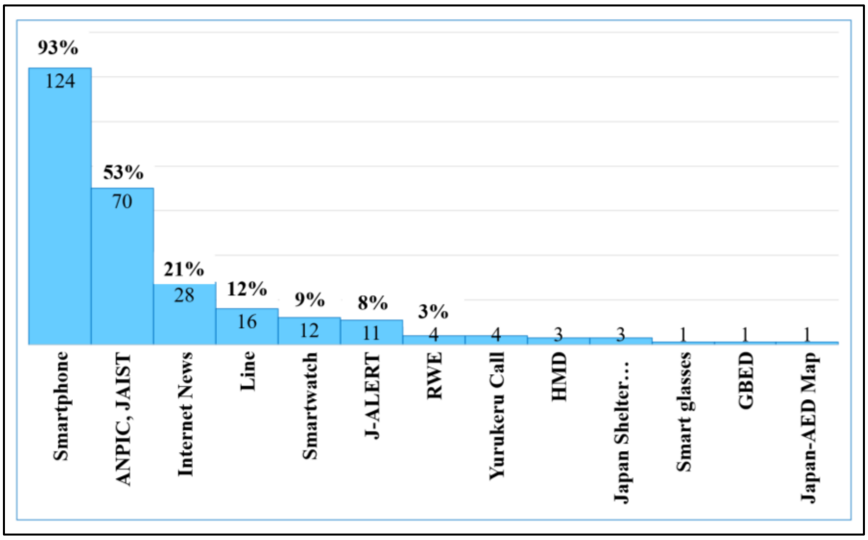

Figure 9: Latest tools and applications used by the students.

2.3.8 Preferred Method of Receiving Disaster Training

The research further inquired about their preferred method or contents to receive disaster training for their convenience. In this query, the students also had the option to select multiple options. Students showed a diverse approach in terms of choosing different types of content. Figure 10 demonstrates that video-based real-life content is preferred by 84 or more than 63% of the students followed by hands-on training by 62 students or around 47%, simulations around 43%, game-based content around 38%, and evacuation drills around 25% of the students. A few students also choose audio recording, discussion, verbal lectures, text, and other kinds of content.

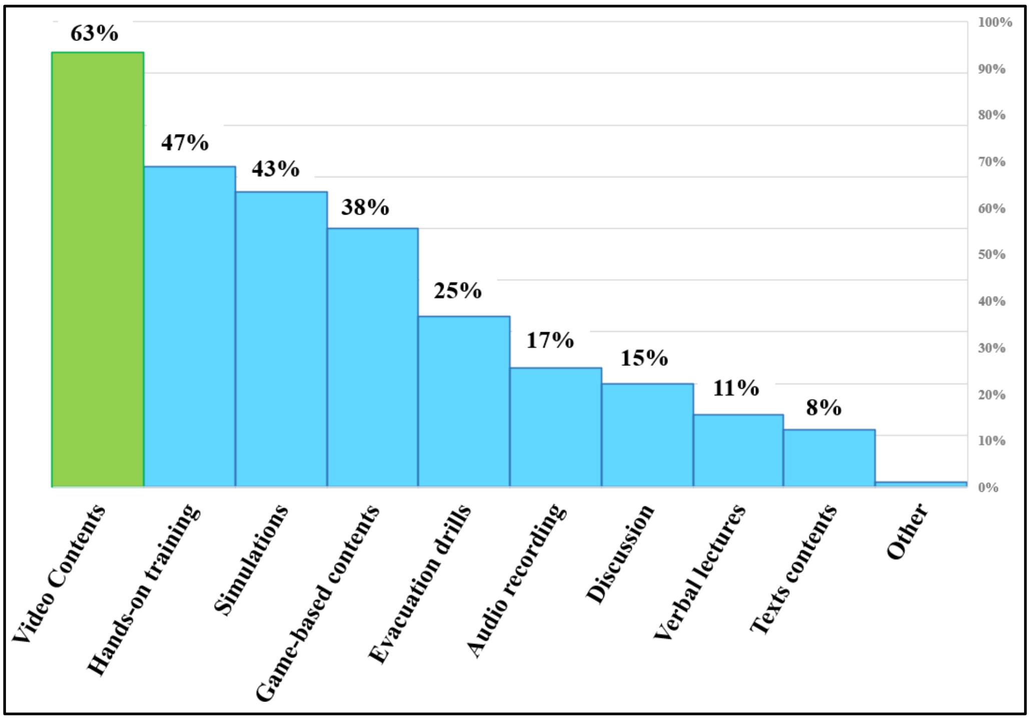

Figure 10: Preferred contents to receive disaster training

Based on the result of the above query, the research found that video-based real-life content or practical/situational disaster video content received attention and was recommended by the highest number of students. However, assuming that many students have classes, tests, report writing, or other work during the day, and many of them also engage with part-time work or other activities, they need a suitable training platform to watch and learn conveniently. Based on the issue, further, we invited them to provide their opinion on whether disaster survival-related video content should be published on the university LMS/website or not. Figure 11 shows the percentages of students' opinions in this issue.

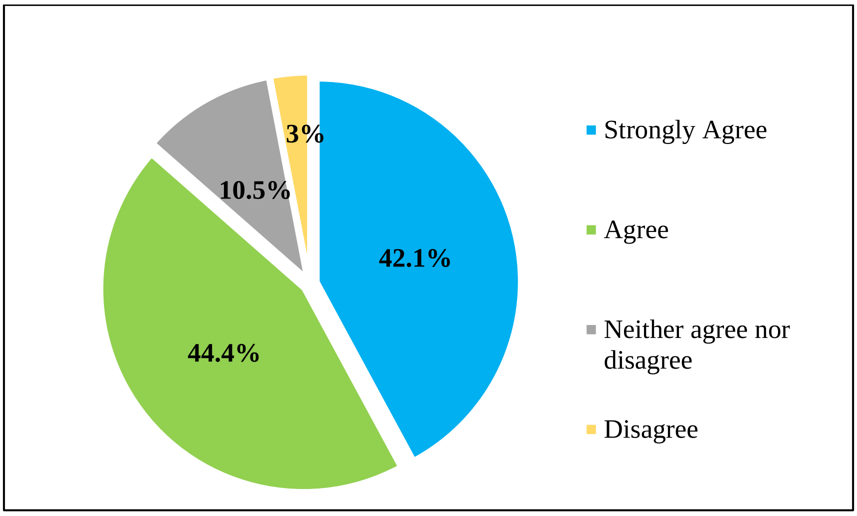

Figure 11: Opinion regarding DSS contents' availability on LMS/website.

At this point, we found that most students (87%) or 115 students out of 133 students agreed to have the availability of DSS contents on the university LMS or website to access it from anywhere anytime and learn from it based on their convenient schedule.

However, the survey also asked them to provide their remarks on the effectiveness of video-based learning systems. We provided them a list of choices, and they could select multiple options and provide their opinion in the 'other' section. Table 6 represents the percentage of the students who selected the given criteria.

Table 6: Students' remarks on video-based learning

Criteria	Number of students
Fractioning long videos into meaningful parts	82 (62%)
Each part should mention the specific topic and duration	78 (59%)
Most important parts should be represented first	62 (47%)
Automatic filtering and recommending important contents	40 (30%)
Focus on students' interest	35 (26%)
Other	5 (4%)

At the end of the questionnaire, students provided their opinion to make the disaster survival training more effective, listed in table 7.

Table 7: Students' remarks on video-based learning

Criteria	**Number of students**
Content should be designed in multiple languages	89 (67%)
The contents should be specific and appropriate	88 (66%)
The contents could be accessed from anywhere at any time	64 (48%)
There should have flexibility in the training schedule	56 (42%)
The training method should be conducted in a different way for international students	42 (32%)
The learning process should be self-directed and collaborative	41 (31%)
Other	4 (3.2%)

Some students also provided their comments in the 'other' options for the last two queries, such as adding some practical parts or real videos, focus on learners' interests, automatic filtering and recommending more important parts, using the timestamp with important headings, training should be conducted in English, training for the disabled people, use sign language for the deaf people, etc. A one-minute short video with important instructions might be shown on the big display monitors so that students can watch it while they move in the university buildings.

2.3.9 Summary of the Survey Data Analysis:

From the above data analysis and discussion, we can summarize the main findings as below:

1. Around 82% of international students did not receive any remarkable training or do not have any effective training experience before coming to Japan. This evidence itself emphasizes providing effective DSS training to international students.
2. 87% of students got familiar with the earthquake disaster, followed by typhoons tornadoes, heavy snow, infectious disease, and some other disasters after coming to Japan, but they do not have enough survival training on these disasters.

3. Most of the students who have received DSS training at their current university in Japan, provided mixed reactions, such as somewhat satisfied, or neither satisfied nor dissatisfied or not so satisfied with the training, etc.

4. Language difficulty is considered as one of the main difficulties that students do not understand content. Besides, lack of specific and interesting content, appropriate content delivery methods, and inconvenient training schedules make them not interested in participating in the DSS training.

5. More than 93% of students use smartphones, and around 53% of students use the JAIST ANPIC system, 21% use internet news sites, and 12% use the Line app to receive disaster updates, alarms, etc. Other tools are not widely used, and they are not much aware of the usage of those tools instantly and effectively in a disaster situation.

6. Students showed a diverse approach in terms of choosing different types of content to receive DSS training. 63% of students selected video-based real-life content, followed by hands-on training 47%, simulations around 43%, and game-based content around 38% of students. So, the researchers assume that it might need to combine the training with real-life and practical videos, game-based content, and hands-on training.

7. 87% of students showed interest in having the availability of DSS contents on the university LMS or website so that they can access it from anywhere at any time. This evidence has provided the chance to develop the DSS content on the web so that students can access and use content by using a computer, tablet PC, smartphone, iPad, and similar devices.

8. Finally, they provided valuable remarks, opinions, and comments mentioned after table 03 and table 04. Such comments could be followed to design, develop, and implement the proposed video-based DSS training system.

2.4 Conclusion

Based on the review of existing literature and findings from the data analysis, this research concludes that universities in Japan organize different disaster awareness pieces of training for their local and international students. The training contents and its objectives are easily understandable to local students. However, such pieces of training are not fully effective for international students due to unfamiliar training environments, not so interesting and specific content, language difficulty, diversified learning attitude, time constraints, etc.

To make the training effective for all levels of students, self-directed video-based learning could be an effective tool. Such learning materials could be easily accessible irrespective of access to media, time, and language issues. Cconsidering this phenomenon, this research motivates developing a flexible DSS training platform for international students studying in Japanese universities. The next chapter demonstrates different criteria for designing such a training model.

Chapter 03: Design Phase

3.1 Introduction

Adaptations in the self-directed video-based e-learning system are based on well-organized models and implementation methods. An adaptive e-learning system requires a huge amount of data to demonstrate the domain knowledge and model the students' learning process. This information is mainly divided into three core models: a domain model, a student model, and an e-teaching strategy or recommendation model [76]. The VART system uses data from all three models to provide effective and adaptive learning support to the students in the self-directed video-based DSS learning in the proposed system.

Based on the discussion in the research methodology and ADDIE model in chapter 1, this chapter discusses how to structure the contents, create required domain functions for the videos, track students' watching behavior and provide support for the students with the support of VART. These four parts are considered as the main functions of this chapter. We have explained these primary functions to clarify the design phase of the students' model, domain model, e-teaching strategy model, and a conceptual model of VART to realize the relationship with VART with these three models.

The main goal of this research is to support international students in video-based disaster survival skill learning. As mentioned, video content, especially real-life scenario-based, situational and demonstration video has the potential that students can learn DSS from it. Nevertheless, the videos are long, and the relationship is not clear in different videos, and the navigation is poor. The short videos are also not organized based on inter-relation and pre-requisite relations. So, the proposed system first organized the videos under different content structures. After that, it provides the function to track the student's activities and the navigation function to improve the retention process for learning. To understand the proposed design models, the retention process is fundamental in DSS learning. Because retention realizes the skill of learning from the videos. Retention, mini-tests, and similar activities can fill the gap between the knowing concept and being able to act. For the first time, watching students get to know the concept, but by repeatedly watching and answering mini tests, they move to act which will ultimately help them to do the right action in case of a disaster situation. So, retention is a process of knowing the concept to move to an act of being able to act [77]. Based on this, we designed these retention-based models. The learners' specific goal is to achieve the skills or act by watching the videos several times effectively. Moreover, the specific skills to be learned are disaster survival skills, i.e., preparedness skills, decision-making skills, and so on based on different video contents.

3.2 Components of VART

3.2.1 Domain Model

The Domain Model is an organized and structured knowledge of a given course, subject, topic, or problem. In some literature, domain models are also described as domain hierarchy, expert model, knowledge model, target model, etc. [78]. A traditional domain model generally uses the vocabulary of the domain and represents the key concepts of the specific domain and identifies the relationships among all the entities within the scope of the domain. Simply this kind of domain model introduces a visual representation of the contents and their inter-relationship, which helps learners to easily navigate their desired subject, topics, or learning objects, etc. [79].

Different types of DSS courses could be designed and structured based on international students' learning requirements in the proposed domain model. The traditional video domains mainly focus on video content management and control, including the organization of subjects and displaying the contents sequentially one after another. However, the proposed domain model includes the traditional features with extended features of VART, which has made the video content more specific and student-centered. These features include the content structuring system, control inside the video, provide adaptation using meaningful indexes to identify important parts, and track, analyze, filter, and recommend features based on student's requirements. Moreover, we use the H5P interactive content plugin integrated with Moodle to create, modify, rich, and interactive video content in the domain. This plugin also adds interactions and mini-tests to the videos to realize students’ retention outcomes or skill learning outcomes.

However, the VART also analyzes and identifies essential parts inside each video, makes virtual fragmentation, puts meaningful indexes, or tags for each inside part, and represents the video with a brief description. As a result, students can easily pick up the most important part in saving their time and concentration. Here, we have designed a sample domain or content model based on the main course DSS on earthquakes since this is a very important topic for all international students. In our proposed system, VART relates to the domain model through Moodle LMS. Figure 12 shows the VART connection with the domain hierarchy. The bottom part of figure 12 shows how it displays the short description of the video and how it analyzes and filters important parts in video content.

Figure 12 also illustrates that, in the domain model, there may have different domain hierarchies based on different subjects or topics. However, in the case of self-directed video-based learning, students should have enough flexibility in their learning. They can choose different topics and sub-topics which are known as Learning Objects (LO) from different modules as they prefer. For example, any student can learn the 'nature of earthquake' and 'preparedness' from module 1 and then move to any module and any topic they like. In the domain hierarchy, contents are interrelated from module to module and LO to LO. The blue arrows show the connection among the module to module, and the green arrows show the connection among LO to LO.

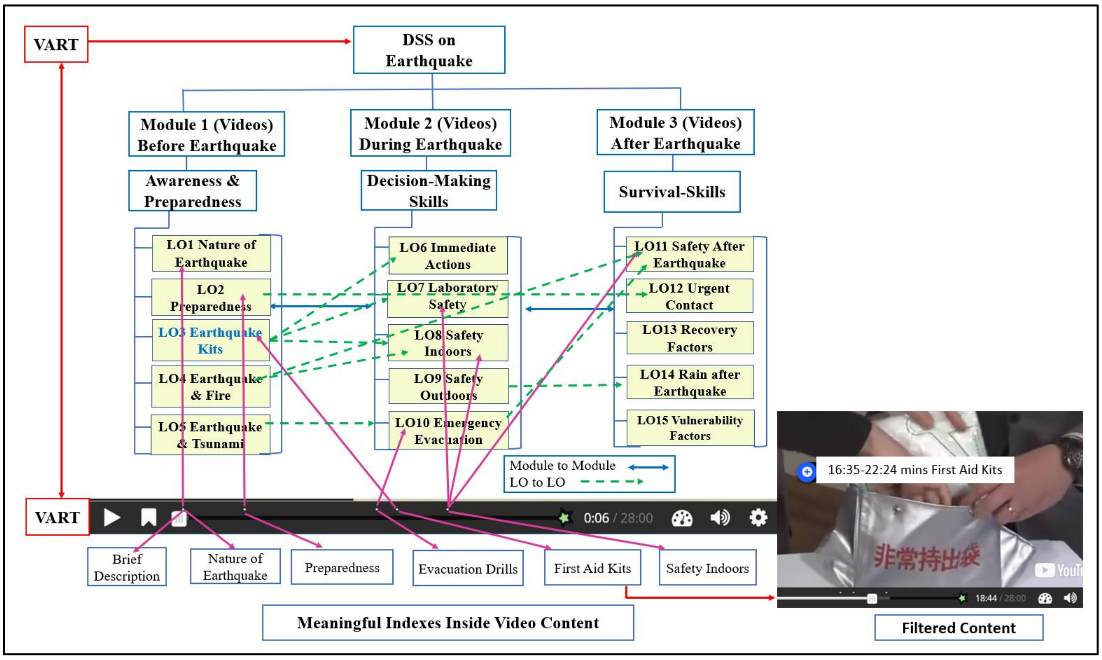

Figure 12: Domain model

3.2.2 Students' Model

Modeling users in e-learning is an essential part of designing adaptive e-learning systems. Shyamala, Sunitha, & Aghila (2011) stated that the learner model is used to modify the intersection between system and learners to suit the needs of individual learners. In principle, effective learners' modeling helps select suitable teaching strategies based on learners' knowledge as well as selecting content relevant to learners' competency. The learners' model serves as a knowledge source in an intelligent system covering different aspects of learners relevant to learners' learning behavior. More specifically, the learners' model represents information on the learner's domain knowledge, goals, preferences of the learning process, learner's progress, and other information about the learners. This information can be obtained from the learner's profile and a pre-assessment questionnaire filled by the learner at the beginning and tracking and analyzing learner's activities in the system [80].

There are different approaches to designing learners' models in an e-learning system. However, three conventional approaches are an overlay model, a stereotypic model, and the perturbation model. The overlay model represents a student's problem-solving approach in a particular domain on a modular basis. Brusilovsky & Millan [81] stated that the overlay learners model represents learners' model as a subset of the domain/expert knowledge. Shyamala et al. [80] described that based on the domain model learners model consists of the value of an assessment module of a particular concept. This value may be binary (0 - does not know or 1 - know) and a categorical variable (low, medium, high).

On the other hand, the stereotypic of learners' modeling represents a frequently occurring behavior of learners. In this approach, learners are assessed based on their performance on a predefined stereotype set by academic experts (fixed stereotype), or learners are stereotyped to a default initial setting. The learning process proceeds to replace individualized settings based on performance data. In the perturbation or buggy approach, the learner model caters to the knowledge possessed by the learner that is not present in the expert domain knowledge [81].

Based on international students' learning requirements, this research designed a students' model following overlay approaches. Figure 13 illustrates the DSS students' model of international students.

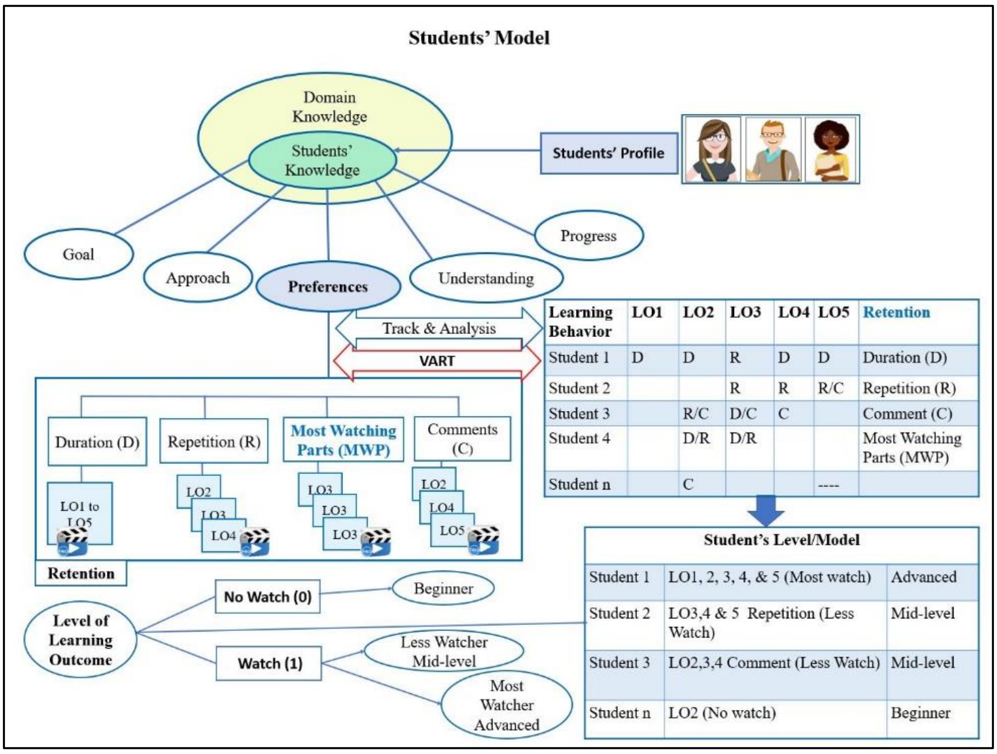

Figure 13: Students' model

International students have different knowledge and skill levels, goals, approaches, preferences, understanding, etc. Based on the preference, students may watch some videos from the domain as retention and the system gets the student's model based on watching duration, repetition, most watching parts or comments, etc. This is considered as students' behavior on the Learning Objects (LO). The students' model basically indicates the relationship between the domain model and the student's activities. In figure 13, there are five learning objects on the upper table at the top right side, and how students watch these objects is a retention process. Figure 14 is a visual example of a single students' retention history on a 15 minutes 27-second video. The student watched the video twice. The blue arrows on the top indicate the student's most watching parts, repetition of watching, duration of watching, and the arrow at the bottom level shows the learner's detail watching fluctuation history. Figure 15 shows the visualization of a group of learner's retention history on a hundred minutes video. The blue arrows indicate the most preferred or most important parts watched by the learners in the video.

This process could be applicable for a certain student or other students or groups of students, such as, 'the watching duration'. Student 1 may watch LO1 9 minutes, LO2 0 mins, LO3, 6 mins, LO4, 5 minutes, or vice versa. On the other hand, student 2 may watch in a different way. Based on students' preference and retention, the system can recommend different videos to student 1 and student 2 subsequently.

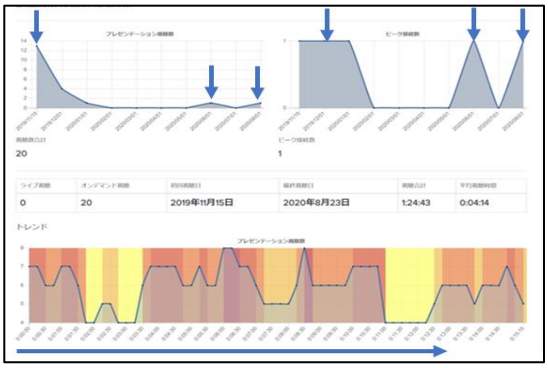

Figure 14: Retention of a single viewer

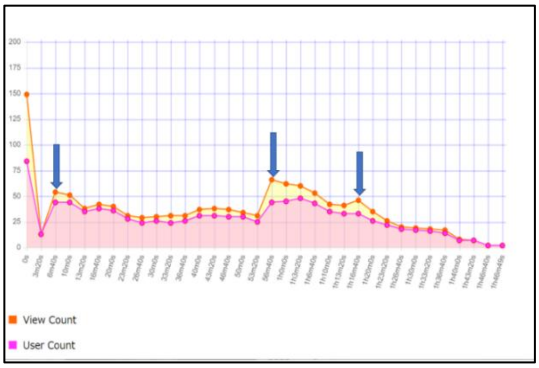

Figure 15: Retention of group viewers

Besides, the level of learning outcome is determined by whether students watch a particular video or not. If a student does not watch a certain video, VART will identify him/her as a beginner. Similarly, if any student watches the video, the VART system will calculate the total number of watching videos, watching duration, repetition, and important parts to identify as a mid-level or advanced level student.

3.2.3 E-teaching Strategy Model

In the proposed system, the e-teaching strategy technique is determined based on the combination of content structure and students' preferences data from the domain model and the students' model. The VART system will combine students' watching history data, including content preferences, watching duration, repetition, most important or most watching parts, number of clicks, scores, and other information from the students' model and domain model and decide the proper recommendation. For example, some contents are considered key content or fundamental concepts to be learned first in the content structure. In figure 15, in the domain model, for instance, learning object 3 has many links to other LOs. Usually, this kind of learning object is considered as the prerequisite object. So, if some students did not learn LO 3, 6, 7, 8, they should learn from LO3 from the content structure. The DSS contents are selected and limited. So, the system can recommend the basic concepts to be learned first. Another strategy is that if someone learns the LO3, following recommended content, they should go to LO 6, 7, or 8. Of course, another idea is LO4, and LO4 has connections with LO8 and LO11. If LO8 is already watched, after learning LO4, they can move to LO11. This kind of relationship is important, with the number of the students who watched the video. It may depend on the students' preferences too. If students want to pick up the important topic, in that case, most haunted parts or most watching parts are okay. But, if they want to learn the concept based on the domain hierarchy, they should follow the domain structure. In this way, the system can also create some teaching strategies from the domain model. So, the system can propose different strategies combining different parameters; for example, content structure and students' preferences, students' preferences, and most-watching part, students' preferences, repetition, or less watching and no watching, etc. The e-teaching strategy model of VART is illustrated in figure 16.

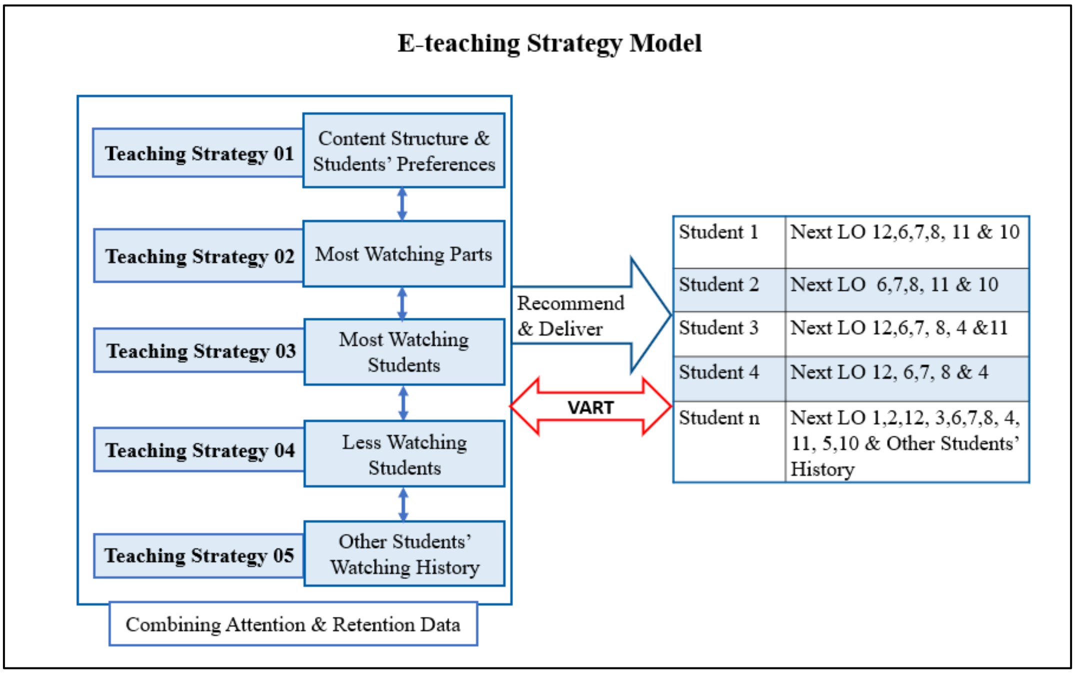

Figure 16: E-teaching strategy model

In the e-teaching strategy model, the system will provide mainly five approaches to the recommendation. Figure 16 shows (i) it will track content structure and students' preferences, (ii) most watching parts, (iii) most watching students, and (iv) less watching student's data. The students' different attributes and attention approaches will filter or recommend and deliver different content to the different students depending on their levels. The fifth approach is to use other students' watching history. If a similar level of other students watches a certain part in the video, the system will recommend it. For example, everyone watches LO3, but a certain beginner did not watch LO3. In that case, LO3 should be recommended to that student. If there is no other student's data in some LOs, the system can recommend based on student's preference data. Another pattern is that if some students are advanced learners and have enough knowledge of earthquake survival, they can skip the earthquake awareness and preparedness basic contents even if other students watched those parts.

3.2.4 Integrated VART Function Model

The VART model has a three layers structure, including the students' model, the e-teaching strategy model, and the domain model. Figure 17 demonstrates the integration of VART functions with different models on the LMS. With the support of VART, the domain model presents the content hierarchy, essential parts with the meaning of the videos, and students watch and learn from the video as retention and the system gets the students' model based on the duration, repetition, number of clicks, scores, comments, or other information. This is considered as the students' behavior on the learning objects. The VART also helps the e-teaching strategy model receive and combine data from the domain model and the students' model and know the student's attention and retention process. Accordingly, it proposes strategies using the parameters on students' models and learning objects. So, students' model and e-teaching strategy models assist students based on their learning process and progress in the domain and adapt to the self-directed video-based learning system. Thus, the three models are the essential computational models inside the VART system. The learning process from LO to the students is retention, and the system filters or recommends the contents to add attention. Therefore, these are the major VART functions with different models, which are the main part of the LMS.

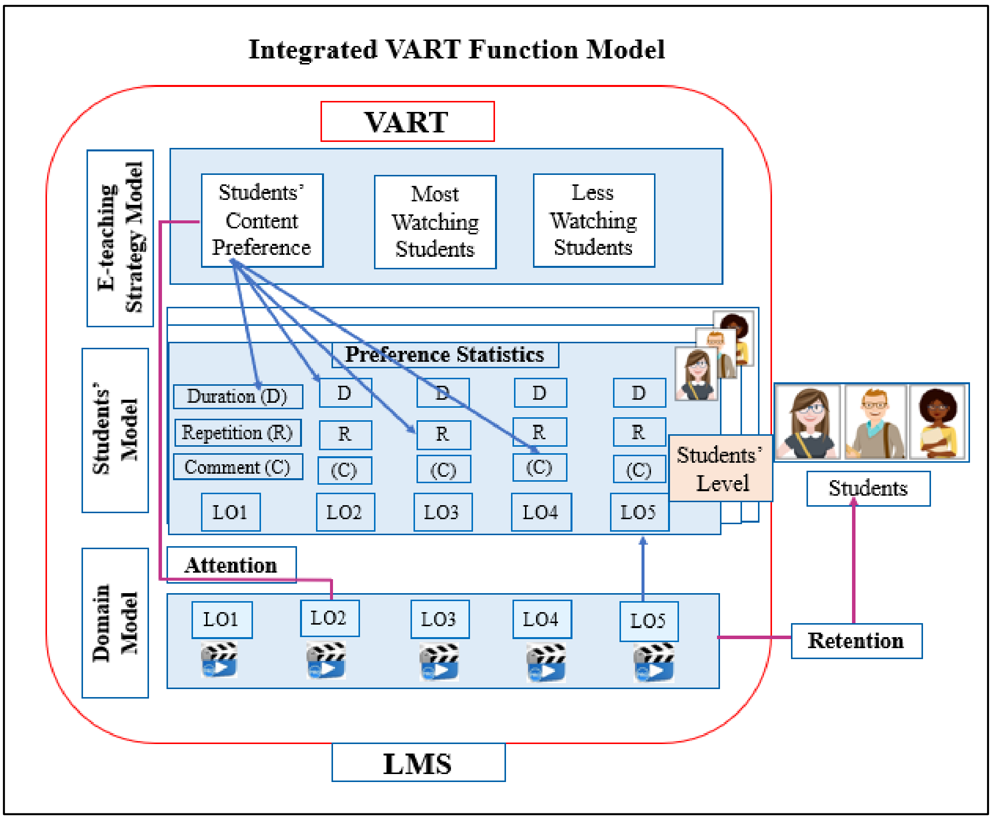

Figure 17: Integrated VART function model

3.3 Conclusion

In this chapter, the research illustrated the design method of the essential components of VART, such as the students' model, domain model, and e-teaching strategy model, and the integrated VART model. While designing the domain, this research focused on international students' learning needs and the appropriate content structure. The domain model includes the traditional features of content hierarchy with extended features of VART, which has made the video content more specific, and student-centered. In addition, the integration of the H5P interactive content plugin with Moodle enabled creation, modification, rich, and interactive video content in the domain. The students' model is designed in this chapter; the modeling helps select suitable teaching strategies based on learners' knowledge as well as selecting content relevant to learners' competency. Using this students' model, an educator can understand the learner's domain knowledge, goals, preferences of the learning process, learner's progress, and other information about the learners. As per the E-teaching model, the system is supposed to provide a different level of recommendation based on learners' learning behavior. Finally, the VART system combines students' watching history data, including content preferences, watching duration, repetition, most important or most watching parts, number of clicks, scores, and other information from the students' model and domain model and decide the proper recommendation. Based on different models designed in this chapter, the next chapter will demonstrate the development part and other related topics.

Chapter 04: Development Phase

4.1 Introduction

This chapter first demonstrates the development method of the proposed system. Thereafter, it demonstrates the functions and the main elements of the VART, different methods of content structuring system, interactive quiz creation, and the development of content visualization maps. The details of development methods, VART functions, and content structuring systems are presented in the following sections.

4.2 Development Method

4.2.1 E-learning Platform

The platform or the Learning Management Systems (LMS) is considered the central destination on the web, and most of the functions are operated from there. The LMS is an authoritative integrated system containing a group of tools that support the teachers/instructors to manage content and deliver learning resources and activities during the e-learning process. It also needs to provide high interactivity with the learners in the self-directed learning process, communication, collaboration, and related activities on the web [82] [83]. However, it is found that, though LMS's are frequently used in e-learning, they cannot always provide the expected level of adaptivity. By combining adaptation and personalization into LMS, a new kind of custom-made learning environment could be created, stimulating learners in their learning process [84].

To fulfill the requirements, the research has selected the LMS tool very carefully, to provide an adaptive learning environment based on learner's expectancy, motivation, learning roles, behaviors, etc. The LMS should also manage learner's profiles and databases, monitor learner's activities, manage diverse contents, provide adaptive course delivery, and adaptive collaboration support in the training-learning process [83]. Therefore, it should be easily customizable and easy to integrate new tools with it as per the demand of the course or training activities.

Accordingly, this research has implemented one of the widely used open-source systems, Moodle LMS, as the e-learning platform. The Moodle is easily customizable with many standard features which suit the above-mentioned requirements [85]. For example, it is possible to manage the training and learning process for the instructors/trainers and students in one dais, including learner's management, delivering content, tracking learner's progress, providing learning support, grading, evaluation, etc. [86].

4.2.2 Content Management Plugin

The research integrated H5P interactive plugin with Moodle to manage, structure, and represent the video contents, create virtual fragmentation, add indexes, add quizzes with a wide variety of formats [87], and many other vital functions for the proposed system. H5P is the short form of HTML5 Package, is a plugin that assists instructors to create, share and run interactive content, including interactive video on the LMS, Content Management System (CMS), and other embedded platforms. It is an open-source and free technology, licensed with MIT [88].

4.2.3 System Development

The technical part started with a server setup with the Moodle environment. After that, we developed the VART Moodle plugin and integrated it with Moodle LMS. At the same time, the H5P interactive content plugin was combined with Moodle to create, modify, rich, and interactive video content [88]. In addition, we used H5P collaborative video features, video structuring system, and Moodle flexible section format to create different types of content structures. We have also enabled multimedia plugins within the course settings as per the demand. Besides, we customized by adding Moodle topics to represent three modules of the DSS contents in the proposed framework as a part of the domain model. We developed and uploaded different types of video and learning objects (LOs) inside the modules. Then developed a mechanism to adapt the contents according to the learner's progress. The content repository was linked with the Moodle platform using the Moodle repository plugin to monitor learner's progress on video data. The following figure 18 shows the image of the proposed platform developed and customized by using Moodle LMS.

However, while developing the technical part, the research used multiple programming languages such as HTML5, PHP, and JavaScript for coding, designing, and scripting. The necessary code has been integrated with the Moodle LMS source code and customized the Moodle platform for the adoption and implementation of VART.

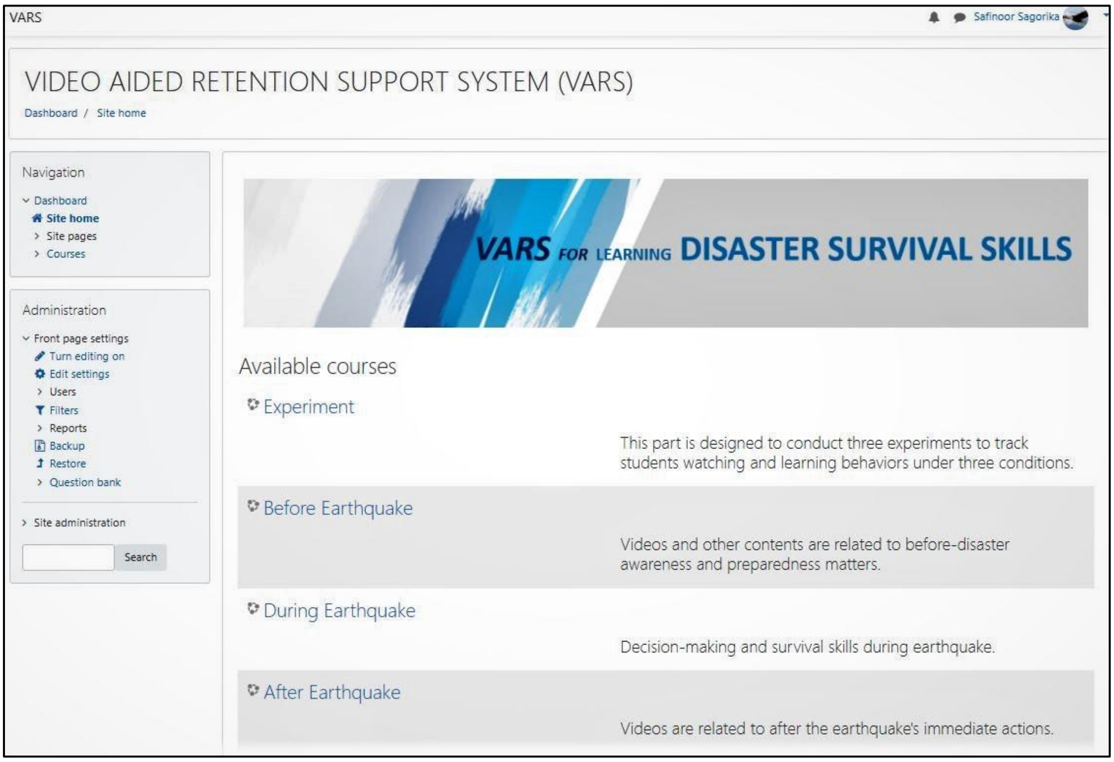

Figure 18: Image of the proposed platform

4.3 Functions of VART

The VART functions are necessary elements to deal with the three models introduced in Chapter 3 on our LMS. This section describes the Video Controller, which implements the content model, the Video Analyzer and Watching Behavior Tracker that realizes the students' model, and the Learning Path Visualization Map as the user interface for the e-Teaching strategy model.

4.3.1 Video Controller

The VART system combines domain hierarchy information, notable attention, and retention parts, and the learning history of the previous students picks up the important video sequence and provides it to the students as a brief description. If students feel the video is useful, they can watch it from the actual learning resources. In the disaster education field, many topics are often included in a single long video. If one video includes almost all the important content, students should learn all of them. So, it is needed to fill the empty knowledge of the students from all the topics. Besides, the content order should be organized by the system to keep interested or motivated or consider the more important skills for the students to be learned first. In this case, the VART organizes and splits long videos into specific topics, makes a hierarchy and controls the learning. It also organizes and displays short videos based on pre-requisite and interrelation among the contents. Moreover, if enough content is not found, the system can recommend different video sources or web pages.

4.3.2 Video Analyzer

Traditional video service platforms, including YouTube, TED, DTube, Dailymotion, Netflix, Google Video, etc., provide a general video's history targeting a group or group of people and their needs or business and advertising purposes. For example, it might predict a movie’s ratings [89] for a specific group of movie watchers, or ratings for sports videos, news videos, TV shows, etc. However, in DSS learning, only such kind of general history data is not enough. Students need to know both about the video and the essential parts inside the video. Besides, students have a variety of learning behaviors, knowledge, and skill levels. In this case, the proposed VART can detect the number of watching and duration of the watching history of the specific part of the video. For example, the part of the watching history from 1minutes to 6 minutes, etc. Only such history data might be a popular part, but if the system can add meaningful indexes or metadata for inside video contents, students can find each part of the videos with meaning. For example, this popular part includes this topic, i.e., from 1-4 minutes nature of the earthquake, 4-10 emergency bags, 10-16 earthquake drills, etc. The VART system can put such indexes for videos, not video files, but tags for each timeline inside videos. Hence, students can easily understand the topics included in the video and which parts are more important for them to learn first based on their knowledge levels, attention, and retention process.

Attention & Retention Process

Educational psychologist Albert Bandura stated that learning could occur by watching others and then modeling what they do or say in observational learning approaches. According to his remark, during the learning process, a learner must concentrate on what the model does or focuses on the verbal instructions of the model or symbolic items [90]. This kind of learning is called attention. Numerous live, verbal, and symbolic instructional DSS videos are available where attention could be determined for the learners from the video contents. On the other hand, retention is observed actions that are cognitively recorded as symbolic pictures in memory to utilize in future activities [91]. Retention indicates that a learner must be able to retain or remember the steps in order to reproduce the activities later, based on his/her learning process. The way a learner learns and remembers is the retention process. The learning system needs to integrate both attention and retention for an effective learning process. In our system, attention will be provided from the video contents based on learners' preferred topics, and retention will be provided based on their learning process through VART.

In figure 19, we have represented the main elements and final output of the VART system. VART uses video data sets and students' watching history from the domain model and student's model as input data. After that, it tracks and analyzes videos based on the student's attention and retention process. In this figure, attention indicates the student's preferred topics or expected parts inside the videos, and retention indicates the remembering process or learning process of a student. However, after analyzing the input data it filters, recommends, and delivers specific content to the students considering different strategies. The detailed functions are described in the components of the VART section.

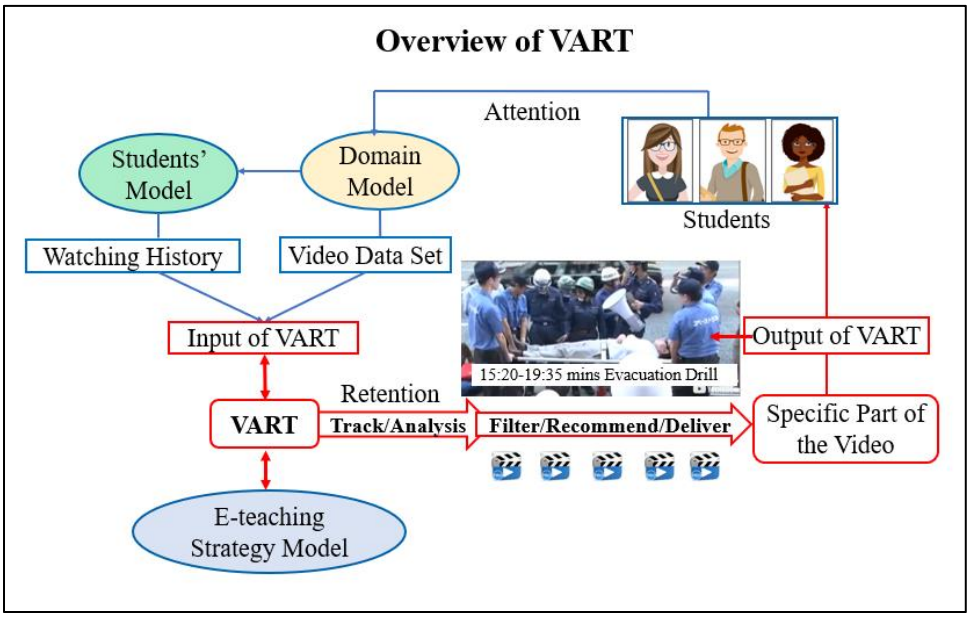

Figure 19: Overview of VART model

4.3.3 Watching Behavior Tracker

The VART first detects each student's ID in the proposed platform and tracks what type of content they seek; this is called attention. At the same time, it follows the students' watching duration and repetition of watching, number of clicks, comments, difficulties, or intentions, which is considered a retention or remembering process. Based on such a learning process and progress history data, the system could analyze, filter, and change how to show the video. Thus, the system can recommend which part is essential using the attention and retention process and watching history data and can filter contents based on students' preferences, learning behavior, and competency level.

4.3.4 Learning Path Visualization Map

The learning path visualization map starts with a simple content visualization map. Students can find the visual display of the contents or LOs as a map in the content visualization. However, after watching videos from the domain, students can find the learning path visualization map based on their attention and retention process that may displays which contents or LOs a learner or group of learners watched, which part they missed or if they missed any important parts, repetition of the LOs, most repeated or most watching LOs and so on.

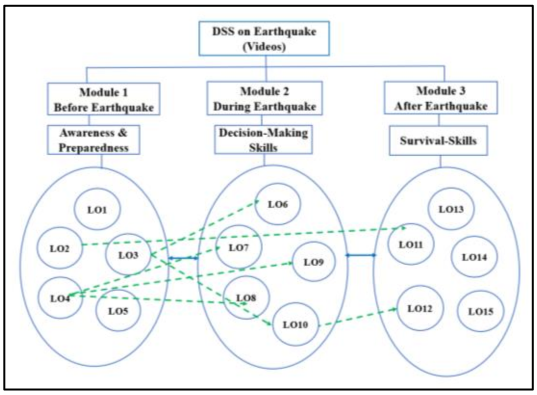

Figure 20: Example of content map

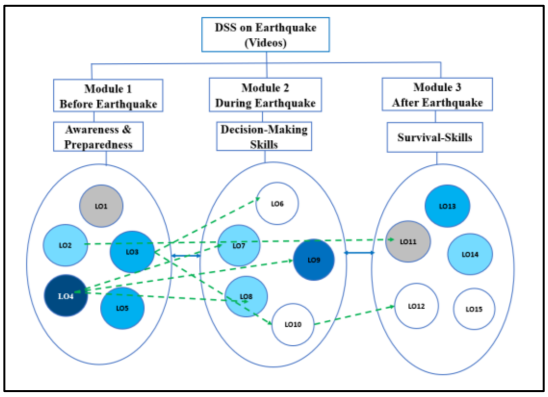

Figure 21: Example of learning path visualization map

Figure 20 illustrates the sample example of the content map. Here all the LOs are white or no color. It means that the system represents the fresh map when a student first-time accesses the domain. When a specific student starts watching, it gets colored based on the student's watching behavior.

Figure 21 illustrates the sample example of a learning path visualization map. Here we used three different colors in the LOs, blue, white, and ash, to identify the importance or level of repetitions and LO watching status. Lighter blue indicates the lowest number of repetitions, and if the number of repetitions increases, the color of the LOs gets darker blue, and finally, for the highest number of repetitions, the color turns into navy blue or the darkest blue for the LOs. In this image, LO2, LO6, LO8, and LO14 got the same light blue color. It means the number of repetitions is the same for these LOs. Similarly, LO3, LO5 and LO13 have a little bit darker blue. It means these three LOs have more repetitions compared to LO2, LO6, LO8, and LO14. LO9's color is close to deep blue, and LO4 has the darkest blue color. It means LO4 got more repetition than LO9, and at the same time, LO4 got the highest repetition among all the LOs in the domain.

The ash color indicates the first time watching or watching an LO for one time only. LOs with white or no color indicates students did not watch these LOs.

But if the white LOs are linked with green arrows it means the student has missed some important LOs, which might be a pre-requisite or interrelated LOs in the domain hierarchy. For example, in module 1, LO7 is a prerequisite LO, and it has a link with LO3. So, this LO is very important compared to other LOs. Similarly, LO10 and LO12 also have prerequisite relations or inter-relation with LO5 and LO2. So, students should watch these LOs, if they missed them.

4.4 Content Structuring Method

In the proposed domain model, contents are structured mainly in three methods, basic content order, prerequisite order, and inter-linked order or sequences. The basic or traditional content order is a general approach, but the other two approaches are new and have additional features in the domain model. First, we used the H5P interactive content plugin and Moodle flexible section format plugin for simple sequencing and representation of the basic content order and the learning objects (LOs)

However, this technique is not enough to represent the other two structures. In that case, we have extended the simple sequencing technique and used H5P interactive video features and H5P branching scenario to add special features in the content, which is considered as an extended function in the content creation, representation, and delivery process. We have used these two techniques to create structured video content and branching lesson scenario contents. With the help of this tool, we have provided a new shape of the traditional long video and created it as structured video content. We also have added meaningful local indexes inside video parts. There are some approaches to put indexes inside the video. For example, VART can apply the H5P interactive content plugin to create virtual fragmentation inside the video parts and provide indexes or necessary meta-data for each video part. Another function is if students make comments for the video, the system can detect such text data as a part of the indexing to provide the meaning of that content. However, to indicate interrelated learning objects and prerequisite learning objects, H5P interactive video features and H5P branching scenarios can add special features to the content model.

The branching scenario lesson is used to represent short videos in an organized manner to provide a gamified feeling among the learners while learning from this kind of content representation. For example, we have created and represented prerequisite LOs using branching scenario features.

The interrelated and prerequisite LOs are considered part of the skill learning contents and very effective in realizing the retention behavior in the learning process. These LOs are learned independently and reused by the learners in various contexts of self-directed video-based learning. It saves time and concentration for the learners and enhances the quality of the learning resources.

In addition, the structured and branching scenario lessons provide learner's interaction during learning and the learning scenario. We also have added interactions and quizzes, timestamps, meaningful bookmarks/indexes, and ranking for the different parts/episodes. So, we proposed these features as a part of the skill learning content.

So, LOs must be created adaptively to achieve high acceptability by the learners and engage them in their learning process [2]. For example, in the domain model, each video part or LO has a meaningful index, timestamp, and ranking, so that it can save the time and concentration of the students to locate their desired parts to learn and provide more adaptation and engagement with the learning objects.

4.5 Basic Content Structure

The traditional or non-support content order in the domain structure diagram is created based on the tree structure. This can achieve the basic functions of a hierarchical instructional arrangement by applying simple top-down sequencing techniques and rules to the content [92].

The traditional domain structure has mainly two parts: learning parts, which contain the LOs, and assessment parts, which contain mini-tests or exercises related to the LOs. Students need to answer all the quizzes. At the end of each module, the student can check their test scores and move to the next module. In this case, until they pass the first module, they cannot move to the next module.

In figure 22, the course called "DSS on Earthquake" is used and structured for the domain content and considered the root aggregation of this content structure. The course is divided into three modules, and each module contains one lesson with 5 LOs. A total of 15 LOs are created under three lessons. Lessons are the collection of LOs. Each LO contains different DSS-related video clips that are related to the topic of the lessons. The learning objects are created by the course authors or instructors and shared or delivered to the students through Moodle LMS.

However, following the basic content order, students can simply learn the LOs from start to end. For example, in figure 22, any student can start from module 1 (awareness & preparedness), and after completing it, the student can move to module 2 (decision-making skills) and then module 3 (survival skills) subsequently and finish their learning.

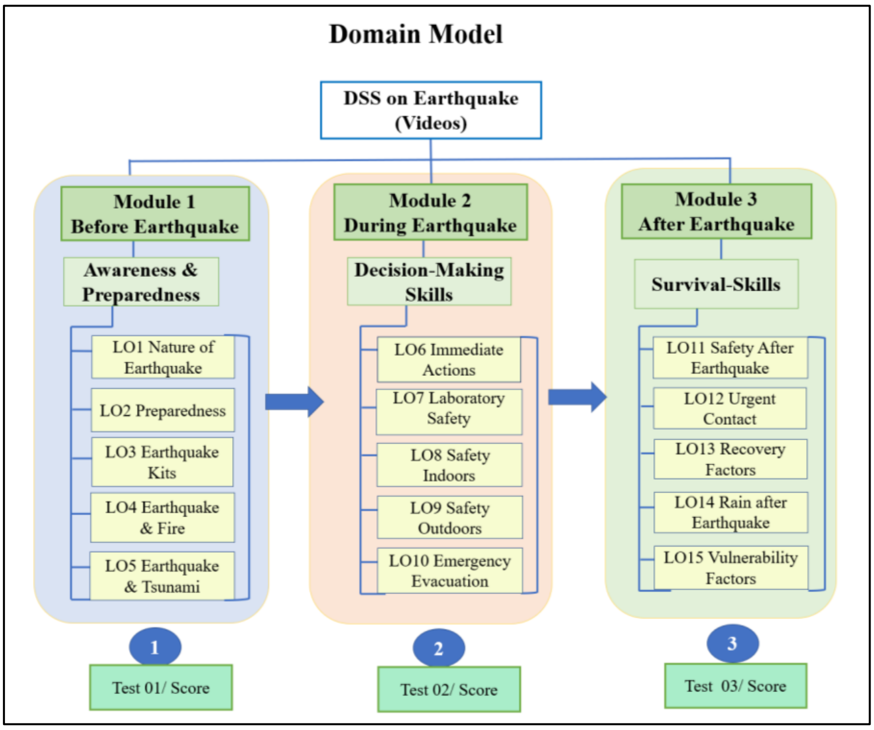

Figure 22: Traditional content structure (domain hierarchy)

Rules:

To complete the Root Aggregation, the learners must pass Module 1, 2, and 3.

Algorithms:

1. If learner pass Module 1, then present Module 2
   Else
   Module 1, repeat.

2. If learner pass Module 2, then present Module 3
   Else
   Module 1: Flow=true
   Module 3: Flow=false

3. If learner pass Module 3, Root Aggregation Rollup: satisfied
   Module 1: Flow=true
   Module 2: Flow=true
   Module 3: Flow=true

4.6 Proposed Content Structures

We have chosen three different videos to create three different types of content structures which are discussed in the following section for the proposed system.

4.6.1 Non-support Video Structure

In the proposed platform, we have simply uploaded a long video content without providing any learning support that is considered traditional. Students just start watching this kind of video without any specific guidelines or support. As a result, it is difficult for them to locate the exact points or topics they are interested in or the important topics they should learn first. So, they might spend a lot of time and concentration on seeking, skimming, or scanning. At the same time, the video is too long to keep their focus during learning. There are no interactive quizzes, activities, or any other support which might navigate them in their attention and retention process. Figure 23 illustrates an image of a non-support or traditional video representation.

Figure 23: Non-support video image
Source: [93]

4.6.2 Structured Content

In the second step, we have created structured video content. With the help of H5P interactive video features, we have provided a new shape of the traditional long video and created it as a structured, interactive video content. To create the structured video, first we have identified the essential inside parts. After that, we have created virtual fragmentation of each essential part and provided the meaningful index for each part with the timestamp. We also have added interactive H5P quizzes inside video parts so that learners can actively engage with the video learning process. These quizzes also navigate them to learn the important topics or skills from the video parts. In the proposed system, inside the course named “Experiment”, we have organized the earthquake safety series videos under the string of a long video, structured them with the virtual fragmentation, and provided meaningful local indexes, shown as “Bookmarks” in figure 24. Inside this video, we have created five small learning objects (LOs) interrelated with each other. These safety series small video parts are called inter-related LOs. Before watching the video, students can first look at the indexes under the bookmark and choose which topics they are interested in watching. They can also jump topic to topic or make repetition of any specific part as many times as they wish. They just need to click on the topics/indexes under the bookmark and instantly reach the desired part. They do not need to spend extra time seeking and locating expected content parts in the long video. This process sets them free and navigates them to learn any interesting, unknown, or difficult topics from the fragmented video parts, saving their time and concentration.

Thus, it helps them in their attention and retention process and improves their learning outcome. We also have added interactive quizzes with the important video parts to be actively involved in the learning process and acquire the important knowledge or skills. One of the examples of interactive quizzes is illustrated in figure 25.

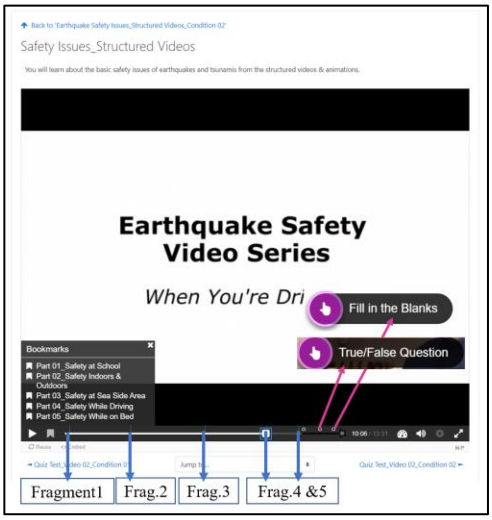

Figure 24: Structured video image

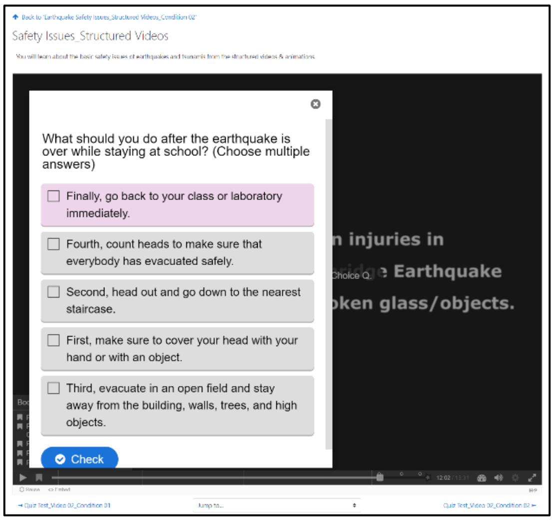

Figure 25: Interactive quiz inside video part

Interrelated LOs:

In the domain hierarchy the modules are interrelated with each other, and also LOs are interrelated within different modules. In figure 26, blue arrows indicate inter-relations among the modules, and pink arrows indicate inter-relations among the LOs. For example in module 2, LO 7, 8, and 9, are interrelated LOs. Similarly, in module 3, LO11 is interrelated with the LOs 7, 8, and 9 in module 2. Figure 27 also illustrates the sample image of interrelated LOs.

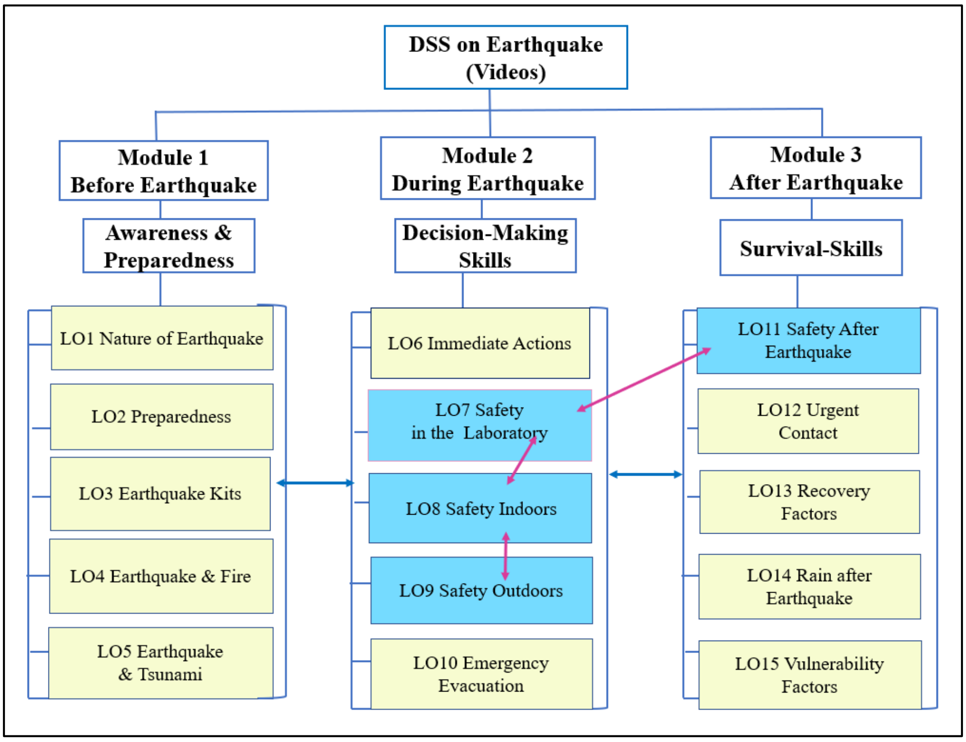

Figure 26: Interrelated LOs in the domain hierarchy

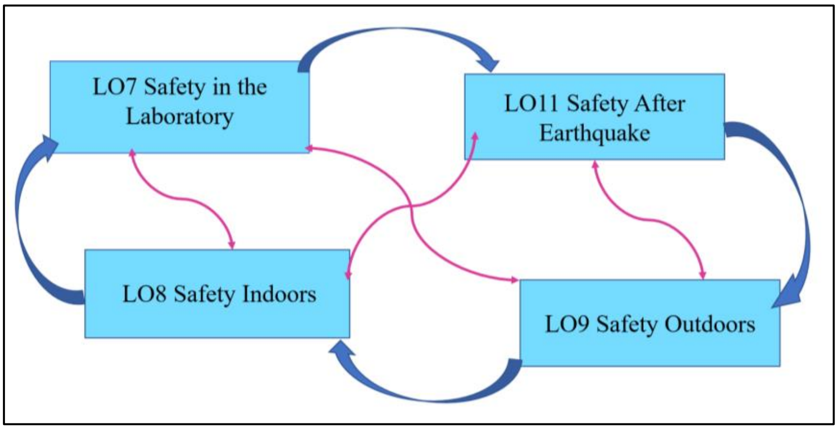

Figure 27: Interrelated LOs

Example:

Set A = {LO7, LO8, LO9, LO11}

Set B = {LOM, LON, LOK}

Rules:

The learner can complete LO Sets in any order, but when starting a LO set, all related LOs to be shown one after another, and learners need to finish watching all the LOs in that set. After completing the current set, learners can move to another set.

Algorithms:

If learner start Set A

Set Aggregation: Choice=true; Flow=true

If a learner starts Set, B, C or any other set.

Set Aggregation: Choice=true; Flow=true

(True, false or it could be yes, no, or 1, 0,)

However, in the case of self-directed video-based learning, students have enough flexibility to choose different topics and subtopics from different modules as they prefer. Any student can learn the LO1 and LO2 from module 1 and then move to any module and any topic they like. Nevertheless, the system can recommend interrelated LOs to the students depending on the content importance to be learned first at the same time.

4.6.3 Branching Scenario Lesson Structure

The HTML5 based branching scenario lessons are a flexible section type content structure that allows instructors to present various rich interactive content and structure the content as a tree with multiple branches and endings. It creates branches and decision-based paths based on learners' preferences that they want to watch next [94]. This kind of flexible section format provides learner's interaction during learning and the learning scenario. Learners can also answer the interactive quizzes, make repletion of specific videos, and provide their feedback in the learning scenario. Figures 28-33 represent a magnificent display of the content series in the branching scenario lessons. First, in figure 28 it launches the course, instructs the learners to start the course, and provides a brief overview of the learning topics. The "proceed" option in figure 29 at the top right corner navigates them to make a learning tour among several videos provided one after another as a branching lesson. However, after they finish watching some interrelated or prerequisite lessons, branching quizzes or interactive quizzes are displayed to them. For example, in figure 32, if they can make correct answers, that is good, but if they cannot make correct answers, they can choose the options from the decision-based paths displayed in figure 33 and re-watch any content many times they wish. Alternatively, if they make all the correct answers, they can still watch previous content based on their interest or proceed to the next episode. This is how the branching scenario stimulates the learners with a gamified feel, navigates learners' step-by-step methods in the learning process, and finishes learning the course.

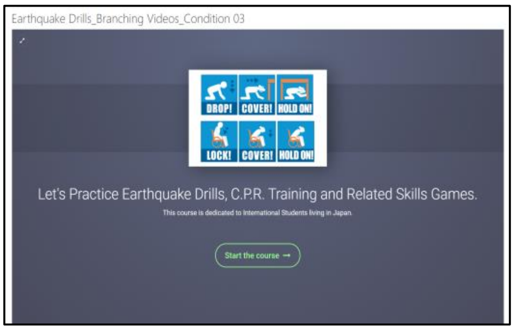

Figure 28: Start of the Branching lesson

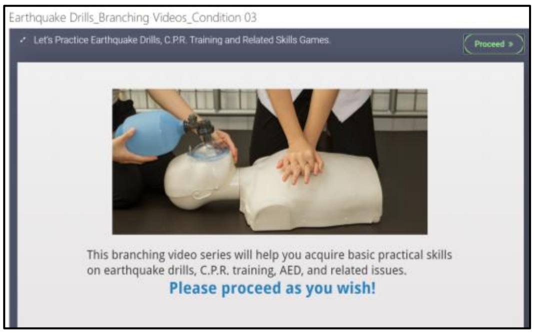

Figure 29: Simple introduction

Figure 30: Earthquake drill, 01
Source: [95]

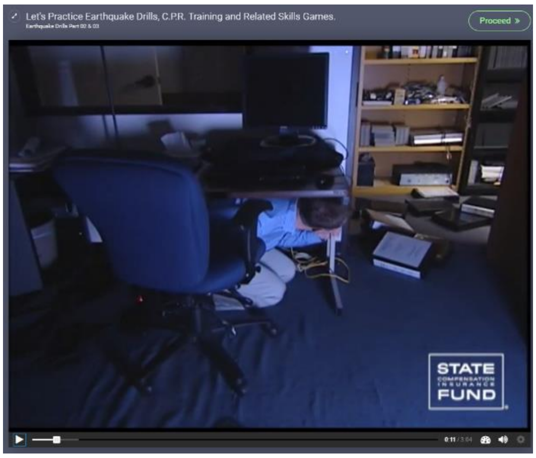

Figure 31: Earthquake drill, part 02 &3
Source: [95]

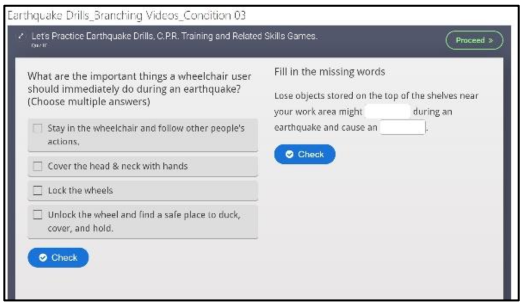

Figure 32: Branching quizzes

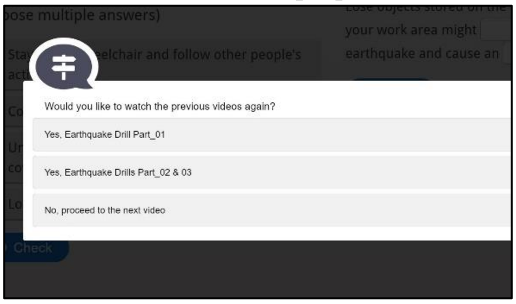

Figure 33: Decision-based path

However, the branching scenario lesson is very well-fitting both for identifying and displaying interrelated and prerequisite learning objects. In the proposed branching lesson structure, we have used several skill-based short videos and organized and displayed them as the prerequisite LOs for practical instances. For example, in figure 30, the first content is "Earthquake Drill Part 01". This is the prerequisite LO of the following content, “Earthquake Drill Part 02 & 03” in figure 31. If someone starts watching episode 2 or 3, he/she might feel some gap or missing parts while learning. In this case, episode 1 is the prerequisite LOs to watch episodes 2 and 3. Also, in the content structure, some LOs have many prerequisite links. In that case, that LO is important than the other LOs and should be watched first.

Prerequisite LOs: In the content hierarchy, some LOs have several pre-requisite links with other LOs. These kinds of LOs are considered as prerequisite LOs. In figure 34, LO3 has three prerequisite links with LO 6, 7, and 8. In this case, LO3 is one of the pre-requisites LOs in the domain. So, after learning LO3, students need to learn LO 6,7, and 8. Alternatively, students should first learn the LO3 and must learn LO 6,7, and 8. In this case, the system can define the importance of the node or LOs. If some LOs have many prerequisite links, in that case, that LO is more important than the other LOs. So, in figure 34, LO3 has three prerequisite links and is more important than the other LOs. Next, LO4 has two links, and LO2 and LO5 have one link but LO1 has no link. From this structure, we can consider that the priority of LO1is lower than other LOs in module 1. Figure 35 illustrates a sample of a prerequisite LO.

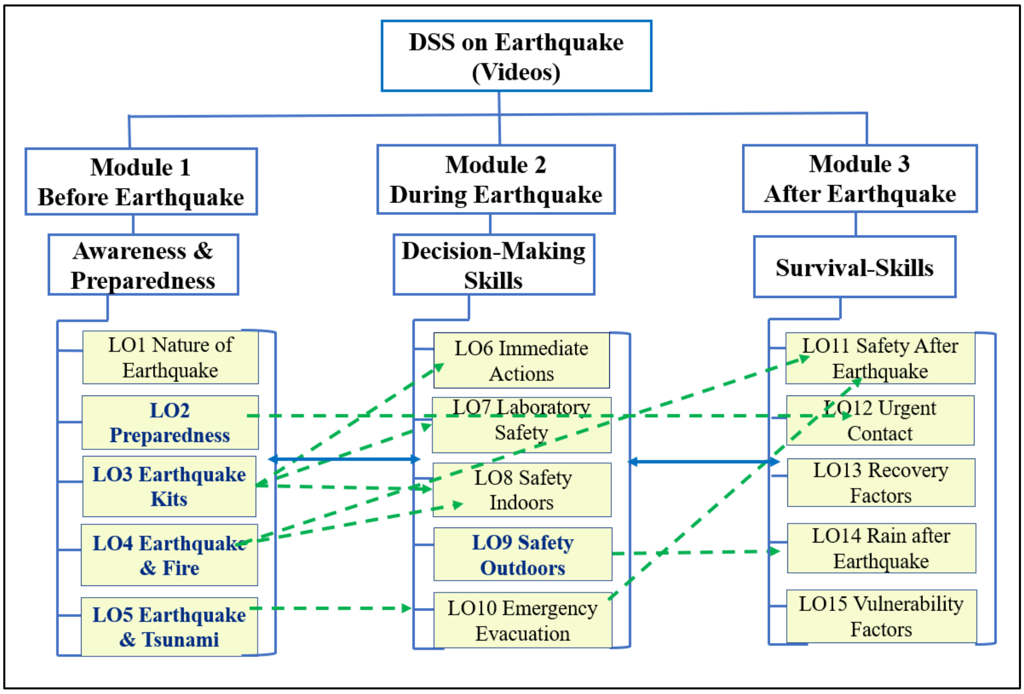

Figure 34: Prerequisite LOs in the content hierarchy

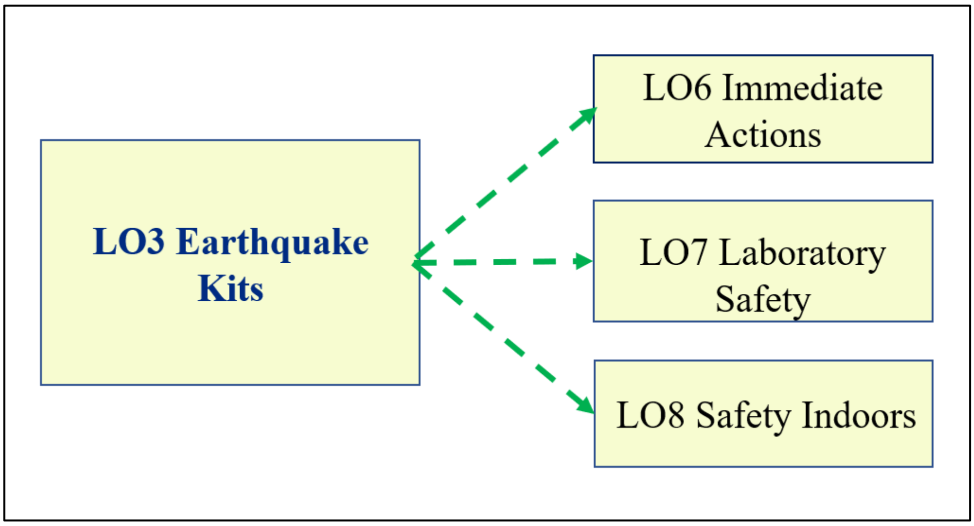

Figure 35: Prerequisite LOs

Prerequisite (pr) LO Example:

Pr. Set = {LO2, LO3, LO4, LO5, LO9}

Pr. LO2= {LO7, LO12}

Pr. LO3= {LO6, LO7, LO8}

Pr. LO4= {LO8, LO11}

Rule:

Learners must complete all the LOs in the given set.

Algorithms:

If learner starts Pr.LO2

Set Aggregation: Choice=true; Flow=true

If learner starts Pr.LO3, Pr.LO4, or any other Prerequisite LO

Set Aggregation: Choice=true; Flow=true

4.7 Interactive Quiz Creation

In the structured and branching scenario lesson, we have added interactions and mini-tests, i.e., quizzes, puzzles, true-false questions, fill in the blanks, etc., to the videos to realize students' retention outcomes or skill learning outcomes. The quizzes are designed very carefully so that students can learn the important parts or acquire essential skills from the given content. In addition, these interactive quizzes help instructors to know whether students have watched the entire video or not."

For example, some students might just start the video. In that case, the system automatically generates access history data, but the system cannot trace whether the student is continuously watching the video or not. Maybe, after starting the video, students can play games or do other things. In that case, mini tests in the H5P tool measure the performance of the students while they watch the video. A good score of H5Ps interaction result might indicate good learning interaction and outcome, while a poor score indicates the poor outcome and vice-versa. In that case, the system can consider the additional calculation of H5P's score with the students' model data. A simple way is if any student fails in the H5P quiz test, he/she might not watch the entire video, and his/her repetition or duration data is reduced. Alternatively, even if he/she clicks for the second repetition, the system might consider that he/she does not have any repetition. So, the student needs to learn the content sufficiently or repeat it. Figure 36 is an example of Interactive quizzes with the video.

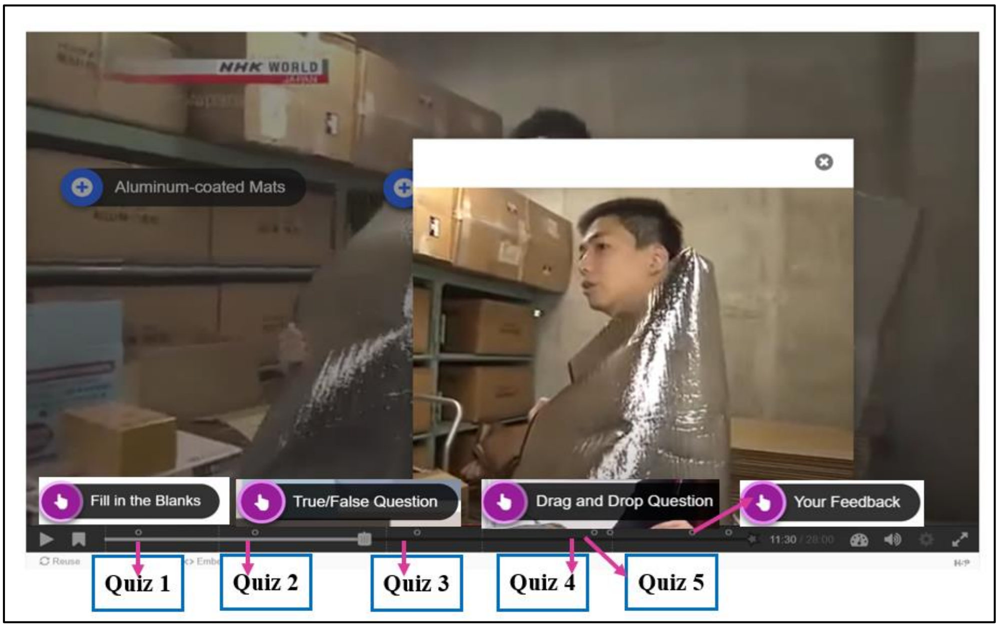

Figure 36: Interactive quizzes with the video
Source: [93]

4.8 Badges

The research used three different types of badges for three different video quizzes to keep motivation among learners. For example, learners were awarded a blue badge for the completion of the quizzes for video 1, a red badge for the completion of the quizzes for video 2, and a golden badge for those who completed all the quizzes for all the videos including video 3.

4.9 Conclusion

In this chapter, the research illustrated the development of the proposed system along with the different functions of the VART system. The video controller tool helps learners pick up important video sequences and guide students to watch them from the actual learning resources. The video analyzer tool helps students to know both about the video and the essential parts inside the video. The video watching behaviors tracker monitors the students' watching duration and repetition of watching, number of clicks, comments, difficulties, or intentions and recommends content based on students' attention and retention process and watching history data. Finally, the VART can detect the number of watching and duration of the watching history of the specific part of the video. Different types of content structures and their features might provide enthusiasm and learning support to the learners to learn from the contents. In the content visualization, students can find the visual display of the contents or LOs as a map that helps students and trainers know the learning process and state of learning. The next chapter demonstrates the real-life experiment conducted with the JAIST students and other related topics related to the experiment.

Chapter 05: Implementation Phase

5.1 Introduction

This chapter describes the experiment result, reflection, and feedback of participants on the proposed system. First, the chapter addresses the experiment environment (selection of participants, experiments tools, etc.). Secondly, this chapter presents the experiment results and identifies and validates the best fit model for video-based DSS learning. Finally, the research illustrates the delayed survey feedback result from the students which was conducted three months after the main experiment.

5.2 Purpose & Hypothesis

The main purpose of this experiment is to identify the appropriate content structure for Video-based DSS training. More specifically, the purpose is to clarify the effectiveness of the structured design and branching scenario design for the video-based skill development training among the participants to provide necessary support and recommendations in their learning process. Therefore, the experiment tracks the students watching and learning behaviors, including the attention and retention process while watching videos and measuring the reflection of the learning outcome through evaluation of the post-test score results.

As the main hypothesis, the research assumed that structured and branching lesson videos might significantly impact learning and acquiring DSS compared to non-support videos.

5.3 Selection of Participants

The experiment content was designed for international students ranging from master to Ph.D. and post-doctoral level. Initially, an open invitation email for participation in the experiment has been sent through the JAIST portal. A total of 47 international students showed their interest to take part in the experiment. However, based on the geographic distribution of the home country, duration of stay in Japan, TOEIC score (650 or above), distribution of the counterbalance, and other issues, 36 participants were finally selected for the experiment. The participants were selected from 13 different countries, including Bangladesh, China, India, Indonesia, Korea, Laos, Malaysia, Myanmar, Nigeria, Pakistan, Taiwan, Thailand, and Vietnam. The academic level distribution of the participants includes 12 masters, 21 doctoral, and 3 post-doctoral grade students. Out of the 36 participants, 21 (58%) were male students, while 15 (42%) were female students. Figure 37 shows the gender ratio among the participants.

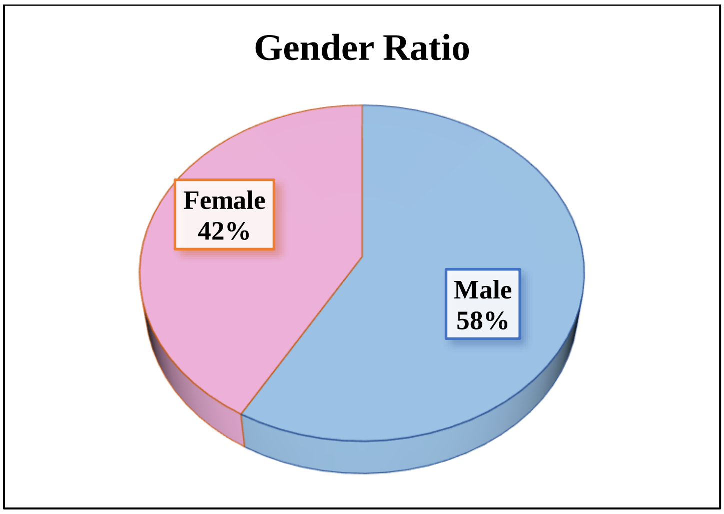

Figure 37: Gender ratio

It was found that among the participants, 44% had the experience of past DSS training once or twice in their life, while 39% of participants had never attended any DSS training. It is assumed that the participants who received the training once or twice in their whole life might have the possibility to forget the training or the experience is not effective at present. It is also found that some students who received a few pieces of training in the past did not receive any survival training on earthquakes and similar disasters because these types of disasters are not common in their countries. So, from the data, it can be said that about 83% of the participants did not receive any training or do not have any effective training experience before coming to Japan. The research also identified the same situation in the preliminary questionnaire survey among the international students, where 82% of students were found to not have any remarkable training before coming to Japan. On the contrary, 14% of participants regularly participated in training at least once every year and 3% once or twice a year. The following figure 38 represents the previous training status among the participants.

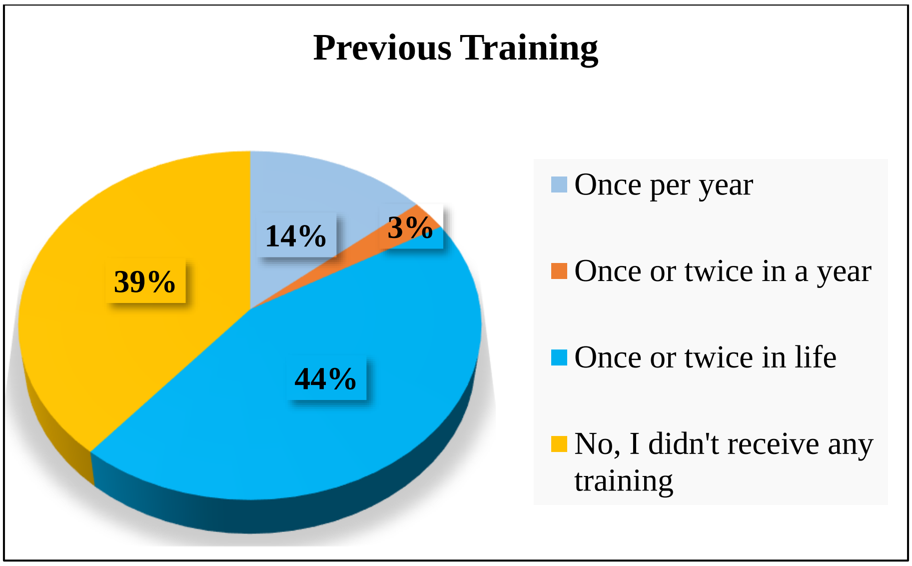

Figure 38: Previous training status of the participants

Country Information of the Participants

The research collected and reviewed the country information and previous knowledge on disasters of the 36 students who participated in the experiment. But we decided not to include the country information in our analysis. To deal with the national origin of the participants, the research applied the Structural Equation Model (SEM) to test the country's information and the previous status of knowledge of the international students. But it couldn't find a satisfactory result. The main reason is that the definition of earthquake dangerous level countries is quite hard to define. For example, the number of earthquakes in China. China is the most earthquake-occurring country in the world. Earthquakes occur many times in the western part of China. But it is a very big country. So, based on the size, the statistical information represents China as not a high earthquake occurring country. On the other hand, there are not many earthquakes in Bangladesh. But if we divide the number of earthquakes by the size of the country, Bangladesh is small, so it represents a high number of earthquakes occurring in the world. This kind of representation is unbelievable. Thus, defining the dangerous levels of earthquake-occurring countries is quite difficult. Even in Japan, the impact of the earthquake is quite different by region. In Ishikawa prefecture, the number of earthquakes is less than in other places. Hokkaido, Tokyo, Tokushima, and some other parts have more impact on the earthquake. But from the country level, it's quite hard to define. Therefore, this research considered that using students' previous experience or past status of DSS knowledge might be better than using more general information about their countries.

5.4 Methods of Experiment

Each experiment included a pre-test first, where participants were asked to answer some selected questions to measure their DSS level of understanding. In this case, they did not watch any disaster-related video. They just accessed the LMS and answered the pre-test quizzes. The pre-test included 12 quizzes, where 4 quizzes were taken from video 1 non-support video, 4 quizzes from video 02, structured video, and 4 quizzes from video 03 branching video. Thereafter they watched three videos one after another, and participants were asked to answer three post-test quizzes after watching each video. The pre-test and three post-test questions were designed with the same structure, score points 15, and time duration 10 minutes. The selected video contents and texts were designed in English. The distribution of 120 minutes of each experiment covers briefing sessions: 10 minutes, video watching/learning time (three videos): 75 minutes, four quiz tests (one pretest + three post-tests): 20 minutes and breaks and small instructions before three different videos: 15 minutes. The nature and duration of the video of the experiment are mentioned in the following table 8.

Table 8 Characteristics of experimented videos

Nature of Video	Length (Minutes)	Content Topics
Video 01 (Non-support long video)	19.4	Nature of earthquake disasters in Japan, awareness, preparedness and alerts, earthquake kits, and emergency bags, earthquake simulation drills, fire drills, etc. Source: NHK World, Japan, Japanology Plus [93]
Video 02 (Structured)	13.31	Earthquake safety issues, i.e., safety at school, safety indoors and outdoors, safety at the sea-side area, safety while driving, safety while on the bed. Sources: American Red Cross, Disaster Preparedness [96],Major Disasters [97], Great ShakeOut Earthquake Drills, Earthquake, Safety Video Series [98].
Video 03 (Branching)	17.25	Earthquake drills, parts 1,2, and 3 (before, during, and after an earthquake), CPR, and AED training. Source: State Compensation Insurance Fund, Earthquake Drills, Part 1, 2, and 3. [95], CPR-First Aid Training Video [99], How to use AED in Japan [100].

To ensure privacy protection and research ethics, each participant was provided the informed consent form to read it carefully and sign on it to clarify that they agreed to take part in the experiment. Each participant was provided a laptop with a headset, and a mouse for watching and learning from the videos in the experiment. A recording device named “Pearl Mini Recorder” with a storage capacity of 1TB was used to screen record the video watching data from the participant’s PC. Participants’ video watching behavior activities data were recorded and screen records were preserved in the JAIST cloud. The experiment environment and the participants are seen in figures 39 and 40.

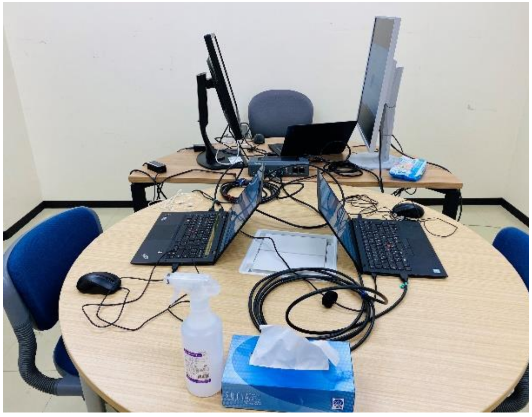

Figure 39: Experiment environment

Figure 40: Experiment participants

Participants were selected within-subject criteria, and two participants were selected to participate in each session of the experiment. For the three condition videos the watching order was defined based on counterbalances and the different groups watched videos in a different order, i.e., Videos1,2,3, Videos 2,3,1, and Videos 2,1,3 orders, etc. During the experiment, participants' learning behaviors, i.e., the watching duration of each video, the number of repetitions, duration/length of repetition, number of clicks, and scores, were monitored and recorded for analysis.

Data Analysis Tools

SPSS/ Friedman's ANOVA was used to calculate normality tests, Friedman test, Nonparametric Tests, Wilcoxon Signed Ranks Test, etc.

SmartPLS created structural equation models to realize the students' behavior and the proposed models are realistic.

Microsoft Excel was used to create miscellaneous graphs, images, pie charts, etc.

5.5 Preferred Content Structures

The research developed three types of content structures: i) Non-support or traditional video, ii) Structured video, and ii) Branching scenario lesson video to conduct the experiment. The main purpose was to identify the learning effects of the learners on three different types of video content structures and if there are significant differences among these three structures in terms of learning behavior, learning outcome, and learners' preferences. We gathered participants' post-experiment reflections regarding their preferred video content structure represented in the figure below at the end of the experiment.

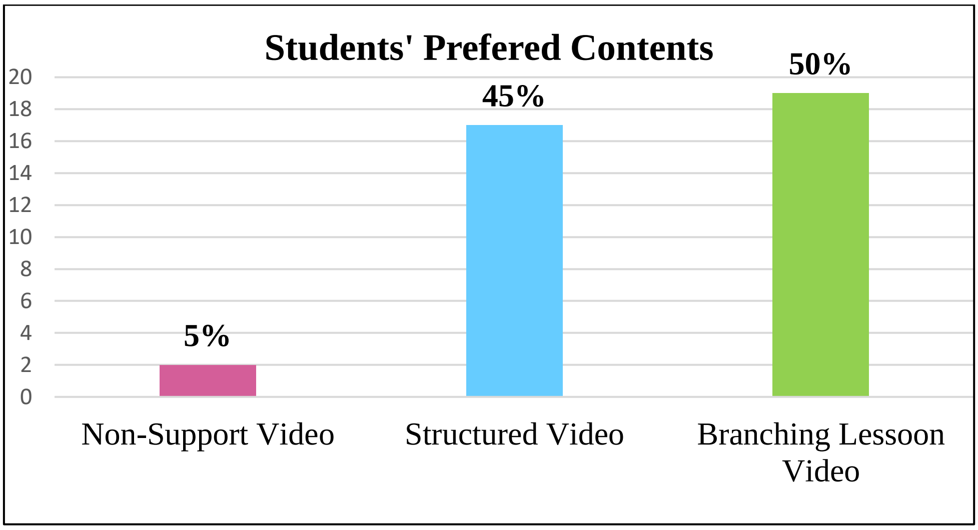

Figure 41: Students' preferred content structure

From figure 41, it is observed that branching scenario lesson structure is the most preferred by the participants (50%) in the video-based learning system followed by the structured video (45%). Very few participants (5%) only preferred non-supported video structure.

5.6 Experiment Results

5.6.1 Normality Test

To determine whether the dataset is well-modeled by a normal distribution and to measure the likelihood of random variables underlining the data set, we executed a normality test. The normality test compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation [101]. However, as the sample size is less than 50, normality tests have modest power to reject the null hypothesis, and therefore small samples most often pass normality tests [102]. Accordingly, the research also conducted the Shapiro-Wilk Test. The Shapiro-Wilk test is based on the correlation between the data and the corresponding normal scores [103]. Lack of symmetry (skewness) and pointiness (kurtosis) are two main ways to deviate from the normal distribution. The values for these parameters should be zero in a normal distribution [101].

Table 9 Result of normality test

Name	**Sample Size**	**Average**	**Standard Deviation**	**Skewness**	**Kurtosis**	**Kolmogorov-Smirnov Test**		**Shapiro-Wilk Test**	
						Statistic D	p value	Statistic W	p value
Pretest Score	36	6.111	2.025	-0.116	-0.849	0.13	0.128	0.962	0.255
Video 01 (N)	36	11.194	2.136	-0.194	-0.802	0.134	0.098	0.957	0.178
Video 02 (S)	36	13.306	1.508	-1.613	3.471	0.233	0.000 **	0.831	0.000 **
Video 03 (B)	36	12.972	1.812	-0.597	-0.807	0.187	0.003 **	0.89	0.002 **

Note: Acceptable value * $p<0.05$ ** $p<0.01$

In table 9, the Shapiro-Wilk Test analysis, it is found that the p-value of video 02 and video 03 are all less than 0.05. Hence, we argue that video 02 and video 03 are non-normal distributions.

From the normality test, it was found that the p-value of the pretest score and video 01 are all over 0.05. So, the pretest score and video 01 are normal distribution. But the p-value of videos 2 and 3 was under 0.05, so they are not normal distribution.

Hereafter, from the normality tests, we found statistical differences among the four conditions. For the pre-test, students accessed the LMS first and then gave the test without watching any videos. So, the average score for the pre-test is comparatively lower than the three post-test scores. After the pre-test, students watched the three different conditions videos (non-support (N), structured (S), and branching (B) and then answered the post-tests quizzes. As a result, their scores improved. The average scores for the pre-test is 6.11, while the score of 11.19 is for video 01 (N), score 13.31 for video 02 (S) and score 12.97 for video 03 (B). Hence, the normality test results illustrated that Video 02 score (S) and Video 03 score (B) are non-normal distribution, while Video 01(N) score and pre-test score are a normal distribution.

5.6.2 Friedman Test

From the normal distribution test, we found pre-test score and video 1 score have the normal distribution but the other two conditions, videos 02 and 03 were non-normal distribution. Therefore, to understand the differences among the three different conditions videos 1, 2, and 3, we could not use the t-test. We only could consider the non-parametric test i.e., the Friedman test.

The Friedman test is a non-parametric statistical test to detect the differences in treatments across multiple test attempts [104]. It is used to measure the analysis of variance by ranks. The procedure of the Friedman test involves ranking each row together followed by considering the values of ranks by columns.

In this research we used the Friedman test to know, the three conditions (non-support, structure, and branching video scores) are statistically different or not, it is important. The differences among the three conditions using the median data by Friedman test are presented in the below tables.

Table 10: Descriptive statistics

Videos	N	Mean	Std. Deviation	Minimum	Maximum
Video 01 (N)	36	11.1944	2.13568	7.00	15.00
Video 02 (S)	36	13.3056	1.50844	8.00	15.00
Video 03 (B)	36	12.9722	1.81244	9.00	15.00

Table 11: Ranks

Ranks	
	Mean Rank
Video 01 (N)	1.43
Video 02 (S)	2.33
Video 03 (B)	2.24

Table 12: Test statistics[a]

N	36
Chi-Square	20.699
df	2
Asymp. Sig.	<.001
a. Friedman Test	

From table 10, we can find the 36 samples for each of the variables, the mean and the standard deviation and minimum, maximum scores, and in table 11, the mean ranks for each of the three variables.

In table 12, we can find the statistical significance <.001, which is below 0.05. So, it is statistically proved that videos 1, 2, and 3 are significant differences.

So, now we need to administer a post hoc test to see where the differences are. We can get some idea from the above descriptive data and the ranks, but we do not know where the differences are until we do the post hoc test.

5.6.3 Wilcoxon Signed Ranks Test

In addition to Friedman's ANOVA test, this research executed the Wilcoxon Signed Ranks Test, known as the post-hoc test, to compare two related samples, matched samples, or repeated measurements on a single sample to assess if their population mean ranks differ.

In the Freidman test, we could identify whether the three video conditions have statistical differences or not. The results only showed that the three conditions have significant differences or not. But still, we need to investigate which condition is different and which condition is similar. So, we did the post hoc test for each condition, i.e., the combination of video 01 and video 02, video 01 &video 03, video 02 & video 03. We did a Bonferroni correction. So, if we divide the 0.05 by 3, then we get about .017.

However, we selected the Wilcoxon Signed Ranks Test because our data do not include two variables. So, it is better not to choose McNemar and Marginal homogeneity tests. Therefore, we only can consider the Sign test and the Wilcoxon test. Nevertheless, compared with the Sign test, Wilcoxon has some extra advantages. Wilcoxon includes the features of the Sign test and additional functions and is the upgraded version of the Sign test. The results of the Wilcoxon Signed Ranks Test among the three videos are presented below:

Table 13: Descriptive statistics, video 01 and 02

	N	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**
Video 01 (N)	36	11.1944	2.13568	7.00	15.00
Video 02 (S)	36	13.3056	1.50844	8.00	15.00

Table 14: Ranks

Video 02 and Video 01			
Ranks	**N**	**Mean Rank**	**Sum of Ranks**
Negative Ranks	4[a]	9.63	38.50
Positive Ranks	26[b]	16.40	426.50
Ties	6[c]		
Total	36		
a. Video 02 < Video_01			
b. Video 02 > Video_01			
c. Video 02 = Video_01			

Table 15: Test statistics, video 01 and 02

Video 02 and Video 01	
Z	-4.009 [b]
Asymp. Sig. (2-tailed)	<.001
a. Wilcoxon Signed Ranks Test b. Based on Negative ranks	

Table 13 shows a greater difference between the means of video 01 and 02, which is 11.19 and 13.30, and in table 14, we found 4 negative ranks and 26 positive ranks, and 6 ties between these two conditions videos.

In table 15, with the Bonferroni correction, we found statistical significance <.001 less than .017. So, there are statistically significant differences between the video 01 scores and the video 02 scores.

Table 16: Descriptive statistics, video 01 and 03

Videos	N	Mean	Std. Deviation	Minimum	Maximum
Video 01 (N)	36	11.1944	2.13568	7.00	15.00
Video 03 (B)	36	12.9722	1.81244	9.00	15.00

Table 17: Ranks, video 01 and 03

Video 03 and Video 01			
Ranks	**N**	**Mean Rank**	**Sum of Ranks**
Negative Ranks	5[a]	10.80	54.00
Positive Ranks	24[b]	15.88	381.00
Ties	7[c]		
Total	36		
a. Video 03 < Video 01			
b. Video 03 > Video 01			
c. Video 03 = Video 01			

Table 18: Test Statistics[a], video 1 and 3

Video 03 and Video 01	
Z	-3.559[b]
Asymp. Sig. (2-tailed)	<.001
a. Wilcoxon Signed Ranks Test b. Based on Negative ranks	

Table 16 also found a greater difference between the means of video 01 and 03, which is 11.19 and 12.97, and in table 17, we found 5 negative ranks and 24 positive ranks, and 7 ties.

In table 18, with the Bonferroni correction, we found statistical significances <.001 less than .017. So, there are also statistically significant differences between the video 01 scores and the video 02 scores.

Table 19: Descriptive statistics, video 02 and 03

Videos	N	Mean	Std. Deviation	Minimum	Maximum
Video 02 (S)	36	13.3056	1.50844	8.00	15.00
Video 03 (B)	36	12.9722	1.81244	9.00	15.00

Table 20: Ranks, video 02 and 03

Video 03 and Video 02			
Ranks	**N**	**Mean Rank**	**Sum of Ranks**
Negative Ranks	16[a]	17.41	278.50
Positive Ranks	14[b]	13.32	186.50
Ties	6[c]		
Total	36		
a. Video 03 < Video 02			
b. Video 03 > Video 02			
c. Video 03 = Video 02			

Table 21: Test Statistics[a], video 02 and 03

Video 03 and Video 02	
Z	-.959[b]
Asymp. Sig. (2-tailed)	.337
a. Wilcoxon Signed Ranks Test b. Based on Negative ranks	

We found a different result from the result from table 19 compared to the other two post hoc tests. There was a slight decrease between the means from video 02 to video 03, which is 13.30 and 12.97, and in table 20, we found 16 negative ranks and 14 positive ranks, and 6 ties between these two conditions videos.

In table 21, with the Bonferroni correction, we could not find statistical significance. The significance was .337, which is greater than .017. So, in this case, we could not find statistically significant differences between the video 02 scores and the video 03 scores.

The p-value of video 01 and video 02, and video 01 and video 03 are under 0.05 or .017. In summary, video 01 is significantly different from videos 02 and 03. However, the comparison between video 02 and video 03 p-value is over 0.05 or .017. Hence, video 02 is not significantly different from video 03.

Table 22: Hypothesis test summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distributions of Video_01_N, Video_02_S and Video_03_B are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	<.001	Reject the null hypothesis.
a. The significance level is .050.				
b. Asymptotic significance is displayed.				

From the above table 22, it is also proved that the three videos are not the same and they have significant differences.

Related-Samples Friedman's Two-Way Analysis of Variance by Ranks

Table 23: Friedman's two-way analysis

Total N	36
Test Statistic	20.699
Degree of Freedom	2
Asymptotic Sig. (2-sided test)	<.001

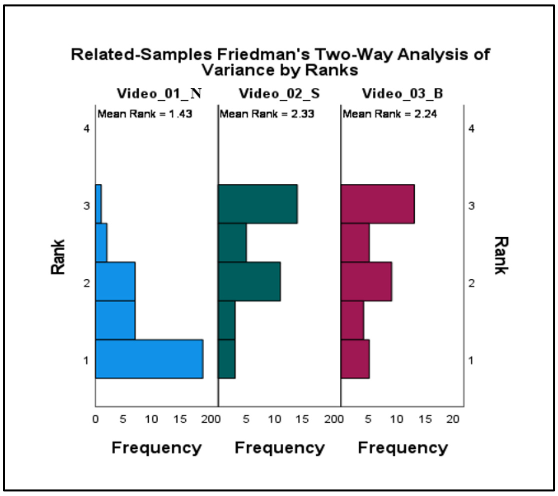

Figure 42: Friedman's two-way analysis of variance by ranks

From table 23 and figure 42, according to Friedman's two-way analysis of variance it is found that, and three videos have significant differences, and video 01 has been grouped separately, while videos 02 and 03 grouped together.

Table 24: Homogeneous subsets

Sample[a]	**Subsets**	
	1	2
Video 01 (N)	1.431	
Video 03 (B)		2.236
Video 02 (S)		2.333
Test Statistic	.[b]	.111
Sig. (2-sided test)	.	.739
Adjusted Sig. (2-sided test)	.	.739
Homogeneous subsets are based on asymptotic significance. The significance level is .050.		
a. Each cell shows the sample average rank.		
b. Unable to compute because the subset contains only one sample.		

From the above table 24, subset 1: Video 01 (N), or non-support video, has significant differences compared to the other two videos. Subset 02: Video 02 (S) Structured video and Video 03 (B) Branching video have almost similar results. In the Friedman test, we found that video 2 & 3 is different from video 1. The p<. 001 showed significant differences.

Therefore, understanding the relationship between the two videos (S and B) in subset 2 is important. In the content structure, we created a support function for videos 02 & 03, but there was no support for video 01. The result showed positive effects on video 02 & 03, and the score results are also higher than video 01. So, the proposed hypothesis worked well and made significant differences among student's learning outcomes.

Hence, from the above analysis, it is statistically proved that the structured method and branching method significantly influence the video-based training and learning for acquiring DSS. This is the main contribution of the experiment.

5.7 Validation of Proposed E-teaching Strategy Model

This research identified three core constructs: past status, learning behaviors, and learning outcomes from the interpretation of data and analyzing the learning trends. Past status includes past training and pre-test score data while learning behaviors cover duration, repetition, and the number of clicks, and learning outcomes are considered the post-test scores. Based on the learning behavior and learning outcomes, the proposed system determines the e-teaching strategy and recommendation for the students.

Reliability and validity among the constructs

However, to understand the relationship among the constructs, it is important to assess the reliability of the measurement scales. In this research, the internal consistency analysis was measured by calculating Cronbach's alpha, rho_A, Composite reliability, and Average Variance Extracted (AVE). Table 25 and 26 illustrates the result of the validity analysis for structured and branching videos.

Table 25: Construct reliability and validity

Structured Video	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted
Learning Behavior	**0.854**	**0.994**	**0.894**	**0.740**
Learning Outcomes	**1.000**	**1.000**	**1.000**	**1.000**
Previous Status	0.377	**1.613**	0.671	**0.555**

Table 26: Construct reliability and validity

Branching Video	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted
Learning Behavior	0.500	0.388	**0.740**	**0.501**
Learning Outcomes	**1.000**	**1.000**	**1.000**	**1.000**
Previous Status	0.358	**1.763**	**0.702**	**0.572**

In general, Cronbach's alpha is used to measure the internal consistency and dimensionality among each construct. However, there are differences in accepting the satisfaction level of alpha among different researchers. Ven & Ferry [105] consider that Cronbach's Alpha 0.55 and higher is acceptable, while Oosterhof [106] suggests the acceptable level is 0.6 or higher. On the other hand, Tavakol & Dennick [107] consider alpha level 0.7 or higher is acceptable. In table 25 and 26, all the green marked values indicate good reliability and validity based on SEM fit criteria analysis.

This research considers the previous status as an independent variable among the three constructs because this variable affects both learning behavior and learning outcome. Accordingly, we calculated the R-squire value of these constructs, and the result is represented in the following table 27.

Table 27: R Square matrix among the constructs

Constructs	**R Square**		**Adjusted R Square**	
	Structured video	**Branching video**	**Structured video**	**Branching video**
Learning behaviors	0.113	0.045	0.087	0.016
Learning outcome	0.055	0.304	-0.003	0.262

Based on the relationship among the constructs, we formulated the following hypothesis which guided the research to formulate and validate an appropriate learning model.

Hypothesis 01:	Previous knowledge and experience have effects on students' learning behavior.
Hypothesis 02:	Previous status of knowledge and experience (pre-train and pre-test) have effects on learning outcomes
Hypothesis 03:	Learning behavior have effects on learning outcomes

Finally, this research developed two models based on the settings of structured video and branching video and measured the fit indexes using structural equation modeling.

5.8 Structural Equation Model (SEM)

This research assumes a core relationship among the duration, repetition, click, and score from the video-based learning environment. However, simply finding this complex relationship is quite difficult. To understand such a relationship, we applied Structural Equation Model (SEM) using SmartPLS. SEM is a multivariate statistical analysis technique that is used to analyze structural relationships. This technique combines factor analysis and multiple regression analysis, and it is used to analyze the structural relationship between measured variables and latent constructs [108].

Accordingly, we have created two SEM models for structured and branching videos. After that, we did Model Fit Comparative analysis between structured and branching videos.

5.8.1 Structural Equation Model: Structured Video

Figure 43 represents the SEM model for the structured video. In this model, yellow nodes indicate measured variables and blue nodes indicate latent construct or conceptual relation among three constructs. From this figure, we have found that students' previous status has a positive correlation with their learning behavior and learning outcome which supports hypothesis 1 and 2. On the other hand students' learning behavior has a minus correlation with students' learning outcome. Table 28 provides a summary of acceptable values for the SEM model for the Structured Video.

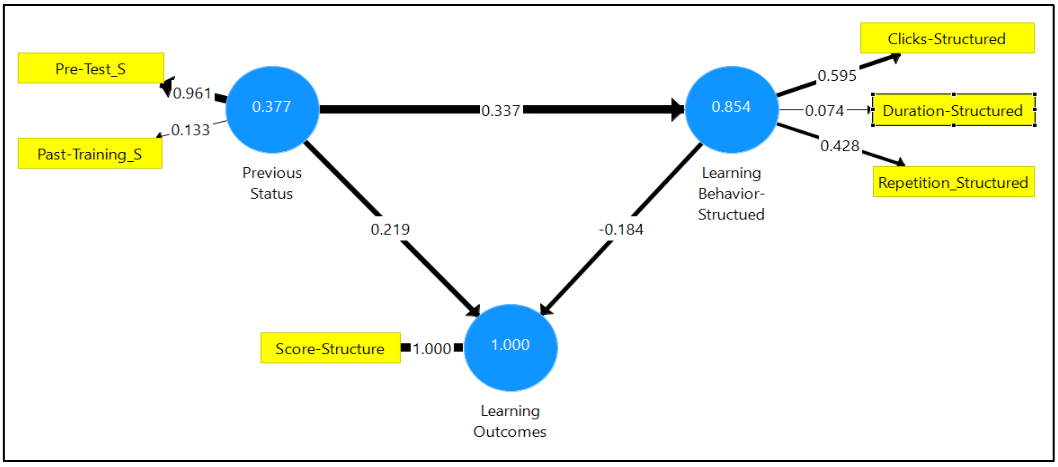

Figure 43: SEM-Structured video

Table 28: SEM Model Fit-Structured video

Fit Name	Saturated Model	Estimated Model
SRMR	0.114	0.114
d_ULS	0.273	0.273
d_G	0.128	0.128
Chi-Square	28.179	28.179
NFI	0.609	0.609
RMS Theta	0.394	

5.8.2 Structural Equation Model: Branching Video

Figure 44 represents the SEM model for the branching video. In this model, yellow nodes indicate measured variables and blue nodes indicate latent construct or conceptual relation among three constructs. From this figure, we have found that students' previous status has a positive correlation with their learning outcome and a minus correlation with their learning behavior. On the other hand, students' learning behavior also has a minus correlation with students' learning outcome. Table 29 provides a summary of acceptable values for the SEM model for the branching video.

The model fit summary and comparison for both videos are provided in the next section.

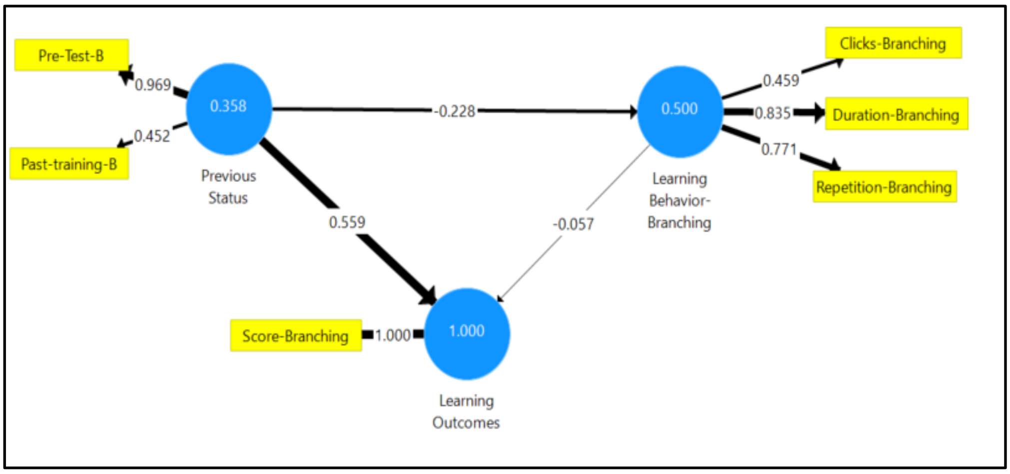

Figure 44: SEM-Branching video

Table 29: SEM Model Fit-Branching video

Fit Name	Saturated Model	Estimated Model
SRMR	0.128	0.128
d_ULS	0.346	0.346
d_G	0.088	0.088
Chi-Square	16.826	16.826
NFI	0.596	0.596
RMS Theta	0.369	

5.9 Model Fit Comparative Analysis: Structured and Branching Videos

In SEM, Model fit analysis is required to describe how well the observed sample matches the expected value. Model fit can be assessed in two non-exclusive ways: i) by means of inference statistics (tests of model fit), and ii) through the use of fit indices (approximate model fit). Partial Least Square (PLS) path modeling's tests of model fit rely on the bootstrap to determine the likelihood of obtaining a discrepancy between the empirical and the model-implied correlation matrix [109]. SmartPLS SEM can be measured through the following parameters [110]:

- **SRMR-** The Standardized Root Mean Square Residual (SRMR) is an index that calculates the average of standardized residuals between the observed and the hypothesized covariance matrices [111]. In SmartPLS fit measurement, a value lower than 0.10 or 0.08 indicates a good fit [112].

- ☐ **Exact Model Fit (d_ULS and d_G):** The exact model fit tests the statistical (bootstrap-based) inference of the discrepancy between the empirical covariance matrix and the covariance matrix implied by the composite factor model [113]. To determine the exact fit criteria in SmartPLS, the upper bound at the 95% or 99% point of the confidence interval should be larger than the values of d_ULS and d_G [113].

- ☐ **NFI** - Normed Fit Index (NFI) computes the Chi² value of the proposed model and compares it against a meaningful benchmark. The acceptable NFI value is between 0 and 1 [114].

- ☐ **Chi-Square** is a function of the sample size and the difference between the observed covariance matrix and the model covariance matrix.

- ☐ **Root Mean Square** (**RMS_theta) -** The RMS_theta is the root mean squared residual covariance matrix of the outer model residuals [115]. The RMS_theta assesses the degree to which the outer model residuals correlate. The measure should be close to zero to indicate a good model fit.

- ☐ **R^2** - R^2value also known as the coefficient of determination. The R^2value represents the proportion of variation in the dependent variables explained by one or more predictor variables [116]. Falk & Miller (1992) [117] propose the minimum acceptable R^2value is 0.10.

However, SEM model tests assume that the correct and complete relevant data have been modeled. In the SEM literature, discussion of fit has led to various recommendations on the precise application of the various fit indices and hypothesis tests. Following table 29 provides a summary of acceptable values for SEM model fit with reference and values of the observable facts of the study.

Table 30: PLS-SEM Model Fit summary

Measurement tool	Acceptable value	Value – Structured video	Value – Branching video
SRMR	<0.10	0.114	0.128
d_ULS (Saturated Model)	95% Confidence Intervals> original value of d_ULS	0.408 (Original value of d_ULS 0.273)	0.346 (Original value of d_ULS 0.121)
d_ULS (Estimated Model)		0.425 (Original value of d_ULS 0.273)	0.346 (Original value of d_ULS 0.121)
d_G (Saturated Model)	95% Confidence Intervals> original value of d_G	0.239 (Original value of d_G 0.128)	0.088 (Original value of d_ULS 0.029)
d_G (Estimated Model)		0.252 (Original value of d_G 0.128)	0.088 (Original value of d_ULS 0.029)
Chi-Square		28.179	16.826
NFI	Between 0 and 1	0.609	0.596
RMS_Theta	close to zero	0.394	0.369

Table 30 illustrates that the SRMS of the proposed models for structured video is 0.114, greater than the acceptable range (<0.10). However, the SRMR for branching video is 0.128, which is also greater than the acceptable range. The 95% confidence interval is larger than the original d_ULS value. The 95% Confidence Intervals of structured video are 0.408 and 0.425 for saturated and estimated models, and the original value of d_ULS is 0.273. Again, the 95% Confidence Intervals of branching video is 0.346 and 0.346 for saturated and estimated models, and the original value of d_ULS is 0.121. Both the saturated and estimated value for structured and branching videos indicate the good fit of the model. Similarly, the d_G value of both models is also well supported. The 95% Confidence Intervals of the saturated model is 0.239, and the estimated value is 0.252 for the structured video, which is larger than the d_G value of 0.128. The 95% Confidence Intervals of the saturated model are 0.088, and the estimated value is also 0.088 for branching video, which is larger than the d_G value of 0.029. At the same time, The Chi-square value of the structured and branching videos are 28.179

and 16.826, respectively. Besides, the NFI values for structured video is 0.609, and for branching video is 0.596, which meets the acceptable range between 0 and 1. The RMS_Theta values for both videos are 0.394 and 0.369, close to zero and acceptable. Hence the overall summary of the proposed Structure Equation Model (SEM) indicates a good fit.

5.10 Effectiveness of the Experiment

At the end of the experiment, the participants were asked to mention their remarks regarding the experiment. Figure 45 illustrates the feedback of participants on the experiment.

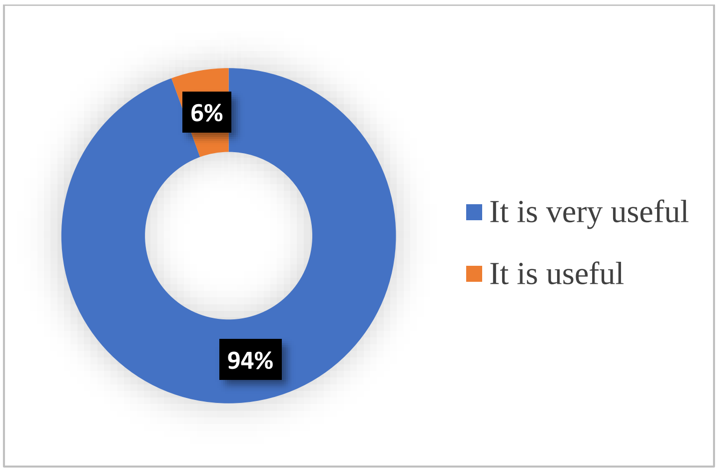

Figure 45: Students' remarks on the experiment

Excerption from Students' Feedback

The research also requested the experiment participants to provide their feedback on whether the earthquake drills, and practice videos were useful to them or not. Most of the students provided their written feedback after watching the videos. Some excerptions of important comments are mentioned bellow:

> "*The video is useful, especially with the bookmarks that point out each topic on the videos that can navigate the viewers/participants to the exact points/topics that they do not understand"*.
>
> "*I think they are useful as currently Japan has a quite number of foreigners, especially in universities. They might not have earthquake drills in their country as it might not be common there. For example, in my home country, I only received fire drill training, and not for earthquakes"*.
>
> *"It's very useful. I had to watch the video without support twice, because the video is too long to keep my focus. The structured video and branching video have solved this problem. During watching the structured video, I feel free to choose the part of contents which I interested in. But the question form in the branching lesson video is the best. If the two styles videos can combine, it will be better"*.
>
> *"It is really helpful to me! I am hoping that there will be real practice provided by our school to students"*.
>
> *"Yes, I learned a lot. It is very helpful"*.
>
> *"I think that these practice videos and earthquake drills are really informative. One can learn in good and easy way to secure himself or herself"*.
>
> *"Yes. They are. This is my first time to watch those kinds of videos. I learned a lot"*.
>
> *"Exactly, it is interesting and useful to everyone. Emergency conditions might happen in any time. So, everyone should watch it"*.
>
> *"I believe these videos should be shown to all international students especially, it is sure to create a lot of impact. And truly I enjoyed learning it"*.
>
> *"I think these earthquake drills and practical videos are useful for me. I have never experienced this kind of disaster before. So, everything is new to me."*
>
> *"The earthquake drills were extremely useful. I believe now I am better trained for facing such disaster."*

5.11 Delayed Survey Feedback

After around three months of the experiment, a delayed survey was conducted with the same 36 participants to investigate their remembering status and preferences of the LOs to be learned next step. In this case, the research designed short post-experiment feedback, or delayed survey feedback on google form and participants were requested to provide their feedback on video 02 structured video and video 03 branching lesson scenario video. The following figure 46 illustrates the list of five LOs for video 02 and figure 47 illustrates the list of five LOs for video 03.

Figure 46: Five LOs of video 02
Source: [98]

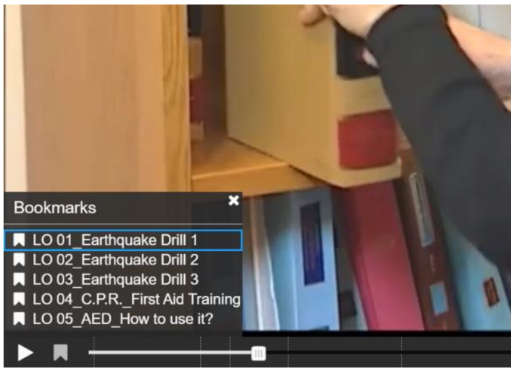

Figure 47: Five LOs of video 03
Source: [95]

This time we represented only the list of the LOs to recall their memory. Based on the memory of the previous experiment, participants picked two LOs as first and second preferences from the list of LOs of both videos 02 and 03. Participants were asked to mark the LOs they consider important or useful to be learned further. Many of them also provided their feedback for the reasons they chose for such kinds of LOs to watch next time in the open choice question at the end of the feedback form. The main purpose of this post-experiment feedback was to realize students' further repetition preferences and help students in their repetition process providing repetitive recommendations for the ongoing repetitive learners.

Table 31: Delayed survey result

	1st Choice					**2nd Choice**				
	LO1	**LO2**	LO3	LO4	LO5	LO1	**LO2**	LO3	LO4	LO5
Video 02	7	**13**	3	9	4	7	**10**	6	5	7
Video 03	9	2	7	**11**	7	6	7	3	**12**	8

From the delayed survey result, it was found that LO2 was selected by the highest number of students both as 1st and 2nd choice LO. Table 31 shows that 13 students choose LO2 as 1st choice and further 10 students choose LO2 as the 2nd choice. The number of 1st and 2nd choices of other LOs are also provided in the same table for video 02.

It is observed that students selected the LO4 maximum times as their first and second preferences from video 03. The Table also shows that 11 students choose LO2 as 1st choice, and again 12 students choose LO2 as the 2nd choice. The number of 1st and 2nd choices of other LOs are also provided in the same table for video 03.

Out of 36 students, 28 provided their feedback for the reasons they chose for such kinds of LOs to watch next time in the open choice question at the end of the feedback form. They provided interesting and mixed opinions such as content importance, very important, and related to practical life, learning, and remembering the necessary topics again, learning some important practical topics such as AED and CPR, difficulties, unknown or less known topics, interesting topics and so on.

5.12 Conclusion

From the above discussion and detailed results from the experiment, it was found that from the three condition videos, the structured and branching lesson video received higher attention than the non-support video (long video) from the students. In addition, the learning behavior and learning outcome also have a significant effect on the structured and branching video-based content compared to non-support video. Hence, our hypothesis for constructing Structural Equation Model found a well fit, and it identified that students' background knowledge and experience have a significant impact on their learning behavior as well as a learning outcome. From the delayed survey feedback, it is understood that repetition and further watching the videos are important for the students to learn and memorize the important, necessary, practical, difficult, and interesting topics. In the next chapter, we have discussed the assessment of the experiment and the delayed survey feedback.

Chapter 06: Evaluation Phase

6.1 Introduction

In this chapter, the research describes the effectiveness of the proposed VART system from different perspectives. First, the chapter addresses a summative assessment of the system from the students' and technical perspectives. The summative assessment includes the clarity of content structure to students and instructors, usefulness of different models and video-based DSS teaching and learning, as well as contribution of the research. Besides, the research answers the research question raised in chapter 1 and discusses the system-generated content visualization map, as well as the evaluation of group students and single students' learning path visualization map after execution of the system. Besides, it also provided mathematical algorithms for the group students' learning path visualization map and single students' learning path visualization map to create necessary recommendations and calculated the accuracy for both approaches. Finally, different levels of evaluation are demonstrated in this chapter.

6.2. Summative Assessments of VART System

After designing and developing the VART system, the research conducted the summative assessment to understand whether the system achieved the targeted objectives and how well the system addresses the research problems. While measuring the effectiveness of the system, the research focused on both students learning perspectives as well as technical perspectives as below:

6.2.1 Summative Assessment for Students

Summative assessment is basically done or proved after the course is finished. It tends to know the effectiveness, whether the training had a positive impact or not, whether the learning goals have been fulfilled or not, what initiatives might be taken to improve or the success of the course/ program etc. [118]. One of the important parameters of summative assessment is to evaluate whether the course goals have been met or not.

One of the major problems of existing DSS training for international students is the scattered resources and unstructured video content. As a result, students either lose their interest or miss many important videos. After applying the domain model in the VART system, related videos were organized together, reducing the risk of missing video content. In addition, fraction of long video contents saved the watching time of the students as well as focused on the important part of the video content. Besides, the VART system provides flexible access opportunities for students based on their competency level and interest. From these points of view, the proposed VART system meets the students' expectations in video-based DSS training. We have summarized how the system meets almost all the requirements of the target learners as below:

(i) In the structured videos, the virtual fragmentation, and meaningful indexes for each part of the long video provided the freedom to the learners to choose their expected topics from the represented LOs list.

(ii) In the branching video, the short video contents' aromatic display and flexible section format provided a gamified feeling to the learners, which increased the learner's interaction during learning and with the learning scenario.

(iii) The creation of interrelated LOs and prerequisite LOs indicated the content importance among the LOs lists, and navigated learners learn the important topics first.

(iv) The careful creation of interactive quizzes inside the important video parts in the structured video, branching quizzes in the branching video helped learners in their retention process, learn important topics, and acquire necessary skills from the video contents.

(v) Content path visualization map enabled both the students and the instructors to find the overall learning scenario immediately, navigate whether any important topic is missed by the learners, and recommend content based on the learning behaviors.

(vi) Developing the web-based DSS training contents enables students to access and learn 24/7, removing the distance between the students and the instructors, their schedule difficulties, and other difficulties for participation in the face-to-face training.

Furthermore, the students' choices and feedback on the three different content structures and overall remarks on the experiment finally proved that the learning needs and expectations of students might have been well fulfilled.

6.2.2 Summative Assessment from the System Point of View

In traditional video-based DSS learning, the contents are usually integrated with several topics or learning objects (LOs) and unnecessary parts. In that case, it is difficult for the system to control the video sequences and the student's watching/learning behaviors. In addition, in a traditional video-based teaching-learning environment, it is not easy to monitor students watching and learning behavior along with the progress of learning.

In the proposed VART system, both students and educators can monitor the learning progress and find difficulties along with knowledge gaps of the students. The content visualization map of the system shows the learning paths and content movement navigation flow. From watching history data and learning movement, the system can determine the e-teaching strategy and make the proper recommendations. Besides, the system guides learners on gaining full competency on skill learning criteria from the DSS contents by displaying diverse relationships among contents to contents.

6.3 Answer to the Research Questions

The research started with introducing the background of disaster situations, education, and training in Japan. More specifically, it examined the DSS training method and content delivery system offered for the international students living in Japan. However, the research identified some problems and research gaps from the existing literature review and preliminary survey. The research formulated one major research question

(MRQ) and five subsidiary research questions (SRQs) based on the problems and research gap. As the research summary, the research highlighted the major findings to answer the research questions.

SRQ1: What type of content structuring systems are appropriate for the DSS video contents?

The research designed and created three different content structuring systems using three different conditions videos on the LMS. After that, it conducted a live experiment where students first answered a pre-test and then watched the three different videos one after another and participated in three different post-tests after watching each video. Students watching and learning behaviors and scores were recorded during watching. However, after collecting and analyzing the data from the experiment, this research concludes that branching scenario lesson structure is the most preferred by the participants (50%) in the video-based learning system followed by the structured video (45%). Very few participants (5%) only preferred non-supported video structure. Details of the appropriateness of the structuring system have been demonstrated in Figure 41 in chapter 5.

SRQ2: What type of domain, students', and e-teaching strategy models are required for video-based DSS training?

The research provided the detailed design structure/architecture of the domain, students', and e-teaching strategy models for the proposed system which have been discussed elaborately in the chapter 3 under 'Design Phase'. In the proposed system, the DSS contents were developed in the domain model based on the design criteria of the domain model. However, students accessed the domain model through the LMS, watched some video content, and the proposed VART created the students' models based on the attention and retention process. The E-teaching strategy model collected watching history data from the content model and students' model to know the learning process and progress of the students. Accordingly, it generated a learning path visualization map and other functions to determine proper recommendations and necessary supports. The creation of learning path visualization maps is one of the practical outcomes of the domain, students', and e-teaching strategy models.

Creation of Learning Path Visualization Map

Before creating the learning path visualization map, we first determined the node size and importance of the nodes based on the total n of repetitions by the total no. of students. In this part, we have used students' repetition data for all the LOs in videos 02 and 03. In the experiment result, it was found that, in the structured video, part 4 or LO4 (Safety While Driving) received the maximum number of attention and retention from the students compared to other LOs. The total repetition for the 5 LOs of the structured video was: LO1=11, LO2=21, LO3=46, LO4=64, and LO5=7 and branching video was LO1=26, LO2=31, LO3=47, LO4=30 and LO5=18. Table 32 represents the total number of repetitions for the LOs of videos 02 and 03.

Table 32: Group repetition results for video 02 and 03

Video 02: Structured					**Video 03: Branching**				
LO1	LO2	LO3	LO4	LO5	LO1	LO2	LO3	LO4	LO5
11	21	46	64	7	26	31	47	30	18
Total Repetitions=147					**Total Repetitions=152**				

The following figure 48 is one of the examples of 36 students' repetition or retention approaches to the LOs of the structured video. In the Cytoscapes in figures 48 and 49, the importance of the nodes and determination of the node sizes are decided based on the total number of repetitions by the total number of students for each LO during the experiment. The larger size nodes indicate the high number of repetitions and the smaller size nodes indicate a smaller number of repetitions.

Group Students' Learning Path Visualization Map

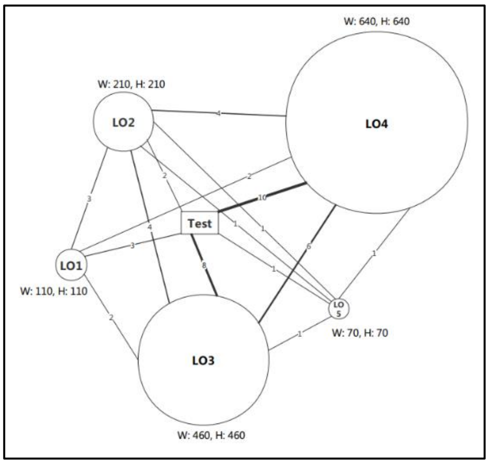

Figure 48: Video 02: learning path visualization map, structured video

Formula: Video 02, Structured
{Expected repetition for LO1 is 11 ÷ 36 = 0.31 ≈ 0, LO2 is 21 ÷ 36 = 0.58 ≈ 1, LO3 is 46 ÷ 36 = 1.28 ≈ 1, LO4 is 64 ÷ 36 = 1.78 ≈ 2, LO5 is 7 ÷ 36 = 0.19 ≈ 0.}

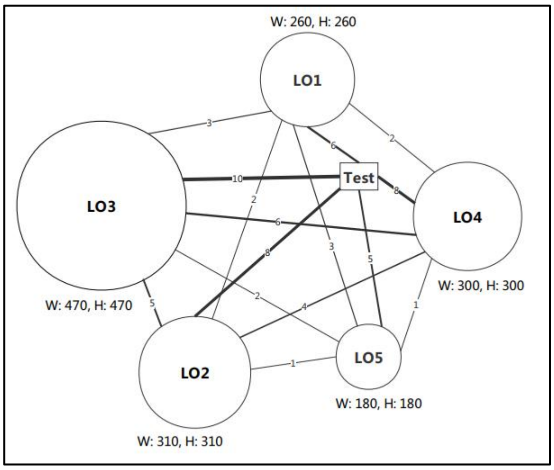

Figure 49: Video 03: learning path visualization map, branching video

Formula: Video 03, Branching
{Expected repetition for LO1 is 26 ÷ 36 = 0.72 ≈ 1, LO2 is 31 ÷ 36 = 0.86 ≈ 1, LO3 is 47 ÷ 36 = 1.31 ≈ 1, LO4 is 30 ÷ 36 = 1.83 ≈ 2, LO5 is 18 ÷ 36 = 0.5 ≈ 1. }

The Cytoscapes [119] in figures 48 and 49 represent the retention path visualization maps or repetition maps of the group viewers for the structured and branching video. These maps are produced from the experiment data, and they re-present the learning scenario of 36 participants who joined in the experiment. The research used the repetition data of 36 participants and software named "Process On" [120] to create the Cytoscape to visualize the learning path of the group of students.

To define the importance and expected repetition of each LO in the content model, we divided the total number of repetitions of each LO by all participants from the experiment data. For example, the formula for the structured video, in figure 48, the video received the total number of repetitions divided by 36: LO1=11/36, LO2=21/36, LO3=46/36, LO4=64/36, and LO5=7/36. Similarly, the formula for video 03, in figure 49, the branching video includes the total number of repetitions and divided by 36: LO1=26/36, LO2=31/36, LO3=47/36, LO4=30/36, and LO5=18/36. This formula indicates which LOs were considered to receive more repetitions (≈ importance). Based on the importance, the size of the nodes or LOs changed, and more important nodes are represented larger.

In addition, we also analyzed data to find out the participants' movement from LOs to LOs along with the direction of movement. We defined the importance of paths between the nodes using correlation rule mining. The thickest lines indicate the highest repetition or stronger relation, and thinner lines indicate less repetition and weaker relation from node to node. For example, in figure 48, the maximum repetition happened from 'Test' to LO4, and the path between 'Test' and LO4 represented the thickest path among all five LOs in the structured video. Similarly, in figure 49, the maximum repetition happened from 'Test' to LO3. So, the path between 'Test' and LO3 represented the thickest path among all five LOs in the branching video.

Formula to Define Node Size

Node size = (W, H) = (Repetition time * 10, Repetition time * 10)

Explanation: If the repetition time is 10, we need to multiply 10 with repetition time to calculate the wide (W) and high (H) of the node. So, the node size should be (W: 100, H: 100). For example, in figure 5, the highest repetition happened with LO4, 64 times. So, according to the rule 64*10 = 640, and the node size should be W: 640, H: 640. The Cytoscape size is defined by the ProcessOn software features.

Evaluation of Group Students' Learning Path Visualization Map

The initial proposed map is assumed that a greater number of group repetitions indicate the greater amount of importance of the LOs. That is, the LOs that received a greater number of views, the map might recommend such LOs to the students. However, the delayed survey results could be a candidate of the indicator (I) of the importance of the LOs. Therefore, Tables 33 and 34 show how well the following importance indices match the results of the delayed survey feedback for both structured and branching videos.

I1: LO with the highest number of group repetitions have the highest importance.

Algorithm: RLO = MAX(NR(LOi))

where, RLO is Recommended LO, NR(LOi) is Number of Repetitions in LOi (i = 1 to 5).

I2: LO with the highest number of group posttest errors have the highest importance.

Algorithm: RLO = MAX(NE(LOi))

where, NE(LOi) is Number of post-test Errors in LOi (i = 1 to 5).

I3: LO with the highest number of group repetitions plus posttest errors have the highest importance.

Algorithm: RLO = MAX(NR(LOi)+NE(LOi))

I4: LO with the highest number of group repetitions minus posttest errors have the highest importance.

Algorithm: RLO = MAX(NR(LOi)-NE(LOi))

Table 33: Video 02 - group accuracy

Indicator	Recommended LO ID	#of agreed 1st choice	1st accuracy	#of agreed 1-2nd choices	1-2nd accuracy
I1	**4**	9	25%	14	39%
I2	**3**	3	08%	9	25%
I3	**3**	3	08%	9	25%
I4	**4**	9	25%	14	39%

Table 34: Video 03 - group accuracy

Indicator	Recommended LO ID	# of agreed 1st choice	1st accuracy	# of agreed 1-2nd choices	1-2nd accuracy
I1	**3**	7	19%	10	28%
I2	**2**	2	05%	9	25%
I3	**2**	2	05%	9	25%
I4	**3**	7	19%	10	28%

In both video conditions, the number of repetitions was better consistent with the delay survey feedback. Therefore, it seems appropriate to use group repetitions rather than delayed survey results as the learning path visualization map. However, the LOs that were most selected in the delayed survey feedback were not selected in any of these indices.

For example, in figure 50, we found LO4 was the most repeated item in video 02 during the experiment. It means students repeated LO4 many times because that might be difficult, unknown, or important for them. But in the delayed survey feedback, from figures 51 and 52, it is observed that students selected the LO2 maximum times as their first and second preferences from video 02 were less repeated during the experiment.

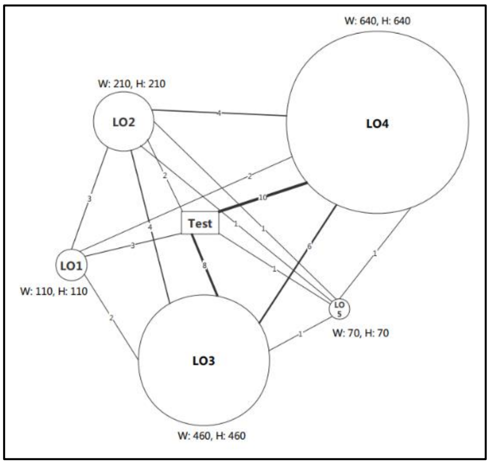

Figure 50: Video 02: group repetition, experiment result

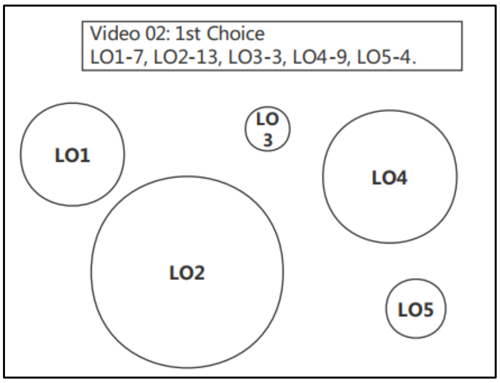

Figure 51: Video 02: students' 1st choice in delayed survey feedback result

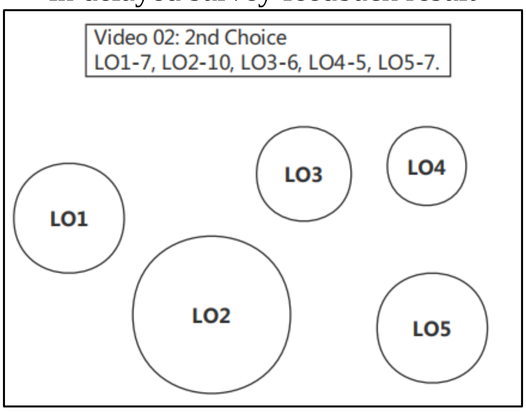

Figure 52: Video 02: students' 2nd choice in delayed survey feedback result

We also have compared the video 03 experiment results with the delayed survey feedback preferences of the students. Remarkably, we also have identified the same kind of tendency among the students' preferred LOs from video 03. For example, in figure 53, we found LO3 was the most repeated item in video 03 during the experiment. Based on the result, and learning behavior of the students, it is assumed that LO3 was the most difficult, important, or unknown content for the students. But in the delayed survey feedback, from figures 54 and 55, it is observed that students selected the LO4 maximum times as their first and second preferences from video 03 were comparatively easy and less repeated during the experiment.

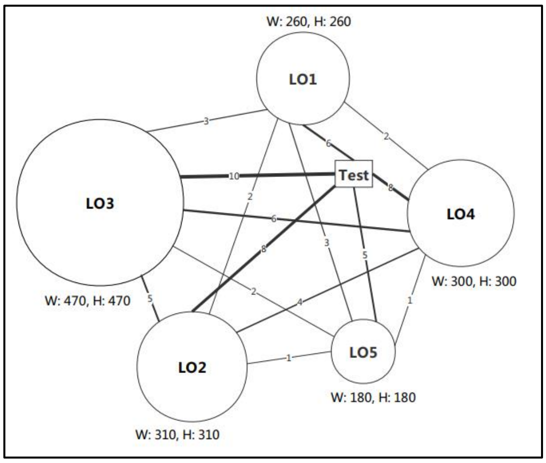

Figure 53: Video 03: group repetition, experiment result.

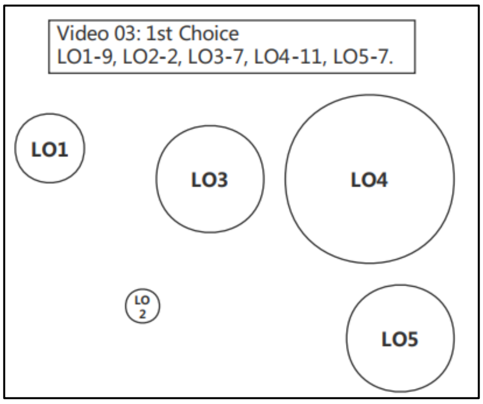

Figure 54: Video 03: students' 1st choice in post-experiment survey result.

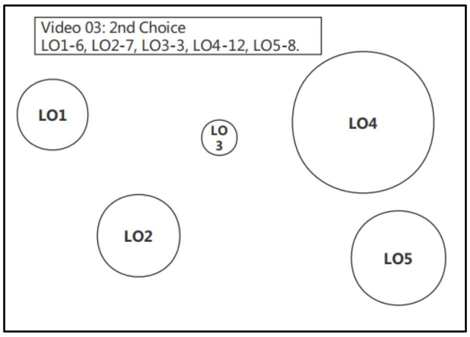

Figure 55: Video 03: students' 2nd choice in post-experiment survey result.

These results show that, for students who have learned once, LOs with neither too many nor too few repetitions are often selected as the next LO to be learned. However, for the cold standby case, where fresh students come and start watching such videos, they haven't provided their profile information yet, and they do not have any previous watching history data. In this situation, the proposed map has the potential to provide recommendations for the new learners, or the learners just start learning from the proposed DSS video domain.

Single Student's Learning Path Visualization Map

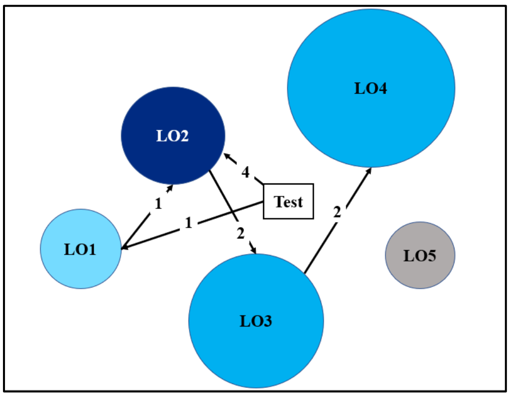

Figure 56: Student A learning path: Structured video

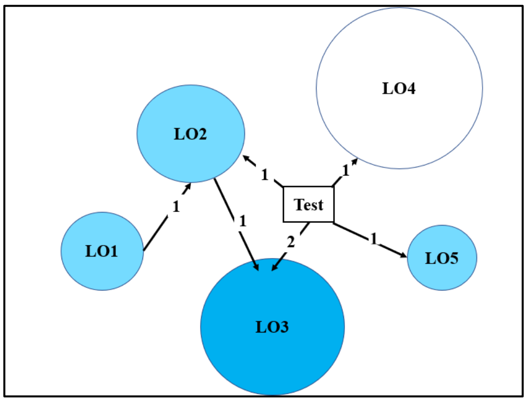

Figure 57: Student B learning path: Structured video

Repetitions: LO1=1, LO2=5, LO3=2, LO4=2, and LO5=0.

Repetitions: LO1=1, LO2=1, LO3=2, LO4=1, and LO5=1

Students' path visualization maps are defined by the colors. We used different shades of blue, light blue, darker blue, navy blue, ash, and white color to indicate a single student's learning path visualization map.

Student A

Student A in figure 56 repeated LO1 one-time, LO2 five times, LO3 & LO4 two times and LO5 had no repetition. So, these LOs got colors based on this student's number of repetitions. LO2 got the darkest color as the student did the maximum number of repetitions for it.

But at the same time, this student made the same number of repetitions for LO3 and LO4. He watched both LOs two times for each. So, the color is similar, but the size is different. Because the group repetition importance is different for these two LOs. LO4 is more repeated or received the highest number of repetitions in the group learning scenario in figure 48. When students see these two nodes there is a possibility that they might choose LO4 first as the next repetition. LO5 has no repetition and it received ash color. Ash color indicates the first time or watching only once.

Student B

Student B in figure 57 repeated LO1 one-time LO2 one time, LO3 two times & LO4 one time and LO5 one time. So, for LO1,2, and 5, the color is similar, but the size is different based on the importance of the nodes. Because group repetition is different for these three LOs.

Concurrently, LO1, 2, and 5 have a comparatively lesser number of repetitions in the group list, so, one-time repetition might be enough for these three nodes.

In contrast, student B watched LO3 two times, and the group repetition for LO3 is 46 times. So, for a single student, two times repetition might be enough. But this student also watched LO4 1 time. The total repetition of this LO is 64 times in figure 48. That means groups watched the video at least a second time. So, for a single student, a one-time repetition is not enough, so the color is still white for LO4. Thus, white color and large size LOs should watch/learn next from the path visualization maps.

Evaluation of Single Students' Learning Path Visualization Map

In the initially proposed map for individuals, the learners can select the next LO to be learned based on the repetition rate of each learner relative to the group repetition. To verify this method, we compare the recommendation methods for individual learners with indices using the individual repetition rate, the individual post-test error rate, and their combinations, in addition to collaborative filtering which is often used for recommendation as a baseline as shown in Table 35 and 36.

I5: LO with the minimum number of individual repetition rates with the highest group repetition number.

Algorithm: RLO = MAX(NR(MIN(NRj(LOi)/NR(LOi)))
where RLO is Recommended LO, NRj(LOi) is the Number of Repetitions by participant j in LOi (i = 1 to 5).

I6: LO with the max number of individual post-test error rate with the highest group post-test error number.

Algorithm:RLO = MAX(NE(MAX(NEj(LOi)/NE(LOi)))
where NEj(LOi) is the Number of post-test Errors by participant j in LOi (i = 1 to 5).

I7: LOs with I5 minus I6 with the highest group repetition number.

Algorithm: RLO = MAX(NR(MIN(NRj(LOi)/NR(LOi) - NEj(LOi)/NE(LOi)))

CF: Collaborative Filtering: Selected most similar behavior participants by the repetitions and post-test errors in each LO and choose their 1st choice.

Algorithm: RLO = FC(P(x = MIN(DIS(NRj, NEj)))
where FC(P(x)) is first choice of Participant x, MIN(DIS(NRj, NEj)) is Participant j (j = 1 to 36) with minimum Euclidian distance of repetitions and post-test errors in each LO (d=10) from participant x.

Table 35: Video 02 - individual accuracy

Indicator	# of agreed 1st choice	1st choice accuracy	# of agreed 1-2nd choices	1-2nd choices accuracy
I5	6	17%	13	36%
I6	6	17%	14	39%
I7	6	17%	15	42%
CF	6	17%	23	64%

Table 36: Video 03 - individual accuracy

Indicator	# of agreed 1st choice	1st choice accuracy	# of agreed 1-2nd choices	1-2nd choices accuracy
I5	11	31%	19	52%
I6	6	17%	17	47%
I7	10	28%	14	39%

CF	5	14%	8	22%

The collaborative filtering process was applied to this individual recommendation task, but the results were not so suitable in both settings. This suggests that the model-based recommendation might be more reasonable than collaborative filtering for these kinds of individual recommendation tasks, where there are various dependencies among the LOs and the number of LOs is limited. In comparison to the results for the group recommendation, the results for the individual recommendations showed that the accuracies were not much improved. However, it indicated that not only the repetition rate but also the error rate might give some effect on the individual recommendation because the number of repetitions and errors were sparse data. Although a simple combination of the repetition and error rates in I7 did not give good results, suitable tuning has the possibility to improve the results. This is because the importance of each index is not the same in this kind of recommendation.

Tuning of Single Students' Learning Path Visualization Map

Based on the findings from these evaluations, tuning for the individual recommendation are conducted based on the following perspectives (P):

- **P1)** Both LOs with more and less repetitions seem not to be recommended.
- **P2)** The relationship between the group and individual recommendations is not included.
- **P3)** Individual behavior for each LO is sparse data (, so diverse data should be used).
- **P4)** Total numbers of repetitions and errors are different (so, contributions to the recommendation are also different).

Based on the above perspectives, the following recommendation indices are proposed.

I8: Learning progress by repetitions for each student

Algorithm: RLO = MEDIAN(PTSj*NRj(LOi) – NR(LOi)/n)

where, PTSj is PreTest Score for student j, n is number of students (= 36).

NR(LOi)/n is the average of group repetitions in LOi, which is the expected number of repetitions for each LOi. Subtracting this average from the number of individual repetitions in LOi of a student j (multiplied by his/her rate of correct answers in pre-test to reflect on P3) indicates whether the student has achieved the expected learning (to reflect on P2). By taking the median of these values (to reflect on P1), I8 recommends the next LO to be learned.

I9: Learning progress by post-test errors for each student

RLO = MEDIAN(NR(LOi)/n -NRj(LOi))

Based on the assumption that LOs, where many participants make mistakes, should be learned more, the post-test learning progress is the number of errors in the post-test in LOi in individual minus the average number of errors in total in LOi (to reflect on P2). A negative value indicates insufficient learning, a positive indicates the expected amount of learning. NR(LOi)/n. By taking the median of these values (to reflect on P1), I8 recommends the next LO to be learned.

I10: Learning progress by both for each student

RLO = MEDIAN(I8+(NE/NR)*I9)

where, NE is Σ NE(LOi), NR is Σ NR(LOi).

To properly combine repetitions and errors, the total number of errors divided by the total number of repetitions is multiplied by the content of I9 (which corresponds to P4). LOs with insufficient learning would have negative values, and LOs with sufficient learning would have positive values. By taking the median among them, the next LO is recommended.

Tables 37 and 38 show the results for I8 to I 10 with video 02 and video 03. Combining the individual and group repetition indices with the pre-test results slightly improved the accuracy of the recommendations for both videos. However, the results did not sufficiently reflect individual preferences, which cannot be specified by current behavior. In this delayed survey, the navigation was done after a certain period of time (3 months), which is an effective setting assuming an annual evacuation drill. However, navigation immediately after learning should be considered in the future.

Table 37: Video 02 - individual accuracy for tuning

Indicator	# of agreed 1st choice	1st accuracy	# of agreed 1-2nd choices	1-2nd accuracy
I8	13	36%	22	61%
I9	7	19%	12	33%
I10	9	25%	18	50%

Table 38: Video 03 - individual accuracy for tuning

Indicator	# of agreed 1st choice	1st accuracy	# of agreed 1-2nd choices	1-2nd accuracy
I8	11	31%	21	58%
I9	8	22%	13	36%
I10	9	25%	18	50%

From the data interpretation, it is found that the number of repetitions of LOs have a significant impact on the group as well as an individual learning process. Hence, the research suggests that the domain model should be formulated based on users' watching and learning history data. This means the LOs which received a greater number of views, the system might recommend such LOs both for the individual or group of students. Similarly, students' models should also form based on the learning behavior, attention, and retention of each student.

The research has created recommendation algorithms and calculated the accuracy of the recommended algorithms from two different aspects: i) group repetition and ii) individual repetition, and difficulties. The primary aim of the proposed mathematical algorithms is to recommend LO to be learned next. From the delayed survey data, we evaluated the algorithms from an accuracy point of view. Nevertheless, group repetition or most watching LOs indicates the global recommendation from the group students' point of view. In this case, most watching, or group data can be applied for cold standby situations. On the other hand, individual repetition or an individual student's most or less watching, or not watching LOs indicates local recommendation from the individual student's importance and difficulties point of view. The local recommendation approaches are applicable for the ongoing repetitive learners which are considered as hot standby cases. Additionally, the application of collaborative filtering algorithms helps to find the participants with the closest behaviors, or choices for each participant based on individual students' learning interests. Hence, the e-teaching strategy should be focused based on recommendation and collaborative filtering output.

SRQ3: What is the process of integrating three models with the VART system?

Creating required domain functions for the videos and analyzing the videos and constructing essential learning support for the students with the support of VART, these three parts were considered as the main functions of the VART system. Accordingly, the research created the platform, developed content under different content structures, added essential support functions to the videos, and allowed students to access the platform and learn from the video domain. With the assistance of VART, the domain model displays the important contents, important parts with the indexes, and students watch some videos as retention and the system gets the learners' model based on watching history data. The VART then assists the e-teaching strategy model in receiving and combining data from the students' model and the domain model and knowing the learner's attention and retention process. Accordingly, it proposes strategies and recommends using the parameters on the learners' model and domain model. This is how the three models are integrated and operated in the VART system and supports students in their learning process.

SRQ4: How to implement the system among the international students for providing DSS training?

The proposed system was developed first and thereafter implemented through an experiment, where 36 international students of JAIST participated in the video-based DSS training system.

Through the experiment, the research identified students' past status of disaster knowledge, a diversity of watching, learning behaviors, their difficulties, preferred content structures, learning outcomes, reflections on the experiment, etc. The detailed descriptions are provided in chapter 5 in the implementation phase. Finally, the research concludes that most students (87%) agreed to have the availability of DSS content on the university LMS or website to access it from anywhere, anytime, and learn from it based on their convenient schedule.

SRQ5: How to assess students' learning outcomes and provide necessary feedback and recommendation in video-based training and learning systems?

The summative assessment was done based on the students’ learning behavior after they finish watching or learning. The watching history data were produced simultaneously to monitor their weakness and strength, adaptation with the provided contents, their learning outcome and if they need any learning support. Based on the watching history data, the system determined instant feedback and recommendation to the students. Finally, with the experiment results, the research determined the effectiveness of the training, and whether the learning needs have been fulfilled or not.

MRQ: How to develop an adaptive self-directed video-based learning support system for enhancing DSS among international students?

The research followed the five phases of the ADDIE model from the beginning to the end of the task to analyze, design, develop, implement, and evaluate the VART system in the proposed platform. While developing the system, the research was highly concerned about the learning needs of the students. The content selection process also emphasized the necessity of disaster awareness and skill-based topics such as earthquake drills, demonstrations, or real-life scenario-based interactive videos described in English. Different conditions of videos and structures were selected and created so that learners can find some variation or enthusiasm during watching. At the same time, necessary supports were created and integrated with the content structuring system to increase the learners' engagement with the learning process.

However, after the development of the whole system, the proposed methods and contents were delivered through the LMS to the experiment participants so that they can learn in a self-directed manner and based on their choice. The contents were developed in an online environment and available 24/7, which removed the time and distance barriers, and learners can learn in their own space. Finally, the experiment results showed the students had a significant learning outcome after watching the videos compared to their previous experiences and pre-test results. Among the three different video conditions, structured and branching videos attained significant learning outcomes and acceptances by the participants than the non-support traditional video condition. Hence, the proposed learning support method worked very well and positively impacted their DSS learning outcome.

6.4 Conclusion

This chapter concludes that the VART system overcomes most of the obstacles faced by international students in DSS training from the above discussion. The VART system can support meeting the teaching-learning goal of students and trainers. Besides, the summative assessment indicates significant improvement of students' learning behavior and learning outcome. Finally, the research answered the research question raised in chapter 1 and discussed the system-generated content visualization map, as well as the evaluation of group students, and single students' learning path visualization map as an important part of the evaluation of the proposed system.

Chapter 07: Conclusion & Future Work

7.1 Originality of the Research

The research encompassed several originalities as stated below:

7.1.1 Content Structuring System

An appropriate content structuring system is an important criterion for Video-based DSS training. But no research has been addressed so far, such a vital issue. This research clarified three different structures among three different videos: traditional long video, structured design video, and branching scenario design videos for the skill training. In the experiment result, the research identified that in the non-support long video structure, the video was too long to keep learners' attention. As a result, students felt bored searching, again and again, to find the specific topic inside the video.

The structured and branching lesson videos solved the problems. In the structured content, the meaningful indexes provided at the beginning of the video navigated them to reach their expected topics directly, and they could frequently move from topics to topics inside the fragmented video parts. Long video content was also used in this part, which was combined with several inter-related learning objects. However, the virtual fragmentation inside the video and meaningful indexes for each fragmented part provided the feelings of microlearning and helped them in their attention and retention process during learning."

Finally, the branching scenario lesson provided them gamification features which first attracted learners' attention to the contents. In this lesson, several short videos and small quiz games were used. The videos were represented based on the prerequisite relations among the contents. Learners also had full flexibility to repeat the content as many times as they wanted or proceed with the next video. These kinds of short videos or small learning objects (LOs) helped them absorb the contents from the microlearning perspective. At the same time, the flexibility in repetition helped them learn important topics or acquire important skills as they desired.

7.1.2 Track Watching Behavior and Provide Recommendation

The researchers revealed that several types of research discussed video-based learning, support systems, and tools from the review of existing literature. However, no research has focused on the essential inside parts with the meaning of video content and providing content based on learners' attention and retention viewpoint and analyzing video watching history and most watching parts and recommendations.

In addition, usual YouTube and traditional systems use overall watching history and general tags for videos and recommend similar videos. However, they do not analyze and consider deeply inside the video contents and do not consider the learner's learning and progress points of view. This research filled this gap.”

7.1.3 Micro-learning and Retention Support

The approach of providing DSS training using selected video contents and fragmentation of the long videos into meaningful chunks in small, highly focused materials has similarities to microlearning. The branching scenario lessons also have the same approach. Microlearning is often referred to as a bite-sized method and allows the students to absorb the long volume contents in an understandable and digestible manner to remember it for a longer time [121][122]. However, small contents are easy to understand, but the complicated content or concept is difficult to understand in microlearning. From the microlearning point of view, we have added a function to navigate or track retention for the important parts of the videos, which added external values in the content structuring system. This research tracks students' video watching behaviors inside video parts, and delivering the contents based on their attention and retention process is different.

The form of the basic content structure is similar to microlearning, but the support method is different. The main algorithm of this research is to provide support in the retention process of the students to understand the difficulties and unfamiliar concepts in the video content.

7.1.4 Learning Path Visualization Map

“In the proposed system, the research has developed the content visualization map and learners' learning path visualization map to visualize the learners' interactions with the contents at a glance. The system represents this map to both the learners and the instructors or teachers to realize the learning scenario with a quick look. This system is developed to monitor the learning progress of each student and assist them in adjusting to the content structure dynamically. If a learner misses any important content from the content list, the map can indicate that missed part/parts, which may lead the learner to watch the content immediately. Similarly, after viewing the learning path map, learners can avoid the contents that he/she has already mastered. This kind of map also offers students the freedom to choose the order of contents they wish to learn from the content structure in the online video-based learning system [123].

7.2 Contribution of the Research

7.2.1 Theoretical Point of View

Some existing research discussed the lack of specific content and content delivery methods, learning environment, socio-cultural, and language barriers for international students. However, nowadays, we also have many effective tools, i.e., smartphones, smart glasses [104], smartphone-based binocular opaque HMD [105], smartwatches, etc. Nevertheless, we cannot operate it instantly and effectively in an emergency disaster situation in most cases. In such a case, a video-based DSS training method could be effective, convenient, cost-effective, and cover many students to provide training in public universities. In addition, from the questionnaire survey, we found that around 82% of students did not receive disaster drills or training before entering Japan. They had no opportunity to receive the training. But if we make this kind of video-based training available, they can receive the training before coming to Japan. However, based on simply watching the videos, the learning process is too general and cannot fulfill the learning requirements in the modern video-based learning environment. In this case, the proposed VART system might help overcome the existing limitations in video-based

DSS learning and support students acquire the necessary DSS skills in a self-directed learning manner.

7.2.2 Practical Point of View

The research experimented to identify the appropriate content structuring system that might help learners and instructors select appropriate video-based content structure in the self-directed video and animation-based teaching, training, and learning. The proposed VART system can represent the video content with a summary along with the duration of each fraction with the meaningful indexes.

It also tracks students watching learning behavior and provides necessary feedback and recommendations during learning. So, it is expected that the experiment results and research outcome might help the instructors/trainers to design and develop a proper model and platform to provide DSS training among international students in Japanese universities in a collaborative manner. In this research, we considered earthquake disasters as a sample topic. However other kinds of natural disasters and human-made disasters survival training could easily include on the same platform using the same support system. In addition, this kind of video-based learning support system might be easily adaptable and implementable to design and deliver diverse types of skill-based training courses among different groups of learners. Hence the range of the research outcome might be extended to many other disciplines.

7.3 Research Limitations

Experiment Samples

First, the experiment samples were comparatively small. If we could include more participants and include international students from other universities, the results might be more significant. Due to the COVID-19 situation, arranging such an experiment was quite difficult. We found that participants preferred the branching video a little bit more than the structured video from the students' remarks. However, the score result of structured video is a little bit higher than the branching video. If we could increase the number of participants, we might identify some differences between these two videos. Thus, we plan to include more participants in the post-training experiment in near future.

Experiment Participants

Second, the experimental data were collected from the student but not from the trainers or the instructors. In such a case, we might receive some different perspectives on DSS education and training.

The Repetition Process

The repletion process had a different meaning to different students. Students made repetition for different purposes, such as making correct answers to the quizzes, knowing specific information, learning a specific skill or knowledge, content is very important or interesting, or difficult to remember, etc. If we could collect data on the different purposes of repetition and try to evaluate it, we might find some important or interesting results.

The Recommendation Method

Third, the experimental data was collected, analyzed, and the results were illustrated and discussed. The next step is to make or create recommendations based on the students' watching history data. The research plans to work on the recommendation process as the next phase.

Compare the Video Learning with Other Drills or Training Methods

Video learning has many advantages and might have disadvantages as well. At the same time, different training methods also have different viewpoints. But in the current situation, it is quite difficult to accomplish actual comparisons with video-based learning and other training methods. The research believes, such kind of comparison is very important. But in the current COVID-19 situation, gathering many students to conduct a practical drill is quite complicated. Therefore, this is one of the limitations of this research. But in the future, if there would be the opportunity, the research will try to consider comparing both the practical drills and video-based DSS learning.

7.4 Range of the Research

The research first started working with the medical videos to create a support system in the selected medical domain for enhancing decision-making skills among the Health Care Professionals (HCPs). During professional life, HCPs try to upgrade their skills by watching a variety of medical video content available on the web. The learning requirements of the HCPs and the features of the medical videos are quite different from the international students and DSS video contents. HCPs are bound to learn medical lessons and improve their skills to survive in their professional life. On the other hand, although acquiring DSS skills are very crucial for international students, they are not so interested in learning such skills.

Medical videos are huge, and complex compared to the DSS videos. In the case of medical videos, filtering expected contents from the ocean of resources and making recommendations are considered the main priority with other requirements. On the other hand, selecting appropriate content and identifying proper content structure represent contents with meaningful indexes so that international students get motivated to learn and acquire essential skills from the DSS video contents are considered as a vital criteria. Because of its adaptive features and flexibility, the proposed VART system is implementable and adaptable for both the medical and DSS domains. The target learners, contents, and learning requirements might be different, but the video-based domain's basic features are almost similar. The research also designed and proposed VART functions for the medical domain, which is our previous work and published as a journal article titled "design of video aided retention tool for the health care professionals (HCPs) in self-directed vıdeo-based learning" [34]. In this research, the international students' learning goal is different from the HCPs, and the learning support provided by the VART has some new features with many similarities with the mentioned article. So, the VART system could be customized based on various learning needs, especially the domain of learning has a wide range to be adopted by numerous video-based and distance learning platforms.”

7.5 Scope of Future Work

Automatic Indexing and Content Structuring for DSS Video and Animations

There are numerous tools available in video-based teaching and learning. Automatic indexing is one of them. However, those tools might be created for different target groups or users, which does not serve the DSS video-based training for international students. So, in the future, there is a potential scope to work on this issue.

In addition, it might be very cost-effective and time savvy for the busy professors if this research could proceed with the automatic generation of the content structures, as well as the automatic indexing of the long video contents. The research also considers this as a very important task, but in the future, there would be a chance to do that. In the current situation, this is out of range from the thesis point of view. Because automatic structuring and automatic indexing have some problems, especially in the educational video contents. In addition, there is a certain cost including, skilled manpower, software, and hardware requirements, system supports, etc. are involved in this process.

Live Visualization of the Content Path

The research designed and developed the content path visualization map. Nevertheless, it cannot produce the map simultaneously and instantly during the watching. It visualizes after finishing watching a specific video. However, it would be better if it could be shown live.

More Adaptive Features

The proposed VART system might include more adaptive features in the future to easily incorporate with other video-based teaching and learning systems. For example, the VART model could enhance decision-making skills among healthcare professionals or create adaptive video-based learning support for delivering content from university lecture archiving systems. In this case, the target learners are different. Their way of learning and teaching strategy may have some additional requirements with the common features. So, one of the next targets is to modify the VART system based on such requirements and make it more flexible to support any video-based teaching-learning platform, including different types of video-based distance learning systems.

References

[1] N. Gavrilović, A. Arsić, D. Domazet, and A. Mishra, "Algorithm for adaptive learning process and improving learners' skills in Java programming language," *Comput. Appl. Eng. Educ.*, vol. 26, no. 5, pp. 1362–1382, 2018.

[2] A. Gordillo, E. Barra, and J. Quemada, "An easy to use open source authoring tool to create effective and reusable learning objects," *Comput. Appl. Eng. Educ.*, vol. 25, no. 2, pp. 188–199, 2017.

[3] Wikipedia, "Survival Skills." [Online]. Available: https://en.wikipedia.org/wiki/Survival_skills. [Accessed: 28-Dec-2019].

[4] A. Dash, *A presentation on survival skills*. 2014.

[5] D. Wahyudin and S. Hasegawa, "Mobile Serious Game Design for Training Ethical Decision Making Skills of Inexperienced Disaster Volunteers," vol. 14, no. 1, pp. 28–41, 2015.

[6] K. Kitagawa, "Disaster risk reduction activities as learning," *Nat. Hazards*, vol. 105, no. 3, pp. 3099–3118, 2021.

[7] Rick, "What's the difference between knowledge and skills?," 2020. [Online]. Available: https://www.ag5.com/whats-the-difference-between-knowledge-and-skills/. [Accessed: 02-Oct-2021].

[8] G. Boulet, "The Difference Between Knowledge And Skills: Knowing Does Not Make You Skilled," 2015. [Online]. Available: 02 October, 2021.

[9] A. Sakurai and T. Sato, "Promoting education for disaster resilience and the Sendai framework for disaster risk reduction," *J. Disaster Res.*, vol. 11, no. 3, pp. 402–412, 2016.

[10] Y. Wang and G. Ruhe, "The cognitive process of decision making," *Int. J. Cogn. Informatics Nat. Intell.*, vol. 1, no. 2, pp. 73–85, 2007.

[11] H. K. Emanuel Leleito, Kaori Shimasaki, Rumi Watanabe, "Disaster Risk Reduction Education for International Students through Inter-University Collaboration," pp. 37–47, 2016.

[12] M. Iwamoto and T. Ishikawa, "Current State of Disaster Mitigation Knowledge and Optimum Way of Providing Information to International Students," vol. 58, 2011.

[13] M. K. Naoto NISHIYAMA, "Study on self-help ability in case of earthquakes based on the level of disaster prevention consciousness of international students," vol. 54, pp. 2–3, 2018.

[14] M. Y. Haburi, Takahashi Sachiko, Miura Emi, "Impacting factors on earthquake preparedness of both Japanese and foreign university students: Focusing on the special factors for foreign students," 2016.

[15] T. Y. Xin, N. Sugiki, and K. Matsuo, "The disaster prevention awareness of foreign residents and disaster management of organizations for foreign employees," *AIP Conf. Proc.*, vol. 1892, 2017.

[16] Q. Aini, M. Budiarto, P. O. H. Putra, and U. Rahardja, "Exploring E-learning Challenges During the Global COVID-19 Pandemic: A Review," *J. Sist. Inf.*, vol. 16, no. 2, pp. 57–65, 2020.

[17] T. V. Yuzer, M. Firat, and G. D. Dincer, "Use of Social Networks in Open and Distance Education: What Sociology Students Share?," *New Trends Issues Proc. Humanit. Soc. Sci.*, vol. 2, no. 3, p. 3, 2016.

[18] A. Nakagawa, "A Study of Japanese Education as Preventive Measures against Disasters Questionnaire Survey about Disaster Prevention Awareness among International and Japanese Graduate Students," 2016.

[19] H. Hayashi, *Natural disasters in Japan*. Palgrave Macmillan, 2010.

[20] M. of F. A. of Japan, "Disaster Prevention," 2019. [Online]. Available: https://www.mofa.go.jp/policy/disaster/21st/2.html. [Accessed: 27-Dec-2019].

[21] Wikipedia, "Natural disasters in Japan." [Online]. Available: https://en.wikipedia.org/wiki/Natural_disasters_in_Japan. [Accessed: 27-Dec-2019].

[22] D. Mcneill, "Japan ' s Universities Struggle to Recover From Earthquake and Tsunami," pp. 1–3, 2011.

[23] N. STAFFORD, "Quake-hit Japanese universities move on," 2012.

[24] K. S. Yasuda, Takahiko, Yusuke Takayama, "Activities of Japanese police in the Great East Japan Earthquake," pp. 1–18.

[25] S. Mori, "After quakes and flooding , Japan picks ' disaster ' as 2018 symbol," 2018.

[26] P. Brasor, "Questions raised over disaster preparedness in wake of Typhoon Hagibis," 2019.

[27] JASSO, "JASSO Outline 2020-2021," 2020.

[28] A. Kawasaki, M. Henry, and K. Meguro, "Media Preference, Information Needs, and the Language Proficiency of Foreigners in Japan after the 2011 Great East Japan Earthquake," *Int. J. Disaster Risk Sci.*, vol. 9, no. 1, pp. 1–15, 2018.

[29] P. Mar, R. Spears, J. Reeb, S. B. Thompson, P. Myers, and R. V. Burke, "Creation of a Collaborative Disaster Preparedness Video for Daycare Providers: Use of the Delphi Model for the Creation of a Comprehensive Disaster Preparedness Video for Daycare Providers," *Disaster Med. Public Health Prep.*, vol. 13, no. 2, pp. 123–127, 2019.

[30] H. Aghababaeian *et al.*, "Triage live lecture versus triage video podcast in pre-hospital students' education," *African J. Emerg. Med.*, vol. 9, no. 2, pp. 81–86, 2019.

[31] P. M. Sejati, C. A. Budiningsih, and Pujianto, "Multimedia in Disaster Risk Reduction," *J. Phys. Conf. Ser.*, vol. 1233, no. 1, 2019.

[32] C. Muryani, U. S. Maret, Y. Yusup, U. S. Maret, S. Prihadi, and U. S. Maret, "The Importance of Disaster Learning Multimedia To Enhance Students ' Preparedness," vol. 262, no. Ictte, pp. 153–156, 2018.

[33] S. Sagorika and S. Hasegawa, "Video Aided Retention Tool for Enhancing Decision-

Making Skills Among Health Care Professionals.,” in *International Open and Distance Learning Conference Proceeding Book*, 2019, pp. 305–312.

[34] S. Sagorika and S. Hasegawa, “Design of Video Aided Retention Tool for the Health Care Professionals in Self-directed Video-based Learning,” *Turkish Online J. Distance Educ.*, vol. 21, no. Special Issue-IODL, pp. 121–134, 2020.

[35] K. L. Gustafson, *Survey of instructional development models*. ERIC Clearinghouse on Information & Technology, 2002.

[36] Wikipedia, “ADDIE Model.” [Online]. Available: https://en.wikipedia.org/wiki/ADDIE_Model.

[37] Serhat Kurt, “ADDIE Model: Instructional Design,” 2018. [Online]. Available: https://educationaltechnology.net/the-addie-model-instructional-design/. [Accessed: 20-Jun-2021].

[38] R. A. Reiser and J. V Dempsey, “Trends and issues in instructional design and technology,” *Up. Saddle River*, pp. 336–341, 2002.

[39] M. Ozeki, K. Shimazaki, and T. Yi, “Exploring elements of disaster prevention consciousness: Based on interviews with anti-disaster professionals,” *J. Disaster Res.*, vol. 12, no. 3, pp. 631–638, 2017.

[40] and T. Ministry of Land, Infrastructure, Transport, “自然災害発生時の訪日外国人旅行者への 初動対応マニュアル策定ガイドライン.”

[41] J. Ministry of Land, Infrastructure, Transport, and Tourism, “公共事業労務費調査（平成26 年10 月調査）における社会保険加入状況調査結果について,” 2015.

[42] K. K. KONDO Yumi, “The causes of inadequate access to disaster prevention education among foreign exchange students: A case analysis of disaster prevention information gathering by foreign exchange students,” *Assoc. Lang. Cult. Educ.*, vol. 13, pp. 118–133, 2015.

[43] O. A. Gómez, “Lessons from International Students ’ Reaction to the 2011 Great East Japan Earthquake : The Case of the School of Engineering at Tohoku University,” vol. 4, no. 3, pp. 137–149, 2013.

[44] M. Bustanul, F. Bisri, and A. Sakurai, “Foreign Residents Risk Perception and Disaster Preparedness Outreach in Kobe City,” no. April, 2016.

[45] JAIST, “JAIST Safety Confirmation System (ANPIC).” [Online]. Available: https://www.jaist.ac.jp/anpic/index-e.html. [Accessed: 20-Feb-2020].

[46] JPSS, “Lectures for Foreign Students on Disaster Control.” [Online]. Available: https://www.jpss.jp/en/life/crisis/1/. [Accessed: 20-Feb-2020].

[47] K. University, “Living Guide: Life Information.” [Online]. Available: http://www.adm.kanazawa-u.ac.jp/ie/e/lifeinfo/guide.html.

[48] H. Hatakeyama, M. Nagai, and M. Murota, “A Flexible Scenario-Based Mobile Learning System for Disaster Evacuation BT - HCI International 2016 – Posters’ Extended

Abstracts," 2016, pp. 360–364.

[49] H. Mitsuhara *et al.*, "Web-based System for Designing Game-based Evacuation Drills," *Procedia Comput. Sci.*, vol. 72, pp. 277–284, 2015.

[50] Y. Toyoda and H. Kanegae, "Gaming Simulation as a Tool of Problem-Based Learning for University Disaster Education," in *Neo-Simulation and Gaming Toward Active Learning*, Springer, 2019, pp. 237–245.

[51] M. H. Furqan, E. Maryani, and M. Ruhimat, "Innovation Learning: Audio Visual and Outdoor Study to Enhance Student's Understanding of Disaster," *Innov. Vocat. Technol. Educ.*, vol. 13, no. 2, pp. 50–55, 2017.

[52] M. Kanadje, Z. Miller, A. Agarwal, R. Gaborski, R. Zanibbi, and S. Ludi, "Assisted keyword indexing for lecture videos using unsupervised keyword spotting," *Pattern Recognit. Lett.*, vol. 71, pp. 8–15, 2016.

[53] A. M. F. Yousef, M. A. Chatti, and U. Schroeder, "Video-based learning: A critical analysis of the research published in 2003-2013 and future visions," *eLmL - Int. Conf. Mobile, Hybrid, On-line Learn.*, no. June 2015, pp. 112–119, 2014.

[54] P. J. Rich, M. Hannafin, and P. J. Rich, "Video Annotation Tools: Technologies to Scaffold, Structure, and Transform Teacher Reflection," 2010.

[55] A. Cebrián-de-la-Serna, M; Bartolomé-Pina, "Study of Portfolio in the Practicum : an Analysis of PLE- Portfolio," vol. 21, 2015.

[56] A. B. Pérez-Torregrosa, C. Díaz-Martín, and P. Ibáñez-Cubillas, "The use of video annotation tools in teacher training," *Procedia-Social Behav. Sci.*, vol. 237, pp. 458–464, 2017.

[57] D. Saravanan, "Segment based indexing technique for video data file," *Procedia Comput. Sci.*, vol. 87, pp. 12–17, 2016.

[58] Y. Tian, Y. Zhang, D. Zhou, G. Cheng, W.-G. Chen, and R. Wang, "Triple attention network for video segmentation," *Neurocomputing*, vol. 417, pp. 202–211, 2020.

[59] C. A. B. Tiellet, A. G. Pereira, E. B. Reategui, J. V. Lima, and T. Chambel, "Design and evaluation of a hypervideo environment to support veterinary surgery learning," in *Proceedings of the 21st ACM Conference on Hypertext and Hypermedia*, 2010, pp. 213–222.

[60] F. Shipman, A. Girgensohn, and L. Wilcox, "Generation of interactive multi-level video summaries," in *Proceedings of the eleventh ACM international conference on Multimedia*, 2003, pp. 392–401.

[61] T. Nazari, F. W. van de Graaf, M. E. W. Dankbaar, J. F. Lange, J. J. G. van Merriënboer, and T. Wiggers, "One Step at a Time: Step by Step Versus Continuous Video-Based Learning to Prepare Medical Students for Performing Surgical Procedures," *J. Surg. Educ.*, pp. 1–9, 2020.

[62] E. Delen, J. Liew, and V. Willson, "Effects of interactivity and instructional scaffolding on learning: Self-regulation in online video-based environments," *Comput. Educ.*, vol. 78, pp. 312–320, 2014.

[63] M. Steedman, M. Abouammoh, and S. Sharma, "Multimedia learning tools for teaching undergraduate ophthalmology: Results of a randomized clinical study," *Can. J. Ophthalmol.*, vol. 47, no. 1, pp. 66–71, 2012.

[64] M. Bétrancourt and K. Benetos, "Why and when does instructional video facilitate learning? A commentary to the special issue 'developments and trends in learning with instructional video,'" *Comput. Human Behav.*, vol. 89, no. August, pp. 471–475, 2018.

[65] S. Hasegawa and J. Dai, "A Ubiquitous Lecture Archive Learning Platform with Note-Centered Approach," vol. 9173, pp. 294–303, 2015.

[66] K. Choroś, "Video structure analysis and content-based indexing in the Automatic Video Indexer AVI," in *Advances in Multimedia and Network Information System Technologies*, Springer, 2010, pp. 79–90.

[67] S. Ding, S. Qu, Y. Xi, and S. Wan, "A long video caption generation algorithm for big video data retrieval," *Futur. Gener. Comput. Syst.*, vol. 93, pp. 583–595, 2019.

[68] S. C. Lin, M. H. Tsai, Y. L. Chang, and S. C. Kang, "Game-initiated learning: A case study for disaster education research in Taiwan," *AAAI Spring Symp. - Tech. Rep.*, vol. SS-13-06, pp. 57–61, 2013.

[69] J. Tobita, "Preparing for a large-scale earthquake disaster at a university," vol. 6 , no. 3 , pp. 157–164, 2015.

[70] H. Shiroshita, "Is disaster education just knowledge transmission ? Changing disaster education into co - learning," 2017.

[71] G. P. Krishna Suryanto Pribadi, Rahma Hanifa, Eliya Hanafi, *Development of Disaster Resilient and Sustainable University Framework : Case of Bandung Institute of Technology (ITB)*. 2019.

[72] APRU, "Report of the APRU-IRIDES Multi-Hazards Program Campus Safety Workshop 2018," 2018. [Online]. Available: https://apru.org/resource-type/report/.

[73] A. Sakurai and T. Sato, "Promoting education for disaster resilience and the Sendai framework for disaster risk reduction," *J. Disaster Res.*, vol. 11, no. 3, pp. 402–412, 2016.

[74] A. Tanner and B. Doberstein, "Emergency preparedness amongst university students," *Int. J. Disaster Risk Reduct.*, vol. 13, pp. 409–413, 2015.

[75] N. Dufty, "A new approach to disaster education," 2018.

[76] V. Esichaikul, S. Lamnoi, and C. Bechter, "Student modelling in adaptive e-learning systems," *Knowl. Manag. E-Learning An Int. J.*, vol. 3, no. 3, pp. 342–355, 2011.

[77] S. Sagorika and S. Hasegawa, "Model of Video Aided Retention Tool for Enhancing Disaster Survival Skills on Earthquake among International Students," 2020.

[78] U. M. Abdelsalam, "A Proposal Model of developing Intelligent Tutoring Systems based on Mastery Learning Keyword :," pp. 106–118, 2014.

[79] P. Brown, "What is the Domain Model in Domain Driven Design?," 2014. [Online]. Available: https://culttt.com/2014/11/12/domain-model-domain-driven-design/.

[80] R. Shyamala, R. Sunitha, and G. Aghila, “Towards learner model sharing among heterogeneous e-learning environments,” *Int. J. Comput. Sci. Eng.*, vol. 3, no. 5, pp. 2034–2040, 2011.

[81] P. Brusilovsky and E. Millán, “User models for adaptive hypermedia and adaptive educational systems,” in *The adaptive web*, Springer, 2007, pp. 3–53.

[82] M. E. Ahmed and S. Hasegawa, “An instructional design model and criteria for designing and developing online virtual labs,” *Int. J. Digit. Inf. Wirel. Commun.*, vol. 4, no. 3, pp. 355–371, 2014.

[83] M. Despotović-zrakić, A. Marković, Z. Bogdanović, D. Barać, O. Sciences, and J. Ilića, “Providing Adaptivity in Moodle LMS Courses Adaptive e-learning systems,” *Educ. Technol. Soc.*, vol. 15, pp. 326–338, 2012.

[84] M. Magdin, “Personalization of Student in Course Management Systems on the Basis Using Method of Data Mining,” vol. 14, no. 1, pp. 58–67, 2015.

[85] “Installing Moodle,” 2019. [Online]. Available: https://docs.moodle.org/37/en/Installing_Moodle. [Accessed: 04-Apr-2019].

[86] R. Beuran, D. Tang, C. Pham, K. ichi Chinen, Y. Tan, and Y. Shinoda, “Integrated framework for hands-on cybersecurity training: CyTrONE,” *Comput. Secur.*, vol. 78, pp. 43–59, 2018.

[87] R. Singleton and A. Charlton, “Creating H5P content for active learning,” *Pacific J. Technol. Enhanc. Learn.*, vol. 2, no. 1, pp. 13–14, 2020.

[88] “H5P,” 2021. [Online]. Available: https://h5p.org/.

[89] M. Nadeem, “How YouTube Recommends Videos,” 2018.

[90] A. Bandura and R. H. Walters, *Social learning theory*, vol. 1. Prentice-hall Englewood Cliffs, NJ, 1977.

[91] Y. Y. Mun and D. D. Fred, “Developing and validating an observational learning model of computer software training and skill acquisition,” *Inf. Syst. Res.*, 2003.

[92] D. Rehak, “SCORM best practice guide for content developers,” *Pittsbg. Learn. Syst. Archit. Lab Carnegie-Mellon*, 2003.

[93] P. Barakan, *Earthquake Preparedness*. NHK, 2018.

[94] H5P, “Branching Scenario (beta),” 2019. [Online]. Available: https://h5p.org/branching-scenario.

[95] S. C. I. Fund, *Drop, Cover & Hold Earthquake Preparedness Training*. 2021.

[96] A. R. Cross, *How to build an Emergency Preparedness Kit*. 2020.

[97] Sikana, *How to Protect Yourself During an Earthquake*. International Federation of Red Cross and Red Crescent Societies., 2016.

[98] G. ShakeOut, *Earthquake Safety Video Series*. 2016.

[99] A. Kelkar, *Cardiopulmonary resuscitation (CPR): Simple steps to save a life - First Aid Training video*. 2020.

[100] J. R. Cross, *How to use an AED in Japan*. 2011.

[101] A. Ghasemi and S. Zahediasl, "Normality tests for statistical analysis: a guide for non-statisticians," *Int. J. Endocrinol. Metab.*, vol. 10, no. 2, p. 486, 2012.

[102] D. Öztuna, A. H. Elhan, and E. Tüccar, "Investigation of four different normality tests in terms of type 1 error rate and power under different distributions," *Turkish J. Med. Sci.*, vol. 36, no. 3, pp. 171–176, 2006.

[103] J. Peat and B. Barton, *Medical statistics: A guide to data analysis and critical appraisal*. John Wiley & Sons, 2008.

[104] M. Friedman, "The use of ranks to avoid the assumption of normality implicit in the analysis of variance," *J. Am. Stat. Assoc.*, vol. 32, no. 200, pp. 675–701, 1937.

[105] A. H. Van de Ven and D. L. Ferry, *Measuring and assessing organizations*. John Wiley & Sons, 1980.

[106] A. Oosterhof, *Classroom applications of educational measurement*. ERIC, 2001.

[107] M. Tavakol and R. Dennick, "Making sense of Cronbach's alpha," *Int. J. Med. Educ.*, vol. 2, p. 53, 2011.

[108] StatisticsSolution, "Structural Equation Modeling," *2021*. [Online]. Available: https://www.statisticssolutions.com/structural-equation-modeling/.

[109] T. K. Dijkstra and J. Henseler, "Consistent and asymptotically normal PLS estimators for linear structural equations," *Comput. Stat. Data Anal.*, vol. 81, pp. 10–23, 2015.

[110] "Fit measures in SmartPLS," *SmartPLS*, 2014. .

[111] F. F. Chen, "Sensitivity of goodness of fit indexes to lack of measurement invariance," *Struct. Equ. Model. A Multidiscip. J.*, vol. 14, no. 3, pp. 464–504, 2007.

[112] R. B. Kline, *Principles and practice of structural equation modeling*. Guilford publications, 2015.

[113] SmartPLS, "Exact Model Fit," 2014. .

[114] B. M. Byrne, "Testing for multigroup equivalence of a measuring instrument: A walk through the process," *Psicothema*, pp. 872–882, 2008.

[115] J.-B. Lohmöller, *Latent variable path modeling with partial least squares*. Springer Science & Business Media, 2013.

[116] A. C. Elliott and W. A. Woodward, *Statistical analysis quick reference guidebook: With SPSS examples*. Sage, 2007.

[117] R. F. Falk and N. B. Miller, *A primer for soft modeling.* University of Akron Press, 1992.

[118] M. Treser, "Getting To Know ADDIE: Part 5 - Evaluation," 2015. [Online]. Available: https://elearningindustry.com/getting-know-addie-evaluation.

[119] "Cytoscape.js: Graph theory (network) library for visualisation and analysis," 2019. [Online]. Available: https://js.cytoscape.org/.

[120] "Prcess On," 2016. [Online]. Available: https://www.processon.com/.

[121] L. Giurgiu, "Microlearning an evolving elearning trend," *Sci. Bull.*, vol. 22, no. 1, pp. 18–23, 2017.

[122] G. S. Mohammed, K. Wakil, and S. S. Nawroly, "The effectiveness of microlearning to improve students' learning ability," *Int. J. Educ. Res. Rev.*, vol. 3, no. 3, pp. 32–38, 2018.

[123] I. Jugo, B. Kovačić, and E. Tijan, "Cluster analysis of student activity in a web-based intelligent tutoring system," *Pomorstvo*, vol. 29, no. 1, pp. 75–83, 2015.

Appendix

Appendix A: Preliminary Survey Questionnaire and E-mail Invitation

Question Cover

Dear International Students/Fellows in JAIST,

Greetings!

This is Safinoor Sagorika, a doctoral student in the Graduate School of Advanced Science and Technology, JAIST, Japan. I am pursuing research on "Design and Development of Video Aided Retention Support System for Enhancing Disaster Survival Skills among International Students" under the supervision of Dr. Shinobu Hasegawa, Associate Professor, Research Centre for Advanced Computing Infrastructure, (RCACI) JAIST, Japan.

This research aims to develop an integrated video-based learning support system to provide training on Disaster Survival Skills (DSS) among the international students in the universities in Japan. In order to obtain the necessary information about international students' current situation on disaster survival skills, we need your kind cooperation. The questionnaire only includes 13 questions which may take 07-10 minutes to complete the response. It is anonymous and your response will be fully used for research purposes only.

We humbly request you to respond to the questions below and click submit to complete the survey.

Thank you in advance for your kind cooperation.

Sincerely

Safinoor Sagorika
Doctoral Research Fellow
ID: s1820014
Hasegawa Lab
School of Information Science
Japan Advanced Institute of Science and Technology (JAIST), Japan

Survey Questionnaire

1. **How long have you been in Japan?**

    - Less than 1 year
    - 1-2 years
    - 2-3 years
    - 3-4 years
    - 4-5 years
    - 5 years+

2. **Your home country belongs to-**

    - Asia
    - Africa
    - Europe
    - North America
    - South America
    - Central America
    - Middle east
    - Oceania
    - Other

3. **Have you received any disaster survival training in your home country before coming to Japan?**

    - Yes, I received once per year.
    - Once or twice in a year
    - Once or twice in life
    - No, I did not receive any training.
    - Other

4. **What type of disasters did you get familiar with after coming to Japan?** [*You can select multiple answers]*

    - ☐ Earthquake
    - ☐ Tsunami
    - ☐ Typhoon/Tornado
    - ☐ Flood
    - ☐ Heavy Snow
    - ☐ Landslides
    - ☐ Volcanic eruption
    - ☐ Thunderstorm
    - ☐ Infectious disease
    - ☐ Terrorist attack
    - ☐ Other: Please state……………………….

5. **Did you receive any disaster survival training at your university in Japan?**
   - o Yes
   - o No

6. **If the Q5 answer is yes, have you faced any of the following difficulties during your participation in disaster survival training/ drills?** *(You can select multiple answers)*

   - ☐ Contents were not fully understandable.
   - ☐ Contents were not sufficient and specific.
   - ☐ I felt language difficulty.
   - ☐ Training methods were not so suitable.
   - ☐ Others please mention……………

7. **If the Q5 answer is yes, what are your overall remarks regarding existing disaster survival training/ drills?**
   - o Very satisfied
   - o Somewhat satisfied
   - o Neither satisfied nor dissatisfied
   - o Somewhat dissatisfied
   - o Very dissatisfied

8. **If the Q5 answer is no, what are the reasons for not taking the training?** *[Select multiple where applicable]*

   - ☐ Training schedules were not convenient.
   - ☐ Did not know about the training/drills.
   - ☐ I do not feel interested.
   - ☐ Not fully helpful
   - ☐ Contents were not interesting.

9. **How would you like to get disaster training for your convenience?** *[Select multiple where applicable]*
   - ☐ Audio recording
   - ☐ Video-based real-life scenario (audio-visual)
   - ☐ Verbal instructions
   - ☐ Cognitive contents/texts
   - ☐ Game-based contents
   - ☐ Simulations
   - ☐ Discussion
   - ☐ Hands-on training
   - ☐ Evacuation drills
   - ☐ Others, please mention…….

10. **What type of tools and applications you usually use for receiving disaster updates, alarms, instructions, training, etc.** *[Select multiple where applicable]*
    - ☐ Smartphone
    - ☐ Smartwatch
    - ☐ Smart glasses
    - ☐ Smartphone-based binocular opaque HMD
    - ☐ Mobile serious games
    - ☐ ANPIC JAIST
    - ☐ Internet news site
    - ☐ Game-based evacuation drill (GBED)
    - ☐ Real-World Edutainment (RWE)
    - ☐ J-ALERT
    - ☐ Japan-AED Map App
    - ☐ Yurukeru Call App
    - ☐ Pocket Shelter App
    - ☐ Line
    - ☐ Japan Shelter Guide App
    - ☐ Tokyo Disaster Preparedness App
    - ☐ Others, please mention…………………………

11. **Video contents are very effective for teaching and learning disaster survival skills. However, keeping concentration in the long instructional video is time-consuming and difficult. For making video-based learning more effective, what are your remarks regarding the following points?** *[Select multiple where applicable]*
    - ☐ Fractioning long videos into meaningful parts for faster skimming and re-watching
    - ☐ Each part should mention the specific topic and time duration.
    - ☐ Most important parts should be represented first.
    - ☐ Automatic filtering and recommending more important contents.
    - ☐ Focus on students' interest.
    - ☐ Others please mention……….

12. **If the disaster survival-related video contents are published on the university LMS or website students can watch and learn from it at their convenient time.**
    - o Strongly agree.
    - o Agree
    - o Neither agree nor disagree
    - o Disagree
    - o Strongly disagree.

13. International students have different disaster knowledge and skill levels compared to Japanese students. For making the disaster survival training more effective what is your opinion regarding the following options? ***[Select multiple where applicable]***

- ☐ The contents should be specific and appropriate.
- ☐ The training method should be conducted in a different way.
- ☐ The learning process should be self-directed and collaborative.
- ☐ The contents could be accessed from anywhere at any time.
- ☐ Content should be designed in multiple languages.
- ☐ There should be flexibility in the training schedule.
- ☐ Other, please mention………………….

Thank you very much for your cooperation.

Appendix B: Informed Consent Form for the Experiment

Informed Consent Form

Title of Research:

Design and Development of Video Aided Retention Support System for Enhancing Disaster Survival Skills (DSS) Among International Students

Investigator: Safinoor SAGORIKA
Doctoral Research Fellow
HASEGAWA Laboratory,
Japan Advanced Institute of Science and Technology (JAIST).
1-1 Asahidai, Nomi, Ishikawa 923-1292 Japan.
Email: s1820014@jaist.ac.jp

Supervisor: Dr. Shinobu HASEGAWA
Associate Professor, Research Center for Advanced Computing Infrastructure (RCACI)
Japan Advanced Institute of Science and Technology (JAIST).
1-1 Asahidai, Nomi, Ishikawa 923-1292 Japan.
Email: hasegawa@jaist.ac.jp

1. **Purpose of the Experiment**
   The main topic of this research is to develop an integrated video-based learning support system to provide training on earthquake Disaster Survival Skills (DSS) among international students in the universities in Japan. Accordingly, the purpose of this experiment is to identify appropriate content structuring systems for Video-based DSS training. Therefore, the experiment will track students watching and learning behaviors including the attention and retention process, to provide necessary recommendations in their learning process.

2. **Description of the Experiment**
   - ✓ Briefing Session: 10 mins
   - ✓ Video watching/learning time (three videos): 75 mins.
   - ✓ Four quiz tests (one pretest + three post-tests): 20 mins
   - ✓ Breaks and small instructions before three different videos: 15 mins.
   - ✓ Total experiment time: 02 hours

3. **Subject Participation**

   The experiment content is designed for the international students and the selected video contents and tests are designed in English. Hence, the experiment requests participants to be able to listen, read and understand the contents in English. So, a TOEIC score of 650 or above is requested.

4. **Confidentiality**
All information taken from the study will be coded to protect each subject's name. No names or other identifying information will be used when discussing or reporting data. The investigator(s) will safely keep all files and data collected.

5. **Potential Risks and Discomforts**
There are no known risks. For any reason, if you feel discomfort, you may withdraw and discontinue participation at any time without penalty.

6. **Voluntary Participation and Authorization**
Your decision to participate in this study is entirely voluntary. If you decide to not participate in this study, it will not affect the care, services, or benefits to which you are entitled.

7. **Withdrawal from the Experiment/or Withdrawal of Authorization**
If you decide to participate in this study, you may withdraw from your participation at any time without penalty. If data has been collected, you may contact the **Faculty Supervisor** for the withdrawal process.

8. I voluntarily agree to participate in this research program.
☐ Yes ☐ No

I hereby authorize the use of my records, any observations, and findings found during the course of this study for education, publication and, /or presentation.

Name of Participant: ____________________

Signature & date: ____________________

Student ID: ____________________

Email address: ________

Appendix C: Post Experiment Survey

Small Survey

Title of Research:

Design and Development of Video Aided Retention Support System for Enhancing Disaster Survival Skills (DSS) Among International Students

Investigator: Safinoor SAGORIKA
Doctoral Research Fellow
HASEGAWA Laboratory
Japan Advanced Institute of Science and Technology (JAIST).
1-1 Asahidai, Nomi, Ishikawa 923-1292
Japan.
Email: s1820014@jaist.ac.jp

Supervisor: Dr. Shinobu HASEGAWA
Associate Professor, Research Center for Advanced Computing Infrastructure (RCACI)
Japan Advanced Institute of Science and Technology (JAIST).
1-1 Asahidai, Nomi, Ishikawa 923-1292
Japan.
Email: hasegawa@jaist.ac.jp

Q1. Have you received any disaster survival training before?

- Yes, I received once per year.
- Once or twice in a year.
- Once or twice in life.
- No, I did not receive any training.
- Others please mention.
  ………………………………………..

Q2. Among the three different videos, which structure would you prefer to watch and learn the video content? (Pl. answer this question at the end of the experiment)

- The video without support
- The structured video
- The branching lesson video

Q3. Please provide your remarks about the experiment- (Pl. answer this question at the end)

- It is very useful.
- It is useful.
- Ordinary
- Not useful
- Very useless
- Other, Pl. mention………………………..

Appendix D: Delayed Survey Feedback (Google form)

In the previous experiment in April 2021, you watched some videos on "how to be prepared for disasters and how to survive in a disaster situation". This time, we would request your feedback on if the same videos are represented again, which video part you will choose to watch first, and second.

For your reference, the video links and images are provided with the queries so that you can remember the experiment videos and make your response easily. The response will be fully used for research purposes only.

Please respond to the queries below and click submit to complete the survey.

Thank you in advance for your kind cooperation.

Email:

Your Name:

Q1. Video 02 (Earthquake Safety Series Videos): If you watch the videos again, which parts would you choose first and second to watch the video? Please provide your answers in two multiple-choice sections. The first answer is for the first choice and the second answer is for the second choice.

Mention your 1st Choice (Earthquake Safety Series Videos)
- Part-1
- Part-2
- Part-3
- Part-4
- Part-5

Mention your 2nd Choice (Earthquake Safety Series Videos)
- Part-1
- Part-2
- Part-3
- Part-4
- Part-5

Q2. Video 03 (Earthquake Drills Videos): If you watch the videos again, which parts would you choose first and second to watch the video? Please provide your answers in two multiple-choice sections. The first answer is for the first choice and the second answer is for the second choice.

Mention your 1st Choice (Earthquake Drills Videos)
- Part-1
- Part-2
- Part-3

- Part-4
- Part-5

Mention your 2nd Choice (Earthquake Drills Videos)

- Part-1
- Part-2
- Part-3
- Part-4
- Part-5

Q3. Why have you chosen those parts as your first and second choice? Your remarks if you have any (optional).