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論文の内容の要旨

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.

論文審査の結果の要旨

　本論文は，日本人学生と留学生の間で自然災害時のサバイバルスキルに関して大きなギャップが存在する現状を解決する一つのアプローチとして，留学生の防災スキルを向上させることを目的として，動画コンテンツによる主体的学習を支援する VART(Video Aided Retention Tool)システムを，教育設計技術である Instructional Design における ADDIE（Analysis, Design, Development, Implementation, Evaluation）モデルに基づいて開発したものである．

　分析フェーズでは，留学生の防災訓練・学習の現状を把握するために，幅広い関連研究の調査を行うとともに，留学生 133 名を対象にアンケート調査を実施し，災害時スキルに関する知識や経験の実態を把握した．設計フェーズでは，VART を構成する概念モデルとして，動画コンテンツを対象として，i) コンテンツ内の知識項目やスキル項目を構造化するためのドメインモデル，ii) 学習者の学習履歴に基づいて学習者の理解度を推定する学習者モデル，iii) 学習者の理解度に応じて効果的なコンテンツを推薦する教育戦略モデル，iv) VART による統合モデルを提案した．

　開発フェーズにおいては，VART における適切な動画コンテンツ構造を検討するために，（N）通常のビデオに加えて，（S）仮想的に断片化した構造型ビデオ，（B）短時間のビデオを組み合わせた分岐型ビデオ，の 3 種類の学習環境をオープンソースの学習管理システムである Moodle 上で構築した．加えて，動画内部にインタラクションを生成する機能や学生の視聴学習行動を追跡する機能，学習者のナビゲー

ションを支援する学習経路推薦マップ機能を実装した．実施フェーズにおいては，36 名の留学生を被験者として，上記 3 種類のコンテンツ構造化システムを利用した学習を被験者内計画として実施し，ポストテストの結果の傾向が(N)<(S)=(B)となることを確認した．評価フェーズでは，導入前後の被験者の学習成果の変化の影響を比較するとともに，3 か月後の動画コンテンツの選択傾向に基づいて，教育戦略モデルによるナビゲーションアルゴリズムの評価を行い，コンテンツに対する反復回数に基づく推薦手法により，一般的な協調フィルタリングよりも精度の良い推薦が行えることを示した．

　以上，本論文は，本研究の成果は，動画コンテンツ内部のインタラクションや視聴範囲に基づく学習活動を収集・分析する基盤をオープンソースの学習管理システム上で提供するものであり，データに基づく学習状態の把握および支援を行う Learning Analytics の観点から学術的に貢献するところが大きい．また，パンデミック下のオンライン環境における防災学習環境の提供という点で実践的な効果が期待できる研究であるといえる．これらのことから，博士（情報科学）の学位論文として価値あるものと認めた．