An evaluation of a Meaningful discovery learning support system for supporting E-book User in Pair Learning

Jingyun Wang[1][0000-0001-9325-1789] and Hiroaki Ogata[2][0000-0001-5216-1576]

[1] Durham University, Durham, UK
[2] Kyoto University, Kyoto, Japan
jingyun.wang@durham.ac.uk

Abstract. In this paper, an experiment was conducted to study the learning performance when learning new knowledge in groups with an e-book system and a meaningful discovery learning support environment. The participants studied target new knowledge with an e-book in pairs; at first, all the knowledge points that appear in the e-book were displayed and learners in each pair were encouraged to actively create relations between the knowledge concepts together; after completing the task, they can compare their learner-generated relations with expert-generated relations. The learning perception of one hundred and forty-three participants are analyzed and discussed.

Keywords: Meaningful learning; Discovery Learning; Topic Map; E-book

1 Introduction

Advance organizers are presented by Ausubel [1] to facilitate meaningful learning which refers to the non-arbitrary substantive incorporation of new concepts or propositions into the existing hierarchical framework of cognitive structure. When new material is presented, with the support of the advance organizer, the learner's attention can be directed to the key concepts and key relations, even to relevant prior concepts. It favors the understanding of new concepts and support the knowledge.

To support meaningful learning in e-book systems, a cache-cache comparison mode which encourages the learner to actively process the e-book information and discover the relation between the given key concepts is implemented in a visualization support system (VSSE)[2][3], in additional to a reception comparison mode which provide complete versions of expert-generated topic maps to learners. A series of experiments had been conducted to examine the learner behaviors and performance while they did review activities with the support of e-books and VSSE. In previous work [3], we found that after review activities learners with low prior knowledge showed greater increases in performance than learners with high prior knowledge when encouraged to actively discover the relations between key concepts appearing in target learning content. This suggests that cache-cache comparison mode is more appropriate than reception comparison mode for learners with low prior knowledge. On the other hand, for learners with high prior knowledge, learning mode made no significant difference to learning

achievement; however, learners felt significantly less pressure and more satisfaction in reception comparison mode than in cache-cache comparison mode. In light of the above, for learners with high prior knowledge, reception comparison mode is indicated.

Instead of studying the effectiveness of VSSE on the review activity, the experiment in this paper studied the learning performance of learners who did self-study in pairs with e-book involving new knowledge under the support of the cache-cache comparison mode.

2 The cache-cache comparison mode in VSSE system

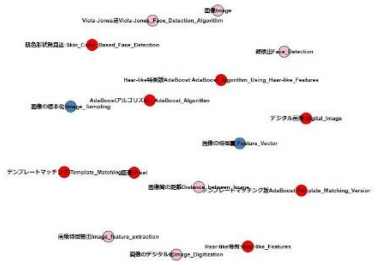

Fig. 1. The cache-cache comparison mode.

Figure 1 shows an instance of cache-cache comparison mode: the content of interest to the learner is pages 1–43 of an e-book titled “Face detection”. First, “cache-cache comparison” mode displays all the knowledge points (KPs, a KP is defined as “a minimum learning item which can independently describe the information constituting one given piece of knowledge in the content of a specific course.”) that appear in the page range of interest in red; the related KPs that do not appear in the pages of interest in ranges in blue; and their upper concepts in pink. Then firstly the learner is required to classify the KPs by connecting them to their pink upper concepts; next, the learner is encouraged to find out the relations between KPs by connecting red nodes or connecting red nodes to blue nodes. The descriptions of the relation arcs made by the learner can be modified and saved anytime. After the learner completes the relation map, she/he can click the “Compare with experts” button. Finally, all the relations extracted from the ontology will be displayed as red lines. The learner can easily compare the red lines with the black lines that she/he has made.

3 Experimental Description

One hundred and forty-three first-year undergraduates from the same class at a University in Japan participated in this study. These students were all taught by the same instructor, who had taught computer science for more than twenty years. Before the

experiment, all the participants had studied Information Science for 13 weeks with learning support system environments (Moodle, Mahara and an e-book system). Learning performance measurement techniques in this experiment included learning achievement tests (pre- and post-test), and a questionnaire for measuring learning related perceptions. Both test sheets had been developed by experienced teachers. The questionnaire consisted of 11 questions involving responses on a seven-point Likert scale (1-3: strongly to slightly disagree, 4: neutral, 5-7: slightly to strongly agree). Question content was related to learning perception, specifically technology acceptance [4][5] cognitive load [6], and satisfaction with learning mode [7]. The reliability of this Japanese version questionnaire has discussed in the previous work [3].

Firstly, all the participants took the pre-test consisting of 19 multiple-choice questions which aimed at evaluating their prior knowledge of Information Science. Subsequently, they received a training about how to use Japanese version of VSSE [3], which can be opened in the browser of any PC, tablet or smart phone. During the 15-minute training, the study procedures were demonstrated using one sample map in cache-cache comparison mode; participants were then encouraged to repeat the demonstrated actions so as to familiarize themselves with system operation. After the training, they were assigned randomly in pairs to study with the support of e-book systems and VSSE for 60 mins. An e-book titled “Face detection” was chosen as target learning content. Since the target learning materials are new for everyone, so they allowed to discuss with their peers in the same group and complete the topic map on VSSE (as Fig. 1) together (only one map will be submitted per group). After that, they took a post-test consist of 3 multiple-choice questions and a questionnaire.

4 Learning perception Results

System evaluation and feedback about the learning activity are shown in Table 1. **Table 1.** Results for learning perception.

Item	**Satisification**	**Mental Effort**		**Mental Load**		**Technology Acceptance**	
		understand the purpose (1-7)	learn the KPs (1-7)	Distraction (1-7)	Pressure (1-7)	Easiness (1-3:no 4-6:yes)	Usefulness (1-3:no 4-6:yes)
Mean	3.75	4.77	4.61	3.52	3.74	3.86	3.90
S.D.	1.26	1.48	1.26	1.52	1.72	1.69	1.50

In terms of "mental effort,” the average rating for "effort required for understanding the purpose of the learning activity" was higher than 4 (the neutral point) but still lower than 5, indicating that most participants felt that it is a bit difficult to understand the purpose of the activity. The average ratings of "effort required for learning the target KPs” was 4.61; this suggests that the difficulty of the learning activity slightly difficult for the participants. In terms of "mental load,” the average rating for degree of distraction and degree of pressure was less than 3; this implies that the participants felt little

pressure while concentrating on learning with VSSE. In terms of "technology acceptance" measures, the average rating on the "perceived ease of use" item and the average rating of “perceived usefulness " was slight lower than 4; most participants reported that VSSE was a bit difficult to operate and become familiar with and did not believe VSSE was useful for improving their learning performance in studying new knowledge. In terms of the average ratings (using the mean rankings for the five related items) for “satisfaction with learning mode” were 3.75(slightly lower than 4); this implies that most participants were slight dissatisfied with the learning mode.

5 Discussion, Conclusion and Future Work

The learning perception result differences between the previous experiments and the one in this study lie in "mental effort," “satisfaction with learning mode” and “technology acceptance". In previous finding[3] which compared the learning effectiveness of two different VSSE modes in supporting review activity, the average rating for "effort required for understanding the purpose of the learning activity" was less than 4 (the neutral point) for both groups, indicating that most participants in both groups felt that they could easily understand the purpose of the activity; The average ratings of "effort required for learning the target KPs” were 4.28 and 3.78 for learner who studied with cache-cache mode and those who studied with reception mode, respectively; this suggests that the difficulty of the learning activity was moderate (neither too easy nor too difficult) for the participants in both groups. Furthermore, the average rating on the "perceived ease of use" item was 4.08 for the cache-cache mode and 4.47 for the reception mode; most participants reported that VSSE was easy to operate and become familiar with. The average rating of “perceived usefulness " was 4.50 for the cache-cache mode and 4.76 for the reception mode, which implies that in both groups, most participants thought that VSSE was useful for improving their learning performance in review activity. Finally, the average ratings (using the mean rankings for the five related items) for “satisfaction with learning mode” were 4.51 and 4.96 for the cache-cache mode and the reception mode, respectively; this implies that most participants in both groups were satisfied with the provided learning mode.

In the other word, the self-study activity with cache-cache mode is a bit difficult than the review activity with either cache-cache mode or reception mode. Without sufficient prior knowledge and guidance, the unassisted discovery learning in the experiment in this research lead to additional cognitive load, lower technology acceptance and dissatisfaction, this finding has also been cautioned by many previous researches [1][8][9]. Although the cache-cache mode hided all the key relation and only presented the key concepts, there were still too much new information for novices in a self-study activity. In summary, compared to the previous experiments [3] where participants attended lecture of the target content weeks before the review activity, the participant precepted higher mental effort, lower satisfaction with learning mode and lower technology acceptance. Due to the small amount of the learner data, further experiment still needs be conducted to confirm those conclusions.

References

1. Ausubel, D.: In defense of advance organizers: A reply to the critics. Review of Educational Research, 48(2), 251-257 (1978).
2. Wang, J. , Ogata, H. , & Shimada, A.: A meaningful discovery learning environment for e-book learners. IEEE Global Engineering Education Conference 2017, 1158–1165(2017).
3. Wang J., Shimada A., Oi M., Ogata H.., Tabata Y.: Development and Evaluation of a Visualization System to Support Meaningful E-book Learning. Interactive Learning Environments, DOI: 10.1080/10494820.2020.1813178(2020).
4. Chu, H. C., Hwang, G. J., Tsai, C. C., & Tseng, J. C. R.: A two-tier test approach to developing location-aware mobile learning systems for natural science courses. Computers & Education, 55(4), 1618-1627 (2010).
5. Davis, F. D. : Perceived usefulness, perceived ease of use, and user acceptance of information technology.MISQuarterly,13(3), 319–340 (1989).
6. Sweller, J., Ayres, P. L., Kalyuga, S., & Chandler, P. A.: The expertise reversal effect.Educational Psychologist,38(1),23–31 (2003).
7. Chu, H. C., Hwang, G. J., & Tsai, C. C. : A knowledge engineering approach to developing Mindtools for context-aware ubiquitous learning.Computers & Education, 54(1), 289–297 (2010).
8. Alfieri, L, Brooks, P. J., Aldrich, N. J. & Tenenbaum, H. R.: Does Discovery-Based Instruction Enhance Learning? Journal of Educational Psychology, 103 (1), 1-18 (2011).
9. Mayer, R.: Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. American Psychologist, 59 (1), 14–19 (2004).