Liu, C.-C. et al. (Eds.) (2014). Proceedings of the 22nd International Conference on Computers in Education. Japan: Asia-Pacific Society for Computers in Education

Visual Behavior and Cognitive Load in Augmented Reality Learning Environment

Wei-Yan LIN *, Meng-Jung TSAI & An-Hsuan WU
Graduate Institute of Digital Learning and Education
National Taiwan University of Science and Technology, Taiwan
*M10211004@mail.ntust.edu.tw

Abstract: This pilot study was attempted to explore the relationships among cognitive load, visual behavior, and reading comprehension in augmented reality (AR) learning environment. An ASL MobileEye-XG eye-tracking system was used to record the participants' visual behaviors while they read Taiwan traditional folk belief information demonstrated by AR technologies. A survey was used to examine participants' cognitive loads due to different cognitive elements (videos, texts and pictures) designed in the AR contents. Currently, the results showed that participants with higher reading comprehensions seemed to have higher cognitive loads from videos. Although no significant relationships were found between visual behaviors and reading comprehensions, some significant correlations were found between visual behaviors and cognitive loads, and also between cognitive loads and reading comprehensions. More results will be discussed in the conference.

Keywords: Cognitive load, visual behavior, reading comprehension, augmented reality

1. Introduction

Augmented reality (AR) technologies, which utilize image recognition technology to link computer-generated virtual elements with real-world elements and display two types of elements on the same platform at the same time, are gradually promoted to be used in educational settings (Chen & Tsai, 2012; Wu, Lee, Chang, & Liang, 2013) in different learning domains. This study was attempted to use augmented reality technology in Taiwanese folk belief exhibition to explore its possibility of use in multicultural education, especially for the cultural inheritance of Taiwan traditional folk beliefs.

Eye movement studies have been applied to learning for decades and have caused increasing attentions in educational research recently (Lai et al., 2013). Visual attentions recorded by eye-tracking systems have been found to be significantly related to learning performance in environments where pictures and texts were displayed simultaneously (Yang, Chang, Chien, Chien, & Tseng, 2013; Ho, Tsai, Wang, & Tsai, 2014). However, little studies explored the situations that videos were added simultaneously as used in AR learning environments. Thus, this study added video into learning environment along with picture and text. Besides, eye tracking measures seemed to be found relating to cognitive load, but didn't analyze which type of cognitive load related to participants' eye movements (Wang, Yang, Liu, Cao, & Ma, 2014). According to the literature, cognitive load can be classified into three different types, i.e., intrinsic cognitive load, extraneous cognitive load, and germane cognitive load (Sweller, van Merriënboer, & Paas, 1998). Therefore, this pilot study aimed to explore the relationships among different types of cognitive loads, visual behaviors, and reading comprehensions in a Taiwanese folk belief exhibition which includes texts, pictures, and videos linked by AR.

2. Method

2.1 Experiment

Seven university students, four males and three females, in north Taiwan were volunteered to participate in a pilot eye-tracking experiment. The average age of the participants was 23.71(SD =

0.756). All of them had little knowledge regarding Taiwanese traditional folk beliefs and little experience in participating related traditional cultural events. Therefore, the participants had about the same level of prior knowledge or experience regarding the learning contents.

The learning material of this study was set as a real Taiwanese folk belief exhibition. There were eight ceremonies' introductions shown as posters in this exhibition. Every ceremony was introduced by one picture with a short caption below, one paragraph of text aside the picture that describes how the ceremony held, and one video showing the procedure of real ceremony situation linked by the augmented reality technology. The videos were designed to be activated by markers on posters and shown in a smart phone.

2.2 Instrument

In order to investigate different types of cognitive load from different types of materials (videos, texts, pictures), nine questions were designed to examine the types of cognitive loads. A self-reported 0-10 scale was used to evaluate each of the questions. The larger the number, the higher the cognitive load was perceived. Besides, an ASL MobileEye-XG system (60 Hz) was used to record the participants' eye movement data during the participants viewing the AR exhibition. After the experiment, a video analysis was used to analyze each participant's visual behavior data. Total reading time on each type of learning materials, total entered count on each type of learning materials, and average entered duration of each type of learning materials were calculated based on the scan path video of each participant. There were total twelve visual behavior measures coded in current analysis. Finally, the posttest in this study was assessed by twenty multiple-choice questions concerning the concepts demonstrated in the AR exhibition.

2.3 Data Collection and Analyses

The procedure of this study's experiment can be divided into four parts. First, each of the participants was taught how to link the video by AR with a smart phone. Second, an eye-tracking calibration was then conducted. Third, the participant started to view the learning materials for twenty minutes. At last, the participant rated the cognitive load questionnaire and received the posttest with a comprehension test of twenty questions. As for data analyses, Mann–Whitney U test was used to analyze the differences of cognitive loads and visual behaviors between high performance group and low performance group. Furthermore, Spearman's correlation analyses were used to analyze the relationships among the participants' cognitive loads, visual behaviors, and reading comprehension.

3. Result

According to the result of Mann-Whitney U test, it was found that there was significant difference between high performance group and low performance group toward extraneous cognitive load from video ($z = -1.999$, $p = .046$). The participants in high performance group had higher extraneous cognitive load from video (Mean = 5.250, SD = 2.062) than the participants in low performance group (Mean = 1.667. SD = 1.155). Moreover, it was found that there was no significant difference between high performance group and low performance group on visual behaviors.

In addition, regarding the result of Spearman's correlations analysis between the participants' cognitive load and visual behaviors, the participants' extraneous cognitive load from picture had significantly negative correlation with total entered count of picture ($r = -.805$, $p < .05$). This finding reveals that the participants who had higher extraneous cognitive load from picture, they had lower counts of looking pictures. It was also found that the participants' extraneous cognitive load from text had significantly positive correlation with average entered duration of pictures' short explanation. This finding reveals that the participants who had higher extraneous cognitive load from text, they had longer average entered durations on the short explanations of pictures.

Finally, based on the result of Spearman's correlations analysis between the participants' visual behaviors and reading comprehension, it was found that there was no significant relationship between the participants' visual behaviors and reading comprehension. However, according to the result of

Spearman's correlations analysis between the participants' cognitive load and reading comprehension, it was found that the participants' extraneous cognitive load from video had significantly positive correlation with the participants' reading comprehension ($r = .972$, $p < .001$). This finding reveals that the participants had higher extraneous cognitive load from video might get higher reading comprehension.

4. Conclusion and discussion

According to the results, the participants in high performance group had higher extraneous cognitive load from video than the participants in low performance group. In addition, the participants had higher extraneous cognitive load from video might get higher reading comprehension. In opposition to general viewpoint, which suggests that extraneous cognitive load should be reduced for better learning (Sweller & Chandler, 1994), it seemed that extraneous cognitive load might actually help the participants to learn better.

In addition, the results showed that the participants who had higher extraneous cognitive load from picture had lower counts of looking pictures. It seems to mean that learners who think that displaying learning contents with pictures is not good for learning might not take pictures as main learning materials; on the contrary, learners who think that displaying learning contents with pictures is good for learning might take pictures as helpful learning materials. Furthermore, the participants who had higher extraneous cognitive load from text tended to have longer average entered durations on the short captions of pictures. It indicates that learners who think that displaying learning contents with texts is not good for learning might need to take more time on realizing what short captions of pictures are talking about; on the contrary, learners who think that displaying learning contents with texts is good for learning might need to take less time on realizing what captions of pictures are talking about. It is interesting to notice that extraneous cognitive load might be the main element that influences the participants' viewing behaviors in AR learning environments.

Furthermore, opposite to the previous study (Yang et al., 2013), it was found that there was no significant relationship between the participants' visual behaviors and reading comprehension in this study. It might be caused by the small number of participants that made the statistical number too hard to be significant. It is suggested that the relationship between visual behaviors and reading comprehension should be paid more attention. More details of the results will be presented and discussed in the conference.

References

Chen, C. M. & Tsai, Y. N. (2012). Interactive augmented reality system for enhancing library instruction in elementary schools. Computers & Education, 59(2), 638-652.

Ho, H. N. J., Tsai, M. J., Wang, C. Y., & Tsai, C. C. (2014). Prior knowledge and online inquiry-based science reading: evidence from eye tracking. International Journal of Science and Mathematics Education, 12(3), 525-554.

Lai, M. L., Tsai, M. J., Yang, F. Y., Hsu, C. Y., Liu, T. C., Lee, S. W. Y., …Tsai, C. C. (2013). A review of using eye-tracking technology in exploring learning from 2000 to 2012. Educational Research Review, 10(0), 90-115.

Sweller, J. & Chandler, P. (1994). Why Some Material Is Difficult to Learn. Cognition and Instruction 12(3), 185-233.

Sweller, J., van Merriënboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. Educational Psychology Review, 10, 251–296.

Wang, Q., Yang, S., Liu, M., Cao, Z., & Ma, Q. (2014). An eye-tracking study of website complexity from cognitive load perspective. Decision Support Systems, 62(0), 1-10.

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & Education, 62, 41-49.

Yang, F. Y., Chang, C. Y., Chien, W. R., Chien, Y. T., & Tseng, Y. H. (2013). Tracking learners' visual attention during a multimedia presentation in a real classroom. Computers & Education, 62, 208-220.