Shih, J. L. et al. (Eds.) (2019). Proceedings of the 27th International Conference on Computers in Education. Taiwan: Asia-Pacific Society for Computers in Education

Investigating the effects of cognitive style on blended museum learning

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Abstract: Museums provide an ideal inquiry learning environment with fruitful learning resources for diverse learners. With digital applications in museums, there is a need to consider the influences of the museum context in the service design to avoid negative effects on museum learning. Besides, there is a need to provide proper learning supports to satisfy the different needs of diverse learners. In order to effectively support diverse learners learning, cognitive style has been the focus due to the significant effects on learning with digital applications. However, as there are limited studies on understanding the effects of cognitive style on museum learning, this study developed a game-based learning service to engage learners in interacting with museum exhibits and other people in a blended museum learning context. The learners' learning experiences were examined to evaluate the service design, and an independent *t*-test was used to identify the differences between learners with different cognitive styles, i.e., the Field dependent (FD) and Field independent (FI). The results show that FI and FD learners have different preferences concerning service design during their visits. Besides, the unmatched service design may influence FI learners better than it would FD learners.

Keywords: Museum learning, cognitive style, field dependence–independence, user-interface design, mental workload

1. Introduction

Museums provide an ideal inquiry learning environment with fruitful learning resources for diverse learners. In this study, we developed a game-based learning service named CoboFun to promote learners inquiring in a blended museum learning context. The various types of problem-solving tasks with fruitful learning resources are provided to engage learners interacting with museum exhibits and other people with digital applications and museum's physical environments. A learning activity was designed for the learners aged ten and above. A flexible game-based learning environment with different learning support design, such as hints and exploration map, were provided to support learners with different cognitive style, i.e., Field independent(FI) and dependent(FD) learners learning in museums. The learning experiences and mental workload were evaluated to examine the design of CoboFun. The results of the study can be used to improve the design of CoboFun and to address issues that do not meet the specifications.

2. Service and Learning Activities Design

A game-based learning service named CoboFun was developed to promote learners' interactive museum experiences during their visits. A learning quest named "Doctor D's Dinosaur Park" was designed for introducing the exhibitions of Life Science Hall on display of National Museum of Nature Science (NMNS) in Taiwan. A total of eight problem-solving tasks were integrated in the quest for constructing the thematic knowledge of the origin, evolution and extinction of life on earth. In the beginning, a simulated story is provided to motivate learners' participation and guide their actions to solve puzzles. The learner is able to use beacon technologies to identify their position and plan their route to the various locations with an exploration map. Each learning task provides a puzzle to engage learners interact with the nearby exhibits and other people. For example, Figure 1 and 2 display an example of task design. The learner is able to find the location of target exhibit and the answers from the descriptions and audio tour. The clues and hints are provided to support the learner identify the keys to solve the puzzle. The learner is able to select their preferred tasks, stop and continue gaming at any

time they want. To promote learner solving all the puzzles, the learner is able to collect Virtual Reality objects (Dinosaurs) after they finish each task. Besides, the learning summary provided illustrated explanations to summarize the thematic knowledge of each task. Once they complete the quest, the learner is able to view the VR video with their collected dinosaurs or take Augmented Reality photos as souvenir picture, and they are able to access extended learning materials related to the quests on a MOOCs platform. Figure 3 shows the service flow of CoboFun.

Figure 1. The learners interact with exhibits with Exploration Map

Figure 2. An example of task design of "Doctor D's Dinosaur Park"

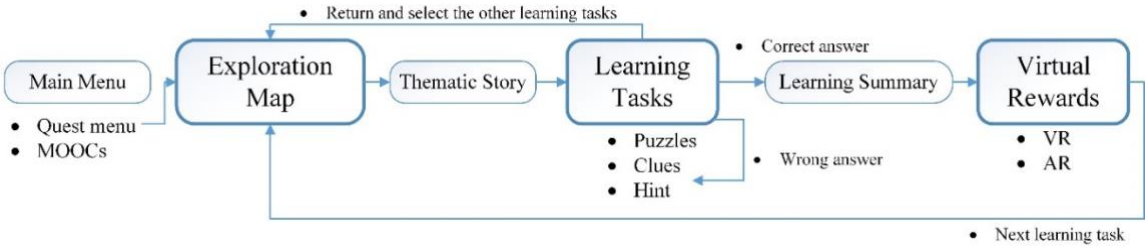

Figure 3. The game-based learning service flow of CoboFun

3. Evaluations

A total of 58 students (28 boys and 30 girls) in the sixth-grade of elementary school participated in this study. Descriptive analysis was applied to examine learners' museum experiences and mental

workloads. We then used a Levene's test to check for homogeneity of variances among the raw measurements. An independent *t*-test was applied to compare the differences of learning experiences between FI and FD. The significance level was $\alpha = .05$ for each statistical analysis.

The results show both FI and FD learners considered that learning with CoboFun required neither low nor heavy mental workload. The results show the workloads of learning with CoboFun to be in the acceptable range, which hardly caused cognitive overload. Most learners considered that learning with CoboFun required more effort on mental demand than physical demand. Besides, the FD learners paid more effort to physical demand (Mean=4.13, SD=2.37) compared to the FI learners (Mean=3.31, SD-1.91).

Regarding the comparison between learners with different cognitive styles, the results echoed previous studies, in that FI and FD learners have different preferences and service design needs(Chen, 2002; Huang, Hwang & Chen, 2016). The t-test results demonstrate that the FD learners' preferences of service design differ from the FI learners. In particularly, FI learners show noticeable preferences on icons with text labels (t (56) =1.93, p=.059) and landmarks (t (55) =1.91, p=.061) in interface design compared to FD learners. Although the t-test results did not reach a significant level, the results are similar to previous studies, which found that FI learners prefer navigational structure such as index or search to identify specific contents (Alhajri & Ahmed, 2016). In addition to the preferences regarding interface design, there is a significant difference in the preferences for corrective feedback design between FI and FD learners (t (56) =2.55, p=.014). The results show FI learners prefer to use the tools to support their efficient locating of specific information, and they expected to have more elaborative corrective feedback compared to the FD learners. The different requirements of service design indicated the need to provide different learning supports to effectively support diverse learning in museums. Besides, the unmatched service design may influence FI learners' perceptions better than the FD learners because they prefer to work alone, without help from others. Although the FI learners were less satisfied with the service design of CoboFun, they judged their performance to be better than the FD learners did. The differences in self-judgments on learning performances may reflect that the FD learners considered that they performed worse compared to those without social supports.

4. Conclusions and Future Works

In this study, a game-based learning service named CoboFun was developed to engage the diverse learners learning in a blended museum context. A flexible learning environment with various types of learning supports and learning activities was provided to encourage diverse learners interacting with museum exhibits and the other learners. Besides, the learners' perceptions were examined to understand the different needs of the learners with different cognitive styles. The results of this study provides practical evidence to understand the learning differences between FI and FD learners. However, there are some limitations. Firstly, this study only evaluated learning perceptions. To better understand how and why diverse learners have different learning perceptions, there is a need for future studies to provide learning analysis of learning behaviors. Besides, the learning achievements can be evaluated as well. In addition to the effect of cognitive style, other human factors, such as prior knowledge and age, can be examined to provide better services and match diverse learners' needs in museum learning.

Acknowledgements

This work was supported by the National Science Council of Taiwan, R.O.C., under contract numbers MOST 108-2511-H-178-001.

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