Live Biblia: Evaluation of a Support System with a Tangible Interface for Viewing Science Museum Exhibitions

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Abstract: In this study, we present a museum exhibit guide system that uses a tangible user interface: Live Biblia. Based on the visitor's learning interests, museum exhibits are sorted and mapped by the system. Thus, it is possible to create a unique viewing map for the visitor, unrestricted by the existing exhibit environment. We describe the development and evaluation of the implemented Live Biblia prototype, which provides exhibit information based on selected material objects. We conducted evaluation experiments to examine the system's effectiveness. The results suggest that the interface prototype using physical objects spurred participants' interest in paleontology and facilitated effective museum exhibit learning. Additionally, we found that presenting information in the prototype animation aroused the participants' motivation to learn and supported the viewing of not only the single fossil object but also the related museum exhibits.

1 INTRODUCTION

In this study, we present Live Biblia, a museum exhibit guide system that uses a tangible user interface. Museum visitors can use Live Biblia to navigate numerous exhibits in an optimal order.

The International Council of Museums (2007) defines a museum as "a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates, and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study, and enjoyment." For this purposes, the museum presents primary source materials as well as secondary source materials created from the primary source materials. When presenting the exhibits, exhibit creators select collections held by each museum hall or cultural property held by other museums; it is necessary to consider the explanations and arrangements that will aid visitors' understanding of exhibits (Dean, 2002; Bell, Lewenstein, Shouse, and Feder, 2009).

However, in case problems arise in the exhibit environment, moving the exhibit is very difficult regardless of whether the relevant exhibit is installed in the same or a separate location. This is due to issues with materials preservation and the need to contemplate matters such as restrictions regarding the utilization of museum space, the appropriate amount of light considering various material qualities, and temperature and humidity constraints.

Further, misguided exhibit configurations may render visitors unable to comprehend the exhibits in their intended continuity (Falk and Dierking, 2013). Such problems may impede visitors' recognition of how exhibits have been systematically configured around a certain theme and, consequently, may prevent visitors from understanding the complete theme.

Therefore, it is necessary to investigate ways to resolve these exhibit arrangement/installation problems from a "soft" perspective, as it is difficult to resolve them from a "hard" perspective. Marty (2000) proposes a system enabling the creation of a digital archive of a museum's materials, and the presentation of listings and image viewings on the Internet. Presenting a recommended route for viewing the related exhibit materials could enhance museum visitors' learning.

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Hence, we developed the Live Biblia concept, a system for flexibly presenting the ideal route for viewing exhibit materials at actual museums, based on visitors' individual learning interests. Live Biblia uses the tangible user interface. Tangible user interface utilizes physical objects as an interface for accessing intangible information (Ishii and Ulmer, 1997; Ishii, 2008). In this study, we devised a method that uses real, hand-size materials as objects that could help indicate visitors' learning interests.

Figure 1 is a conceptual diagram of the Live Biblia system. Based on the visitor's learning interests, museum exhibits are sorted and mapped. Subsequently, it is possible to create a unique viewing map for the visitor, unrestricted by the existing exhibit environment. It is also possible to update maps without moving exhibit items, thereby reducing the incidental burden of exhibit development.

Figure 2 is a conceptual diagram of Live Biblia usage. Museum visitors first externalize their personal interests by selecting material objects. Live Biblia provides exhibit information based on these selections. These activities help visitors acquire perspectives for motivated and effective learning about museum exhibits. Next, Live Biblia lists relevant museum exhibits based on the visitor's selected group of objects and provides the visitor with an appropriate viewing order, thereby allowing the visitor to obtain structured knowledge.

In this paper, we describe the development and evaluation of the implemented Live Biblia prototype, which provides exhibit information based on selected material objects.

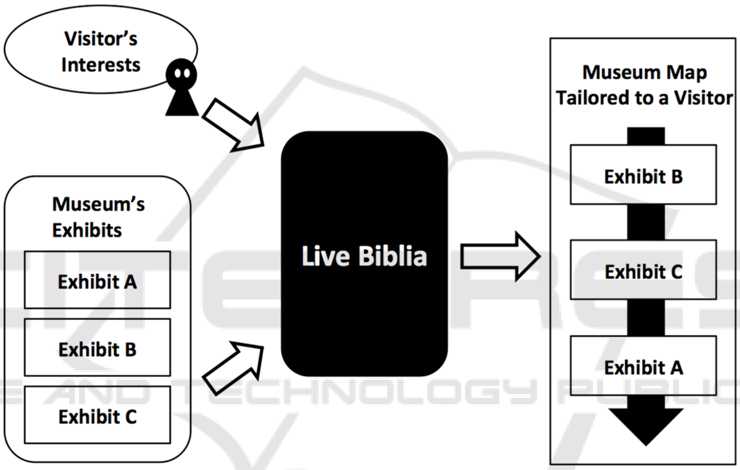

Figure 1: Conceptual diagram of the Live Biblia system.

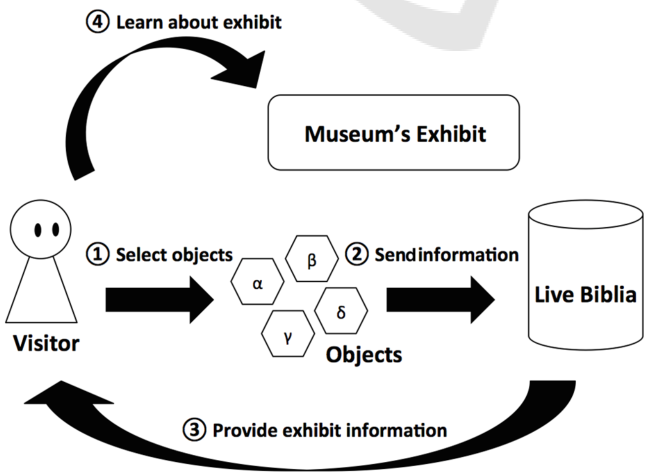

Figure 2: Conceptual diagram of Live Biblia usage.

2 PROTOTYPE SYSTEM

Figure 3 shows the framework of the prototype system. The Live Biblia system framework comprises a laptop PC, projector, RFID reader, and (passive) objects with RFID tags. Live Biblia was developed using Adobe ActionScript 3 and Adobe Flash CS6.

The selected theme of the prototype system was paleontology, for two reasons. First, paleontology involves the study of fossils that can be used as tangible materials. Second, it is possible to variously classify a particular number of relevant fossil materials, such as by the era in which the fossilized item was alive, its living environment (land, sea, etc.), predation method, and evolutionary lineage.

Figure 4 indicates an example of an object with an RFID tag in the prototype system. An actual ammonite fossil is embedded in the object. The visitor can touch the ammonite directly and view it in close proximity. The objects are hand-sized and it is easy to compare multiple objects. RFID tags are embedded in the objects and, by moving close to the RFID reader, RFID information is recorded and transmitted.

Figure 5 shows a device with a built-in RFID reader. By placing the object underneath the magnifying glass, RFID information is read. In addition to intuitively showing where to place the object, the magnifying glass can be used to view the fossil in detail. When the RFID information is read by the PC, an animation providing information on that fossil is displayed on the projector.

Figure 6 shows an example of an animation projection on ammonites. The animation highlights ammonite and explains its ecology. The predation relationship between ammonites and the mosasaurus, an animal that lived during the same period, is also explained. Thus, presenting other materials related to the materials of interest helps in creating a viewing route for the museum exhibits. Figure 7 shows an animation of the usage setting. Projecting the animation on a screen enables multiple visitors to share the information.

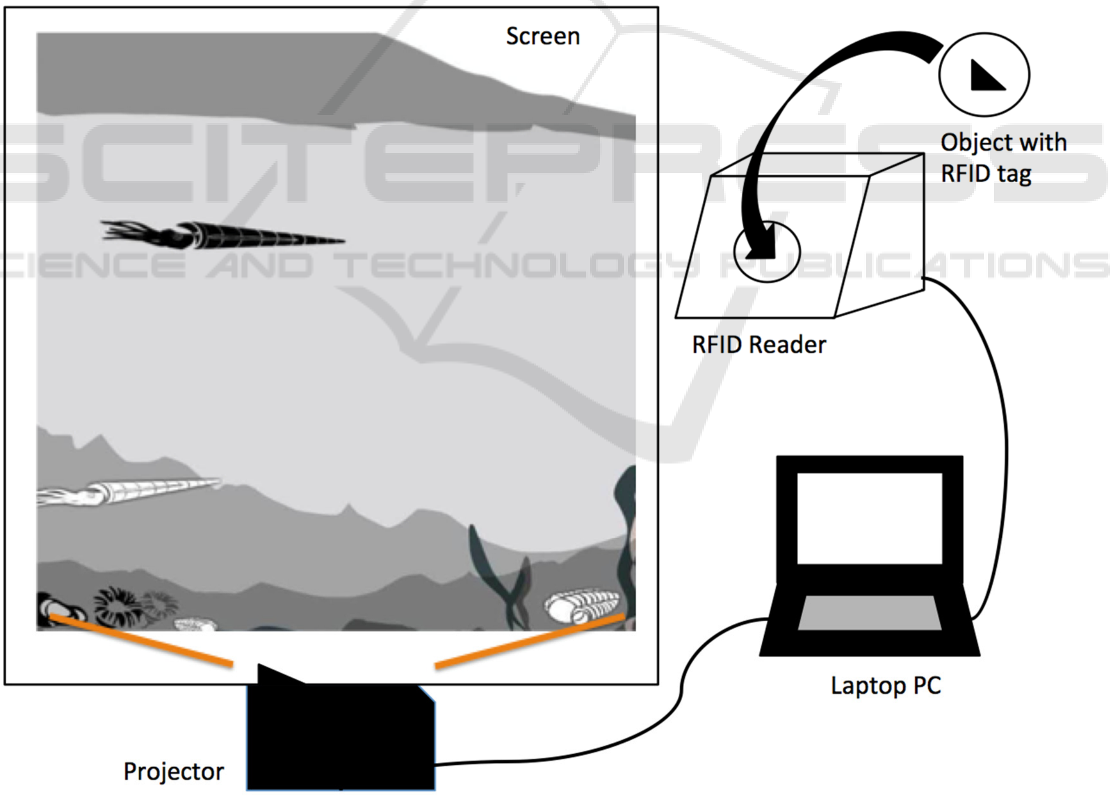

Figure 3: Framework of the prototype system.

Figure 4: Fossil object with an RFID tag.

Figure 5: RFID reader.

Figure 6: Projection of animation.

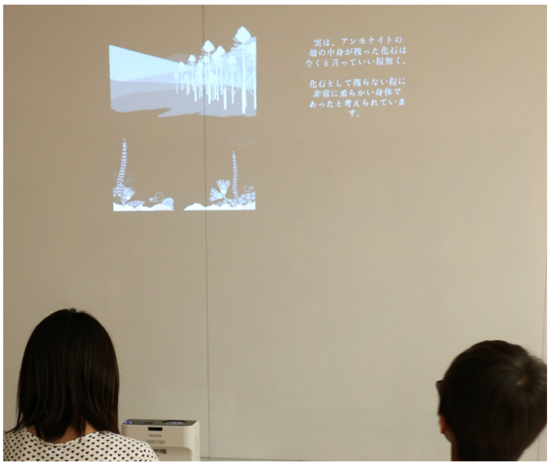

Figure 7: An animation of the usage setting.

3 EVALUATION

3.1 Method

The participants comprised 28 fifth graders in elementary school (13 boys and 15 girls). The location was the H Prefectural Museum of Natural History. The participants used the prototype system in groups of two and three. A total of nine fossil objects were used, comprising three objects from each of three geologic eras: Paleozoic, Mesozoic, and Cenozoic. The participants were each responsible for one of these geologic eras. The system trial transpired as follows.

First, participants touched three fossil objects related to the geologic era they were responsible for, and selected a fossil that aroused their interest. Next, they watched the animation that provided information about the selected fossil. Then, participants viewed related exhibits in the museum. After viewing these, they selected another object of interest from the remaining objects. The above activities were performed for all three fossils from the geologic era for which they were responsible.

Finally, participants evaluated the prototype system using a questionnaire comprising 10 questions; 4 questions pertained to the objects and 6 pertained to the information provided by the animation. The participants evaluated each question using a 7-point scale ranging from "strongly agree" to "strongly disagree."

3.2 Results

First, we classified the responses; "strongly agree,"

"agree," and "agree somewhat" were classified as affirmative responses while "no opinion," "disagree somewhat," "disagree," and "strongly disagree" were classified as neutral or negative responses. Subsequently, the affirmative responses and neutral or negative responses were analyzed using a 1 x 2 uneven distribution binomial test.

Table 1 presents a summary of the evaluation results for the fossil objects. For all four items, affirmative answers exceeded the neutral and negative answers (as the students indicated, "The fossil object sparked my interest," "I observed the fossil object closely," "I was able to understand the relationship between the fossil object and the fossils exhibited in the museum," and "I made new discoveries by closely observing the fossil object and the fossils exhibited in the museum"). A significant bias was found in the number of responses for all items ($P < .01$).

Table 2 presents a summary of the evaluation results for the information in the animation. For all six items, affirmative answers exceeded the neutral and negative answers (as the students indicated, "Watching the presented animation sparked my interest in the fossil as an object," "Watching the presented animation sparked my interest in the era in which the animal lived," "Watching the presented animation made me want to learn more about the animal at the museum," "Watching the presented animation sparked my interest in exhibits at the museum related to the animal," "By watching the presented animation, I was able to better view the exhibits at the museum related to the animal," and "I watched the presented animation and thoroughly read the explanation paragraphs in the exhibits at the museum related to the animal"). A significant bias was found in the number of responses for all four items ($P < .01$).

Table 1: Evaluation results for the fossil objects.

Item	7	6	5	4	3	2	1
The fossil object sparked my interest. **	14	7	6	1	0	0	0
I observed the fossil object closely. **	8	10	8	1	1	0	0
I was able to understand the relationship between the fossil object and the fossils exhibited in the museum. **	12	8	7	1	0	0	0
I made new discoveries by closely observing the fossil object and the fossils exhibited in the museum. **	12	8	7	1	0	0	0

N=28
7: Strongly Agree, 6: Agree, 5: Agree Somewhat, 4: No Option, 3: Disagree Somewhat, 2: Disagree, 1: Strongly Disagree
** P<0.01

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Table 2: Evaluation results for the information in the animation.

Item	7	6	5	4	3	2	1
Watching the presented animation sparked my interest in the fossil as an object. **	12	8	7	1	0	0	0
Watching the presented animation sparked my interest in the era in which the animal lived. **	11	9	6	1	0	1	0
Watching the presented animation made me want to learn more about the animal at the museum. **	12	8	7	1	0	0	0
Watching the presented animation sparked my interest in exhibits at the museum related to the animal. **	12	8	7	1	0	0	0
By watching the presented animation, I was able to better view the exhibits at the museum related to the animal. **	12	8	7	1	0	0	0
I watched the presented animation and thoroughly read the explanation paragraphs in the exhibits at the museum related to the animal. **	12	8	7	1	0	0	0

N=28
7: Strongly Agree, 6: Agree, 5: Agree Somewhat, 4: No Option, 3: Disagree Somewhat, 2: Disagree, 1: Strongly Disagree
** P<0.01

4 CONCLUSION AND FUTURE WORKS

This paper described the development and evaluation of the Live Biblia prototype. In the evaluation, the number of affirmative responses exceeded the number of neutral and negative responses for all 10 items (four pertaining to the objects and six pertaining to the animation). Moreover, there were significant differences in the number of responses.

These results suggest that the interface prototype using physical objects spurred participants' interest in paleontology and facilitated effective museum exhibit learning.

Additionally, we found that presenting information in the prototype animation aroused the participants' motivation to learn and supported the viewing of not only the single fossil object but also the related museum exhibits.

Future tasks include the development and implementation of a function to navigate exhibit routes within the museum, as well as collecting user data on actual visitors in the museum and investigating the effectiveness of Live Biblia's support of museum learning.

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