A Self-Made Personal Explanation Aid of Learning Materials in a Museum for Naïve Developers

Ayako Ishiyama
Tama Art University, Tokyo Institute of Technology
Tokyo, Japan
ishiyama@tamabi.ac.jp

Satoru Tokuhisa
Yamaguchi University
Yamaguchi, Japan
dangkang@yamaguchi-u.ac.jp

Fusako Kusunoki
Tama Art University
Tokyo, Japan
kusunoki@tamabi.ac.jp

Shigenori Inagaki
Kobe University
Hyogo, Japan
inagakis@kobe-u.ac.jp

Takao Terano
Tokyo Institute of Technology
Kanagawa, Japan
terano@dis.titech.ac.jp

Abstract—**Explanation of museum exhibits must give useful and adequate information to museum visitors. However, good explanation costs a lot and is hard to be maintained by museum curators. To make explanation contents easier, this paper proposes a novel personal support aid: Stamp-On Developers Toolkit (Stamp-On/DT), with which let visitors to easily develop the richer explanation contents by themselves. Stamp-On/DT consists of smart devices with explanation contents and 'stamp' devices attached to corresponding exhibits. The unique features of Stamp-On/DT are summarized as follows: (1) the digital contents of the corresponding explanation can be created by both visitors and curators, (2) the contents are described with conventional web tools such as HTML, CSS, or Java script, and (3) users are only required to save exhibited images in the same exhibited location with the same names. To validate the effectiveness of Stamp-On/DT system, we have conducted a workshop in a museum to let visitors create digital contents and then we have evaluated their performance. Furthermore, we have conducted usability test to evaluate whether naïve users are able to their own explanation aids using Stamp-On/DT system. From both experiments, we conclude that Stamp-On/DT is an effective, easy and interesting aid in understanding museum exhibits.**

Keywords- tangible user interface; digital content; museum explanation

I. INTRODUCTION

The purpose of museums is to collect, store, and educate people with different exhibits. In recent years, lifelong learning has become active and schools have created comprehensive classes. Therefore, demand for education in museums is increasing. With regard to the opportunity for visitors to learn about museum exhibitions, digital exhibition support systems and experiential exhibitions have increased. We have surveyed to identify the expectation of curators from museum visitors. The participants of the survey have indicated that they hope for visitors to have interests in the exhibits, to observe the exhibits more comprehensively, and to feel familiar with the exhibits. Because most visitors often enjoy video games, museum exhibition support systems are required to be both interesting and enjoyable for visitors so that they can engage in observing the exhibits.

Based on such background, in this paper we propose a novel personal support aid: Stamp-On Developers Toolkit (Stamp-On/DT) for visitors, developed by the visitors themselves. This paper is an extended version of our previous work [1] with additional revisions and amendments. The rest of the paper is organized as follows: In Section II, we present a literature survey to highlight the current problems; In Section III, we describe the system configuration and functions of the proposed system; In Section IV, we explain the usage of Stamp-On/DT; In Sections V and VI, in order to validate the effectiveness of Stamp-On/DT, we carry out workshop experiments, then give the findings and discussions; In Section VII, we describe the development of web-based online manual, which we newly designed for provider-visitors to easily use Stamp-On/DT. In Sections VIII and IX, in order to validate the effectiveness of the manual, we carry out the usability test; Finally, Section X concludes the paper.

II. LITERATURE REVIEW

A. Study on Museum Exhibit Explanations

There are many studies on digital explanations for museum exhibits aimed at people accustomed to interactive stimuli, such as video games [2][3][4][5][6][7][8][9].

Such digital explanations have the same structure as video games. If visitors stand in front of a given exhibit, the digital explanation starts. There are interactive elements to push buttons for more details, but in general, visitors watch the exhibit passively. Experts on exhibits system developments (system experts) are responsible for creating such digital content. Therefore, to fix and/or modify these digital contents, hard work from system experts is required.

B. Authoring Tool for Museum Exhibit Explanation

Koleva et al. [10] developed an authoring tool that curators are able to use to connect 3D digital content and sounds for exhibits with a visual programming language. Even with this tool, however, system experts must prepare the 3D parts in advance. Roussou et al. [11] made a website to be used for museum learning, in which they use the pictures drawn by eleven years old children. In Roussou et al.'s study, they report that children made a paper prototype for the web contents. However, finally, a professional web designer created the actual website. Also they reported that the children's pictures required much time to digitize.

C. Digital Education Tools in Museums

Many museums, including the British Museum and the Louvre, have a digital presence on the Internet. People can watch exhibits remotely [12][13]. On the other hand, Google created a virtual museum for access on the Web in cooperation with different museums, including the National Museum of Western Art [14]. In addition to the Web, museum–display-support applications such as 'Tohaku Navi' [15] and 'e-Museum' [16] are employed. People can confirm the availability of certain exhibitions before visiting a given museum. Okumoto et al. [17] described that watching images and exhibit commentary on the Web before attending a museum was more effective for visitors than using the museum exhibit support system without watching the online commentary prior to visiting the museum. However, it is difficult for all visitors to learn information about exhibits in advance from a museum website. Furthermore, Okumoto et al. indicated that visitors only watched museum exhibits briefly because visitors were preoccupied with awareness of digital content.

D. Summary of the Survey and Research Statements

Currently, experts are required to make digital exhibition support systems. If only experts create the content, there is a limitation in that modifying existing content or adding new content requires considerable time. Although digital exhibition commentary has a level of interactivity because visitors can press a button, visitors mostly watch the exhibition support system passively. There is also a limitation in that visitors observe digital content more closely than the actual exhibits. Therefore, we believe that museum support systems require a mechanism that can help visitors interact more actively with museum exhibits.

From the literature survey, in an exhibition support system, the roles of visitors are considered very low. However, we believe digital contents should be generated by visitors themselves. It can be attained if the contents are easily developed and modified. Furthermore, if visitors are familiar with interactive video games, they are able to enjoy such digital contents interactively. In this paper, we would like to validate such visitor behaviors.

E. Usability Evaluation Experiments with WEB sites

S. E. Ozimek [22] evaluated the effectiveness of a web-game in a museum. They took the online survey from 303 people, then found more than half of the subjects felt that the mobile game will be help in the learning experience. After having visitors play a mobile game, Rubino et al. [23] evaluated the effect of learning through a questionnaire survey about exhibited objects. The results were positive. Yiannoutsou et al. [24] summarized the learning at the museum. They suggested that the involvement of the visitors themselves in the production of content related to the exhibition is important. In this paper, we would like to evaluate these effectiveness with Stamp-On/DT at a real museum environment.

F. Usability Evaluation Experiments of WEB sites

According to Nielsen and Landauer [18] or Albert and Tullis [19], they stated that even the number of the subjects of a usability test is only the five people, it is enough to evaluate the behaviors. We follow the statements in the experiment in Sections V and VI.

III. SYSTEM CONFIGURATION AND FUNCTIONS OF STAMP-ON/DT

Stamp-On/DT system is an extension of Stamp-On exhibition support tool [20] (Figure 1). The system configuration and functions are, thus, almost the same we have already reported. Based on the previous paper, we explain the outline.
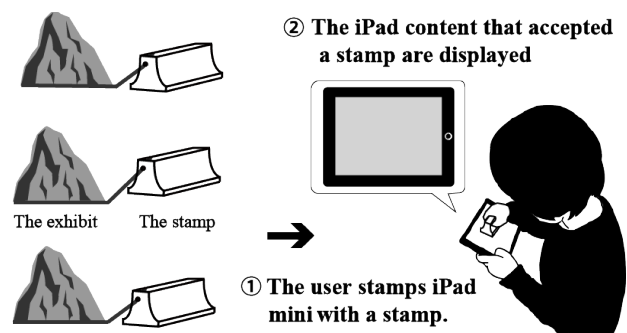

② The iPad content that accepted a stamp are displayed

The exhibit   The stamp

① The user stamps iPad mini with a stamp.

Figure 1.   Overview of Stamp-On system[20].

A. Hardware

The Stamp-On/DT system hardware is composed of a Nexus 7 tablet, stamp, scanner, special paper, and stationary (Figure 2).

Figure 2.   Stamp-On/DT system hardware.

1)   Nexus 7 tablet: We need Chrome browser equipped on Nexus 7 tablet: Chrome. However, devices which satisfy the following conditions also run Stamp-On/DT systems:

a) Device with a multi-touch screen, which is used to detect four or more point coordinates.

b) Browser with JavaScript-compatible software.

2)   The stamp: Aluminum tape is pasted on a stamp from the bottom of the stamp to the side of the stamp. The stamp has dot patterns on the bottom (Figure 3), on which the stamp has four convex points. When provider-visitors press the Nexus 7 tablet with the stamp, the tablet reads the dot patterns of the bottom. Each of the stamp pattern identifies the corresponding information attached on the pattern. The corresponding digital contents will change through this pattern (Figure 5).

The   design of the stamps was improved from the one in Figure 3 to the one in Figure 4. The main difference is that we use simple rivets to specify the dot patterns so that we are able to easily make higher precision patterns and that we easily maintain the work of the stamp. We utilize the new version stamp to evaluate the usability of the online manuals.
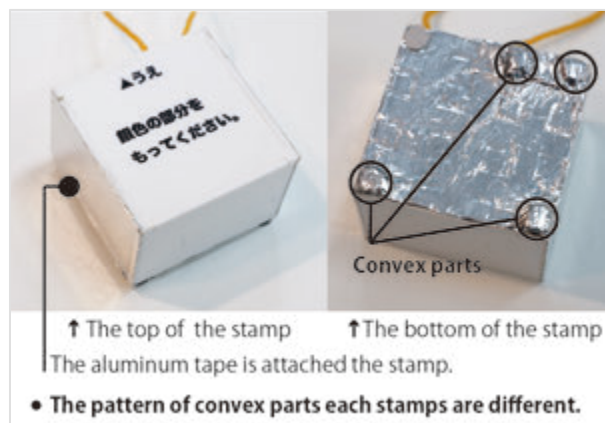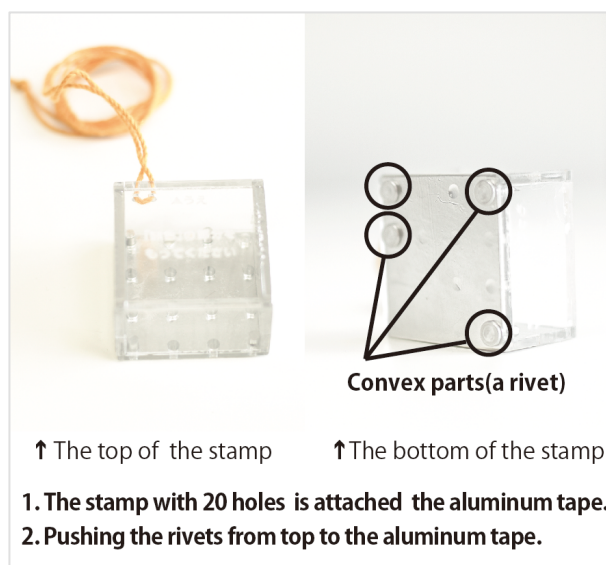

Figure 3.   Stamp interface.

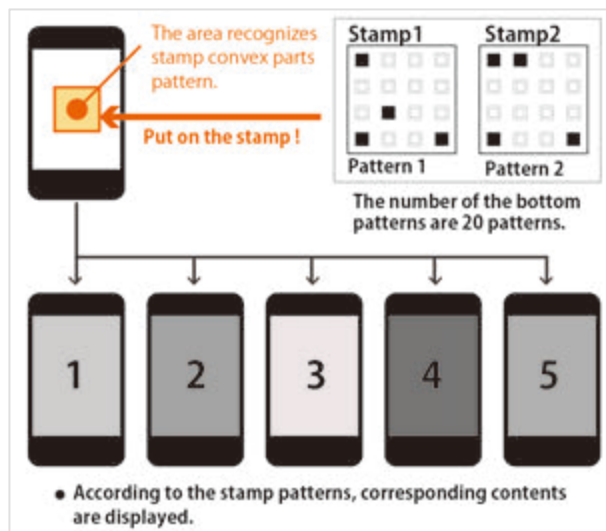Figure 4.   Improvement on Stamps After Experiment

Figure 5.   Mechanism to switch digital content.

3)   PC and Scanner: A PC and a scanner are required in order to digitize the paper on which provider-visitors write some information on the exhibited items in the form of a single quiz. After the sheet with the quiz is scanned and converted to an image file (jpg format), a support staff will cut unnecessary portions using an image processing software then save the file.

4)   Display design sheets and stationeries: To convert digital data, the sheet pre-prints i) a frame in the same screen ratio as the Nexus 7 screen and ii) an area to press the stamp (Figure 6). Stationeries are used by provider-visitors to write the text and / or to draw the picture to be used.
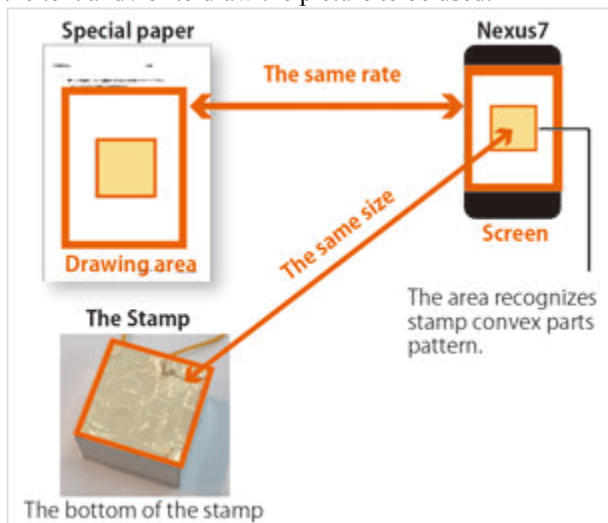

Figure 6.   Method for digitizing paper on which provider-visitors draw illustrations for museum exhibits. Method for uploading to Nexus 7 tablet.

B. Software

The software used for the proposed system is written in HTML, CSS, and JavaScript. The image file URLs are written in the HTML source file in advance. A new image file is displayed when the image file in the image folder is overwritten. First, provider-visitors bring their paper with the exhibit quiz and commentary to museum staff. Second, the staff overwrites the image file in the specified folder by scanning with the scanner and PC. Finally, the digital content is completed when the staff copies the folder to the Nexus 7 tablet. (If the PC and the Nexus 7 are connected to a web server, the folder is only required to be uploaded). All these operations are performed on a PC. A general file transfer tool is used between a PC and a Nexus7 terminal. We tune the Stamp sensitivity up, so that a user of Stamp-On/DT smoothly and easily use the system, In the current version, we use Nexus7 as a terminal, however, if we would change the CSS, we would be able to use various conventional portable devices.

IV.   USAGE OF STAMP-ON/DT SYSTEM

Provider-visitors who would like to use Stamp-On/DT are required to perform the following two tasks:
1)   To create digital contents (Figure 7).

2)   To play with the digital contents (Figure 8).

A. Task of the Content Creation Phase

At the first task, provider-visitors are required to follow the steps:
1)   Make a quiz regarding a given museum exhibit.
2)   Learn about the exhibit while taking notes.
3)   Write a quiz related to the exhibition on the sheet with   texts and/or illustrations.
4)   Scan the sheets then put them into the PC by the staff.
5)   Put the generated image files to HTML pages by the staff.
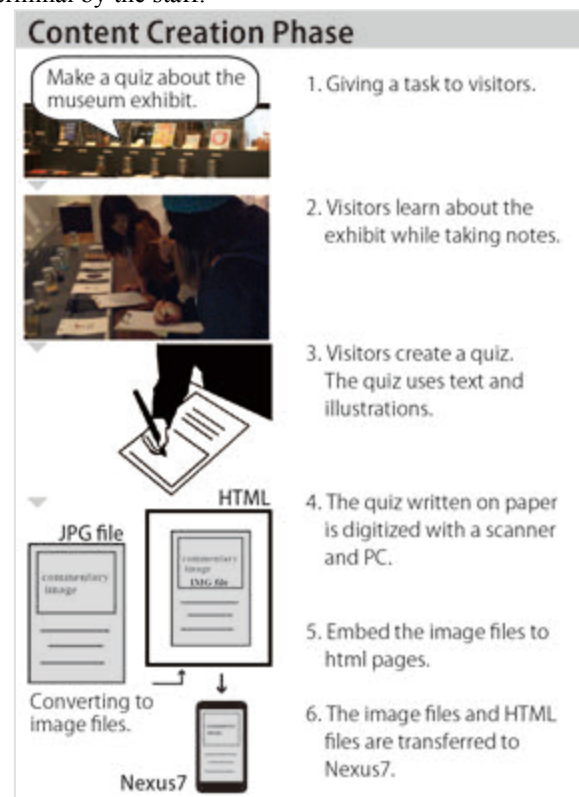6)   Transfer the image files and HTML files to Nexus7 terminal by the staff.

Figure 7.   Content Creation Phase.

B. Task of the Playing Phase

At the second task, provider-visitors are required to follow the steps:
1)   Place a stamp in front of the museum exhibits.
2)   Display the question on the screen of Nexus7.
3)   Look for the answer stamp in front of the exhibits.
4)   Put the stamp on screen of Nexus7 tablet.
5)   Display corresponding contents according to the patterns of the stamp.
6)   Display a correct or wrong image. If provider-provider-visitors choose a wrong answer, Nexus 7 displays 'try again'. If provider-visitors choose a correct answer, Nexus7 displays the commentary image which provider-visitors drew.
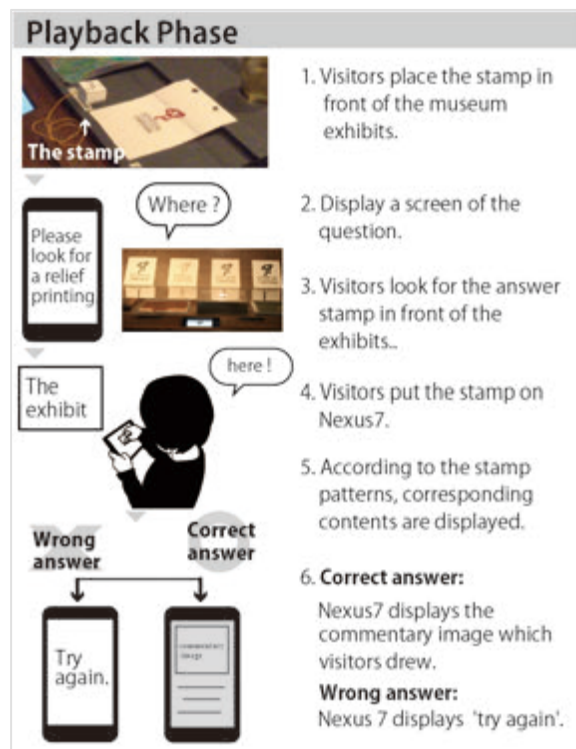
Figure 8. Playback Phase.

V. EXPERIMENT OF STAMP-ON/DT SYSTEM

A. Design of WorkShop

To evaluate the effectiveness of Stamp-On/DT, we have organized a workshop in a museum where provider-visitors were able to observe and enjoy the exhibits actively. Provider-visitors to the workshop were instructed to create digital content to explain the museum exhibits.

When provider-visitors create digital contents, we expect them to show the following behavior:

• Provider-visitors will watch the exhibit more carefully than usual.

• Because provider-visitors are required to create a sheet that explains the exhibit, they need to arrange exhibit information in a header and collect it. Therefore, provider-visitors will understand the exhibit more comprehensively than usual.

B. Experimental Environment

We conducted an experiment to evaluate our system at the Printing Museum in Tokyo, on Saturday, September 27, 2014. The participants were nine female college students, and none of the participants had seen the exhibits previously. The number of the subjects seems too small to statistically evaluate the experiments, however, the limitation of the cost and the museum capacity, we selected these nine subjects. In order to support the results, instead, we had intensive interviews after questionnaire surveys.

Three days before the experiment, we trained two students for thirty minutes to assist with the activities of the participants to support digitizing, resizing, and saving the information collected during the experiments. Consequently, on the day of the experiment, the participants had no trouble because of the help provided by the student staff members.

Before the experimental workshop, all participants expressed an interest in printing and enjoyed drawing pictures. We divided the students into two groups (four and five people in each group), and the groups were labeled as Group A and Group B.

For both groups, the required task was to create several quizzes regarding the exhibition after observing their assigned exhibits (Figure 9, Figure 10). Each person was assigned one of two different exhibits randomly.

After a pre-test, Group A started to create digital contents immediately. On the other hand, after the pre-test, Group B observed the exhibits as usual and required to answer a mid-test. After the mid-test, Group B was required to start to create the corresponding digital contents. As indicated in Table I, we gave the pre- and post-test to Group A as follows:

• T1. pre-test: the participants answered the test without seeing the exhibits in the museum in advance.

• T3. post-test: the participants answer the test after using the Stamp-On/DT system.

As indicated in Table I, to Group B, we gave pre-, mid- and post-tests as follows:

• T1. pre-test: the participants answered the test without seeing the exhibits in the museum in advance.

• T2. mid-test: the participants answered the test just after watching the exhibits as regular visitors.

• T3. post-test: the participants answer the test after using the Stamp-On/DT system.

Figure 9. Experiment participants who observed exhibits.

Figure 10. Subjects drawing picture for exhibit commentary.

TABLE I. FLOW OF THE EXPERIMENTS

Group A

Time	Action	States
10min	Pre questionnaire	T1
1h45min	Digital content creation (Watch Exhibits and production)	
30min	Playing with the digital content they made	
10min	Post questionnaire	T3

Group B

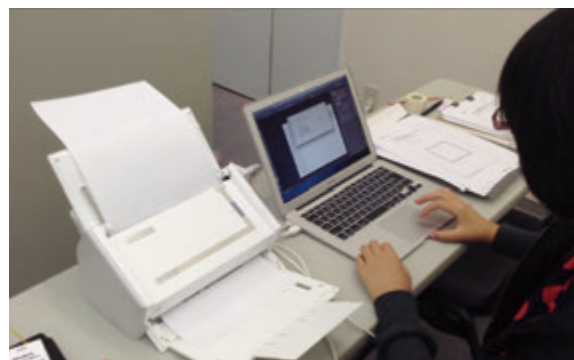| Time	Action	States
10min	Pre questionnaire	T1
20min	Watch as usual	
10min	Intermediate questionnaire	T2
70min	Digital content creation (Watch Exhibits and production)	
30min	Playing with the digital content they made	
10min	Post questionnaire	T3

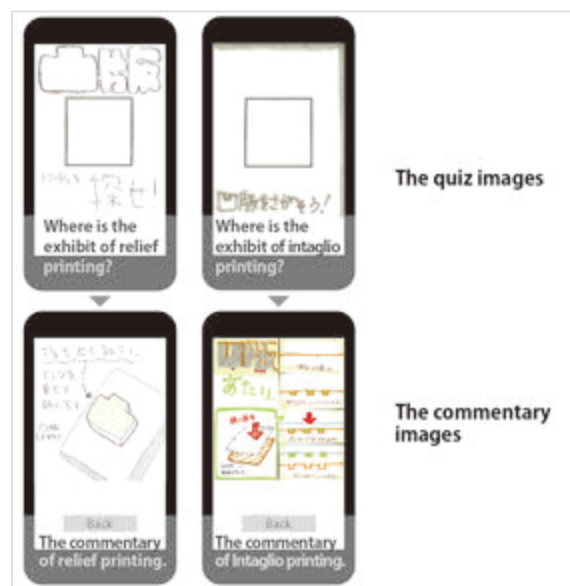Figure 11. Staff digitizing exhibition commentary sheet drawn by participants.

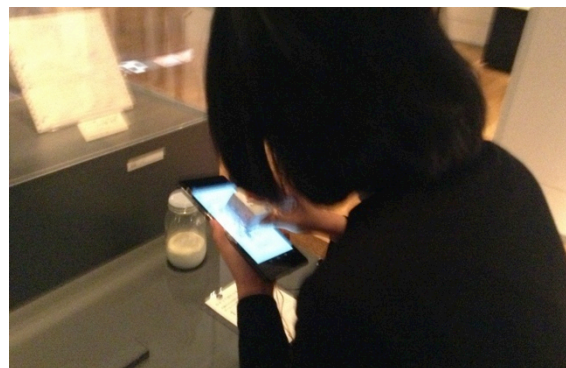Figure 12. The pictures and texts which subjects painted.

Figure 13. Subjects pressing stamp on Nexus 7 tablet.

C. The Objectives of the Evaluations

We specified the evaluation items of the experiments as follows:

1) How provider-visitors learnt from the observations on exhibited items.

- Evaluate the difference in the observations and the learning effects of pre- and post-tests with Groups A and B between (T1) and (T3).
- Evaluate the difference in the observations and the learning effects of pre-, mid-, and post-tests with Grope B among (T1), (T2), and (T3).

2) How provider-visitors enjoyed the experiences:

- Evaluate how the provider-visitors enjoyed the proposed systems through the questionnaire analyses.
- Let provider-visitors specify the enjoyable points of the proposed system through questionnaire analyses.

D. Evaluation Methods

We use the following methods to carry out the evaluation:

1) Questionnaire Analysis

a) Viewing exhibits and learning effects: Multiple-choice and fill-in-the-blank questions were provided in order to determine how the participants learned from the exhibits. Group A answered two questionnaires, before and after the experiment. Group B answered three questionnaires: before, during, and after the experiment.

For the post-test questionnaire, the participants answered five questions (Q1 to Q5) with five-grade relative estimation.

Q1 and Q2 are related to viewing the exhibits, and Q3, Q4, and Q5 are related to the enjoyability:

Q1. Did you observe the exhibit carefully?

Q2. After the experiment, did you become more careful in observing the general printed information familiar with you and your neighbours?

Q3. Was it interesting for you to make your own descriptions of the exhibited items?

Q4. Was it interesting for you to use the stamp interface?

Q5. Do you like to participate in another similar event, if we would provide the Stamp-On/DT system?

E. Interview

After the questionnaire sessions, we have made oral interview sessions against randomly selected participants.

1) About viewing the exhibits: The interview consisted of the following questions: "Did you carefully observe the exhibits?', 'What were different points between your usual museum visits and this experimental observations on the museum exhibits?', 'What were different points between usual explanations of the exhibits and the digital contents you made?'

2) About enjoyment: The interview questions were as follows: 'Was it interesting for you to play with Stamp-On/DT?', and 'Was it fun to make your own digital contents?'

VI. FINDINGS OF THE MUSEUM EXPERIMENT

A. Discussion of the Experiments

1) Questionnaire Survey Results.

The answers to the questionnaire survey for Groups A and B are summarized in Table II. Table II depicts experimental results about pre- and post-tests. The sign testing method is applied. The results suggest that there are statistical differences with the 95% reliability. To Group B, we apply the Freedman Testing to pre-, mid-, and post-testing. The results also suggest that there are statistical evidences (Table III).

Table IV summarizes the response distributions. Most participants responded positively to all questions. We investigated the response trends after separating the responses obtained from the questionnaire surveys into two groups: positive responses, including 'completely agree' and 'agree', and negative responses, including 'somewhat disagree' and 'completely disagree'. Fisher's exact tests (1×2) showed a statistical significance at 95% level for all items.

TABLE II.   THE LEARNING EFFECT ON THE EXHIBIT

The fill-in-the-blank questions from related to the print.

Subjects No.	1	2	3	4	5	6	7	8	9
The pre−test (T1).	6	6	4	8	5	4	1	3	5
The post−test (T3).	15	14	16	18	13	10	8	9	7

p= 0.003906, (p<.05).   ↑ The number of correct answers

T1,T3 = states.

Four questions about the type of printing.

Subjects No.	1	2	3	4	5	6	7	8	9
The pre−test (T1).	1	0	1	0	0	0	1	0	2
The post−test (T3).	4	4	4	4	4	4	4	1	2

p=0.007812, (p<.05).   ↑ The number of correct answers

T1,T3 = states.

TABLE III.   TABOUT THE DIFFERENCES BETWEEN PRE-, MID-, AND POST-TESTING

The fill-in-the-blank questions from related to the print.

	The pre-test (T1).	The intermediate test (T2).	The post-test (T3).
SubjectsB1	6	8	15
SubjectsB2	6	10	14
SubjectsB3	4	6	16
SubjectsB4	8	9	18
SubjectsB5	5	10	13

Friedman chi-squared = 10, p=0.003906 (p<.05).

T1, T2, T3 = states.

Four questions about the type of printing.

	The pre-test (T1).	The intermediate test (T2).	The post-test (T3).
SubjectsB1	1	4	4
SubjectsB2	0	4	4
SubjectsB3	1	1	4
SubjectsB4	0	2	4
SubjectsB5	0	4	4

Friedman chi-squared = 8.375, p=0.01518 (p<.05).

T1, T2, T3 = states.

B. Results of Interview Survey

1) About viewing the exhibits.
- Participant A: I observed the exhibit carefully more than usual with the intention of preparing a quiz about it.
- Participant B: Commentary must be written to be easy to understand because it will immediately become the corresponding digital contents and will be shown to other participants. I observed the exhibit seriously to try to understand it properly in order to clearly make the contents.

TABLE IV.   RESULT OF OBSERVATION AND ENJOYABILIT

About Observation.

	5	4	3	2	1
Q1. Do you think you carefully viewed the exhibit? **	3	5	1	0	0
Q2. Do you think that you tried to more carefully view a printed item that is more familiar to you? **	3	6	0	0	0

**p<.05, 5=completely agree, 1=completely disagree.

About enjoyability.

	5	4	3	2	1
Q3. Do you think that it was fun for you to write a description of the exhibit? **	2	7	0	0	0
Q4. Did you think that it is fun to press a stamp? **	2	7	0	0	0
Q5. If there were another event of this type, do you think that you would want to participate? **	6	3	0	0	0

**p<.05, 5=completely agree, 1=completely disagree.

2) Utterlance of Enjoyable Aspects

- Participant A: I was impressed at the fact that just after making the quiz, it quickly became the corresponding digital content.
- Participant B: When I pressed the stamp, the immediate reactions the system made was quite interesting.
- Participant B: It was interesting to see the digital contents the other participants developed, because the contents gave me different others' perspectives on their focal points and explanations of the exhibits.

C. Summary and Discussion of Experiment Findings

Based on the questionnaire and interview results, the participants viewed exhibits more carefully with the proposed system than usual visits. All participants suggested that (i) it was pleasant to partake of the interview of the experiment, (ii) creating the digital content is much more interesting than making usual paper contents.

The experimental results have revealed that museum provider-visitors would observe exhibits more carefully than usual visits, if the provider-visitors could create quizzes about the exhibits. Furthermore, all participants have interests in the beautiful printing techniques, which curators of the museum usually use to make explanations of the exhibited items. Therefore, the participants have more interests in the various printings among them in the sense of color, styles, and materials.

When the nine participants used the Stamp-On/DT system at the same time, it was possible for them to produce 18 items of digital contents within 2 hours. These results have shown the superiority of the proposed system against prior digital contents research in the literature [11] on the points of the agility and non-professional support to produce the digital contents.

VII. ONLINE MANUAL

We develop web-based online manuals for the Stamp-On/DT system to extend users' community. The manuals describe how to make stamps and the explanation contents, and how to play with Stamp-On/DT. The manuals are available in the Stamp-On/DT website [21]. The web-site contains six movie files. The one is a summary video of the Stamp-On/DT system and the other five contain the instructions about the operation and usage (Figure 14).

A. The Topics of the Online Manuals

The explanation contents of Stamp-On/DT System are different from each other in various museums. As a typical example, in the manual, we deal with wooden materials, which are familiar to both developers and provider-visitors. As a result, a naïve user of the Stamp-On/DT system will make explanation contents to answer the kinds of various wooden materials. They are required to create three quizzes and correct and/or incorrect answers with drawings. Furthermore, they are required to prepare explanation contents referring to various internet and/or book information of the materials.

B. Videos

The video information of the manual contains the following six items:

1) The summary video of the Stamp-On/DT system.
2) How to download Zip files from the WEB site, then to print out the paper sheets in from the download file.
3) How to draw pictures on the specified paper sheets (Questions 1-3, Answers1-3, and Try again).
4) How to scan the paper sheets and save the resulting scanned image files to the PC (Question1-3, Answer1-3, and Try again).

The scan image files are clipped and saved to the "img" folder (Question1-3).

5) How to clip and save the scanned image files to 'img' folders (Questions 1-3, Answers 1-3, and Try again information).

6) How to install "Android transfer" and "File manager", then how to check both the correctness of image files and playing on Stamp-On/DT system.

That is, VIDEOs 4, 5, and 6 explain the details of how to digitize and edit the image data. In the museum experiment, the trained staffs digitalizes and edited the image data, however, with the web-based manuals the naïve user must digitalize and edit all the information by themselves.
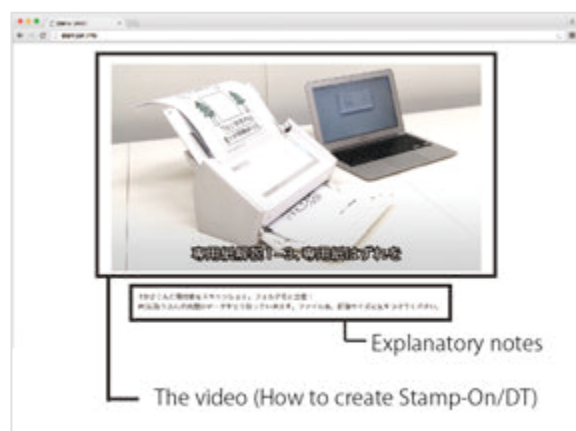

Figure 15. Subjects researches the book of wood.

Figure 16. Subjects drawing picture after checking in the book.

Figure 14. Stamp-On/DT WEB site.

VIII.   USABILITY TEST

The purpose of the usability test is to evaluate whether naïve users of Stamp-On/DT are able to develop the explanation information of Stamp-On/DT System by themselves without any experts assistances. For the purpose, we select five female student subjects from Tama Art University in order to let them develop the corresponding explanation materials with the web-based manuals. They are students of the information design course. Thus, they are able to use Photoshop and Illustrator. However, they are less skillful with the computer usage than students at the computer science course. All the subjects have a teacher-training course to be able to be schoolteachers in the future. The reason we choose the subjects are to evaluate whether the system are able to be applied to the development of digital educational contents in a classroom beyond museums explanations settings.
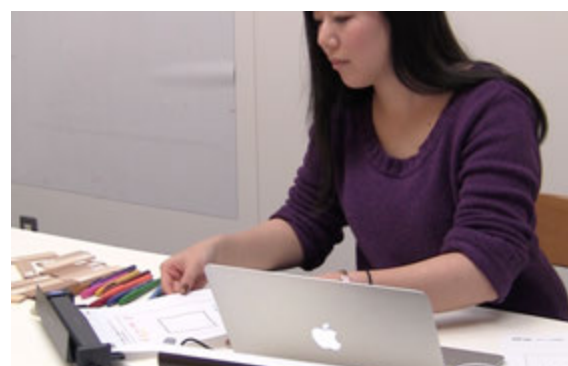

Figure 17. Subjects scaning the paper.

Figure 18. Subjects clipping the image.

Figure 19. The pictures which subjects painted.

A. Experimental Environment

The experiment continues a three-day period from January 13 to 15, 2016. The subjects are between the ages 20 to 23. The subjects have the teacher-training course. They do not know about the Stamp-On/DT system prior to the test. Of the subjects, the three are fairly familiar with using computers, whereas the rest two are not. The two of the subjects state they often use to image editing software, while the other three are not. The experiment is conducted one person at a time. We set cameras on the side and front of the subjects in order to capture the subject's actions, as well as the computer screen images. Prior to the experiment, the subjects are asked to fill out a survey. We also have interview sessions with them after the experiment.

B. The Criteria of the Evaluations

We evaluate the experiment using the following criteria:

1) Whether the subjects are able to create Stamp-On/DT system contents only referring the web-based information.

2) How long it takes for the subjects to create all of the digital contents. Which processes of the development will takes time. In which part of the development processes, the subjects have troubles.

3) Whether the subjects would like use Stamp-On/DT system to develop digital contents when they will become teachers.

C. Evaluation Methods

We evaluate the subjects whether they complete the assigned task, and if completed, we measure the time needed. After the experiment, we have additional interview sessions.

1) Tasks

We break the flow of usage of Stamp-On/DT system into 52 sub-tasks and we examined whether the sub-tasks are completed.

2) Time

Using video information, the time spent in each sub-task was measured.

3) Interview

After the experiment, we make oral interview sessions against randomly selected participants. The interview involved questions about how they feel when creating the given problem with the web-based manuals.

IX. FINDINGS OF THE USABILITY TEST

A. About the Tasks

Every subject shows successful completion of a given task in Table V. Following the steps shown in the videos in the manuals, the subjects are able to create contents without severe troubles. As a result, all subjects are able to display proper information to the screens. We evaluate the results with the following symbols: AA is very good. A is good, however, less than that of AA. B is not good. Next, we explain why tasks scored A or B occur.

Task 11: Subject 1, who is not familiar with the PC, makes a mistake to save the destination of the scanned data. This is caused by the fact that she does not follow the instruction of the manual, thus, we evaluate the operation is bad (B). But there is no problem in the end.

Task 14: Subjects 1 was lost the way to cutout the image for a while. We evaluate the operation is not good (B).

Tasks 27,31,35: Subjects 2 and 5 are not able to display the commentary screen because of their mistakes. In the image file name, they were not able to notice the difference between character o and number zero. For this reason, although they are able to display the results of tasks 49-51, they fail to display commentary screens. Therefore, the task49, 50 and 51 were evaluated as not good (A).

Such mistake happens because of improper fonts are used in the manuals and videos. Thus, the manual can be modified so that such small mistakes would not happen, again. By telling the subjects the correct file names, they properly manipulate all contents. For tasks 45-47, the stamp's reactions are also important. All subjects are able to load the corresponding digital contents without troubles. Finally, the subjects are able to enjoy interactive contents.

B. Time Measurements

Table VI shows the time required to complete each sub-task. All the subjects create their digital content to for a series stamp work within two hors. The time consuming sub-tasks are (1) to draw the contents information on a designated paper sheet, (2) to transfer the final contents to the terminals, and (3) check the all contents are properly plays. About (1), every subject takes time, while, about (2) some of the subjects must fix the transfer mistakes. Also, subjects without image editing experience encounter difficulty in cropping images.

TABLE V. TASK LIST AND RESULT

No.	Task Details	S1	S2	S3	S4	S5
1	Did she can download the Stamp-On3ver.zip	AA	AA	AA	AA	AA
2	Did she can print out the paper.	AA	AA	AA	AA	AA
3	Did she draw the question1?	AA	AA	AA	AA	AA
4	Did she draw the question2?	AA	AA	AA	AA	AA
5	Did she draw the question3?	AA	AA	AA	AA	AA
6	Was She able to draw the answer1?	AA	AA	AA	AA	AA
7	Was She able to draw the answer2?	AA	AA	AA	AA	AA
8	Was She able to draw the answer3?	AA	AA	AA	AA	AA
9	Did she can draw the screen of "Try again"?	AA	AA	AA	AA	AA
10	Did she can scan the papers?	AA	AA	AA	AA	AA
11	Did she can save the scan data at other than "img" folder?	B	AA	AA	AA	AA
12	Did she can create the "img" folder?	AA	AA	AA	AA	AA
13	To selected the image corresponding to 1.jpg and edited it.	AA	AA	AA	AA	AA
14	Was she able to clipping the 1.jpg?	A	AA	AA	AA	AA
15	Was she able to save as 1.jpg?	AA	AA	AA	AA	AA
16	Was she able to save the 1.jpg at "img" folder?	AA	AA	AA	AA	AA
17	To selected the image corresponding to 2.jpg and edited it.	AA	AA	AA	AA	AA
18	Was she able to clipping the 2.jpg?	AA	AA	AA	AA	AA
19	Was she able to save as 2.jpg?	AA	AA	AA	AA	AA
20	Was she able to save the 2.jpg at "img" folder?	AA	AA	AA	AA	AA
21	To selected the image corresponding to 3.jpg and edited it.	AA	AA	AA	AA	AA
22	Was she able to clipping the 3.jpg?	AA	AA	AA	AA	AA
23	Was she able to save as 3.jpg?	AA	AA	AA	AA	AA
24	Was she able to save the 3.jpg at "img" folder?	AA	AA	AA	AA	AA
25	To selected the image corresponding to 1OK.jpg and edited it.	AA	AA	AA	AA	AA
26	Was she able to clipping the 1OK.jpg?	AA	AA	AA	AA	AA
27	Was she able to save as 1OK.jpg?	AA	B	AA	AA	B
28	Was she able to save the 1OK.jpg at "img" folder?	AA	AA	AA	AA	AA
29	To selected the image corresponding to 2OK.jpg and edited it.	AA	AA	AA	AA	AA
30	Was she able to clipping the 2OK.jpg?	AA	AA	AA	AA	AA
31	Was she able to save as 2OK.jpg?	AA	B	AA	AA	B
32	Was she able to save the 2OK.jpg at "img" folder?	AA	AA	AA	AA	AA
33	To selected the image corresponding to 3OK.jpg and edited it.	AA	AA	AA	AA	AA
34	Was she able to clipping the 3OK.jpg?	AA	AA	AA	AA	AA
35	Was she able to save as 3OK.jpg?	AA	B	AA	AA	B
36	Was she able to save the 3OK.jpg at "img" folder?	AA	AA	AA	AA	AA
37	To selected the image corresponding to NG.jpg and edited it.	AA	AA	AA	AA	AA
38	Was she able to clipping the NG.jpg?	AA	AA	AA	AA	AA
39	Was she able to save as NG.jpg?	AA	AA	AA	AA	AA
40	Was she able to save the NG.jpg at "img" folder?	AA	AA	AA	AA	AA
41	The "img" folder contains the seven images.	AA	AA	AA	AA	AA
42	"img" folder has been overwritten with the same name.	AA	AA	AA	AA	AA
43	Did she can download the "android transfer"	AA	AA	AA	AA	AA
44	Was she able to install the android transfer.	AA	AA	AA	AA	AA
45	To copy the "img" folder by using "android tansfer" to Nexus7.	AA	AA	AA	AA	AA
46	Was she able to install the "File manager app".	AA	AA	AA	AA	AA
47	Display the content using HTML viewer of the file manager.	AA	AA	AA	AA	AA
48	The images was displayed without distortion.	AA	AA	AA	AA	AA
49	Was she able to play Q1.	AA	A	AA	AA	A
50	Was she able to play Q2.	AA	A	AA	AA	A
51	Was she able to play Q3.	AA	A	AA	AA	A
52	Was she able to play NG.	AA	AA	AA	AA	AA

TABLE VI. RESALT OF TIME MEASUREMENT OF EACH VIDEO.

Video No.*	S1	S2	S3	S4	S5
1	3min36sec.	2min42sec	2min49sec	3min02sec	3min10sec
2	7min04sec	9min10sec	8min13sec	6min20sec	5min02sec
3	46min24sec	29min26sec	14min11sec	27min17sec	41min17sec
4	20min49sec	19min23sec	21min46sec	28min08sec	17min43sec
5	21min22sec	10min37sec	12min40sec	9min53sec	5min57sec
6	12min21sec	29min43sec	19min17sec	37min06sec	19min05sec
Total	1h51min	1h41min	1h18min	1h51min	1h32min

* Video1 : The summary video of the Stamp-On/DT system.
* Video2 : Downloading of the Zip file and Printing out the paper from the download file.
* Video3 : Drawing on the paper (Question1-3, Answer1-3, and Try again).
* Video4 : Scanning the paper and saving to the PC. The scan files are clipped and saved.
* Video5 : The scan image files are clipped and saved to the "img" folder (Answer1-3, Try again).
* Video6 : Installing the two application. Checking the image files and Playing by the Stamp-On/DT.

C. Results of Interview Survey

• Participant A: Though it seems complicated at first, following the video makes it easy. It is actually enjoyable to move the images around.

• Participant B: I feel it important for me to search for information by myself in order to create digital contents. It is a good learning experience.

1) As a teacher candidate.

• Participant C: I think teaching contents by Stamp-On/DT system is immediately effective in an actual science class.

• Participant C: Another way of the usage, I think that it is fun and interesting for both of students and teachers to develop the contents together in the class of Information Study.

D. Discussion

According to the task analysis, to follow the instructions in the web-based manuals, most of the subjects are able to easily create their own contents. All subjects properly display the target information on the screens. However, two of the five subjects cannot open the instruction pages

because of mistakes on file names. This was the result of the font used in the video, as well as the lack of adequate explanations in the manuals. Both of these issues are able to be improved in the future. After we suggest to the subjects about the spelling error, they are able to manipulate the contents without a trouble. Also, the stamp interface works well without any troubles.

About the time required to the tasks, the most time-consuming sub-tasks are to draw the information on the problems and explanations on the designated paper sheet. The sub-tasks they tend to get stuck is to crop the images, when they have not used image editing software. The subjects that typed in the wrong file name spend more time to correct the error. At the interview after the test, the subjects claimed it was enjoyable. They mention the searching tasks to create contents are a good learning experience. They also mention that while it seems complicated at first, it is easy to develop the contents following the instructions in the video. Therefore, from the experiment, we conclude that, following the web-based manuals, even naïve users are able to make digital contents for stamp collecting activities.

X. CONCLUSIONS AND FUTURE CHALLENGES

This paper has described the design principles, functions, components, usages, and experiments on Stamp-On/DT system, which is a new extension of our Stamp-On [20]. Stamp-On/DT is a toolkit to let museum provider-visitors develop digital contents. The unique features of Stamp-On/DT are summarized as follows: (1) the digital contents of the corresponding explanation can be created by both provider-visitors and curators, (2) the contents are easily described with conventional web tools such as HTML, CSS or Java script, and (3) users are only required to save exhibited images in the same exhibited location with the same names. To validate the effectiveness of Stamp-On/DT system, we have conducted a workshop in a museum to let provider-visitors create digital contents and to have their performance evaluated. From the workshop experiments, we conclude that Stamp-On/DT is an effective, easy and interesting aid in understanding museum exhibits.

From the experimental workshop, we have suggested that i) Stamp-On/DT system is successful to create digital contents in a short time without professional assistances; ii) the participants observed museum exhibits more carefully than usual, and iii) the learning effects on the exhibits observation was also attained. When the digital contents developed by provider-users will be in real use, the curators will check the correctness, interestingness, and friendliness of the digital contents, again. Thus, the quality of the developed contents will be assured.

The proposed system will be further enhanced so that more kinds of tablet devices other than a Nexus 7 can be used in the proposed system. Also, we will prepare manuals and videos, and improve the stamp shapes so that even naïve users can use the stamps.

The other future work includes 1) the improvement of stamp performance, 2) the introduction of the other kinds of hardware devices to assist the usage, and 3) the improvement of manufacture the stamp development.

REFERENCES

[1] A. Ishiyama, S. Tokuhisa, F. Kusunoki, S. Inagaki, and T. Terano, " A Self-Made Personal Explanation Aid for Museum Visitors," Proceedings of The Seventh International Conference on Creative Content Technologies (CONTENT 2015), 2015, pp. 49-56.

[2] Y. Ohashi, H. Mashima, F. Kusunoki, and M. Arisawa, "Science Communication from Primary Learning Group to Secondary Learning Group by Adopting Voice Information [in Japanese]," Kagaku Kyoiku kenkyu (Journal of Science Education in Japan) Japan Society for Science Education, 2008, pp. 103-110.

[3] C. Cahill, A. Kuhn, S. Schmoll, W. T. Lo, B. McNallu, and C. Quintana, "Mobile Learning in Museums: How Mobile Supports for Learning Influence Student Behavior," Proceedings of the 10th International Conference on Interaction Design and Children (IDC'11), 2011, pp. 21-28.

[4] F. Kusunoki, T. Yamaguchi, T. Nishimura, and M. Sugimoto, "Interactive and enjoyable interface in museum," Proceedings of the 2nd ACM SIGCHI International Conference on Advances in Computer Entertainment Technology (ACE'05), 2005, pp.1-8.

[5] D. Raptis, N. Tselios, and N. Avouris, "Context-based design of mobile applications for museums: a survey of existing practices," Proceedings of the 7th International Conference on Human Computer Interaction with Mobile Devices and Services (MobileHCI'05), 2005, pp. 153-160.

[6] I. Rose, N. Stash, Y. Wang, and L. Aroyo, "A personalized walk through the museum: The CHIP interactive tour guide," Proceedings of the 27th International Conference Extended Abstracts on Human Factors in Computing Systems (CHI '09), 2009, pp. 3317-3322.

[7] T. Yamaguchi, F. Kusunoki, and M. Manabe, "Design of a System for Supporting Interaction in Museums and Zoos with Mixed Media," Journal of Science Education in Japan, 34(2), 2010, pp. 97-106. (in Japanese).

[8] K. Yatani, M. Onuma, M. Sugimoto, and F. Kusunoki, "Musex: A System for Supporting Children's Collaborative Learning in a Museum with PDAs," Systems and Computers in Japan, 35(14), 2004, pp. 54–63 (in Japanese).

[9] C.M. Medaglia, A. Perrone, M. De Marsico, and G. Di Romano, "A Museum Mobile Game for Children Using

QR-Codes," Proceedings of the 8th International Conference on Interaction Design and Children (IDC '09), 2009, pp. 282-283.

[10] B. Koleva, S. R. Egglestone, H. Schnädelbach, K. Glover, C. Greenhalgh, T. Rodden, and M. Dade-Robertson, "Supporting the Creation of Hybrid Museum Experiences," Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '09), 2009, pp. 1973-1982.

[11] M. Roussou, E. Kavalieratou, and M. Doulgeridis, "Children Designers in the Museum: Applying Participatory Design for the Development of an Art Education Program," Proceedings of the 6th international conference on Interaction design and children (IDC 2007), 2007, pp. 77-80.

[12] The British Museum Explore. http://www.britishmuseum.org/explore.aspx (accessed 2014-10-20).

[13] Louvre Online Tours. http://www.louvre.fr/jp/visites-en-ligne (accessed 2014-10-20).

[14] Google Cultural Institute. https://www.google.com/culturalinstitute/home?hl=ja (accessed 2014-10-20)

[15] Tohaku Navi. http://www.tnm.jp/modules/r_free_page/index.php?id=1467 (accessed 2014-10-20).

[16] e-Museum. http://www.tnm.jp/modules/r_free_page/index.php?id=168#e-museum (accessed 2014-10-20).

[17] M. Okumoto and H. Kato, "The Learning System Linking Pre-Visit and Museum Learning Materials [in Japanese]," Proceedings of Japan Society for Educational Technology 36 (1), 2012, pp.1-8.

[18] J. Nielsen, and T. K. Landauer, "A mathematical model of the finding of usability problems," Proceedings of ACM INTERCHI '93 Conference (CHI '93), 1993, pp. 206-213.

[19] W. Albert and T. Tullis, "Measuring the User Experience, Collecting, Analyzing, and Presenting Usability Metrics," Morgan Kaufmann, July, 2013.

[20] A. Ishiyama, F. Kusunoki, R. Egusa, K. Muratsu, S. Inagaki, and T. Terano, "Stamp-On: A Mobile Game for Museum Visitors," Proceedings of 6th International Conference on Computer Supported Education (CSEDU 2014), 2014, pp. 200-205.

[21] Stamp-On/DT. http://stampon.info/ (accessed 2016-2-20)

[22] S. E. Ozimek, "Museum Visitors' Perceptions of Mobile Games: A Case Study," Thesis, Rochester Institute of Technology, 2014.

[23] I. Rubino, C. Barberis, J. Xhembulla, and G. Malnati, "Integrating a Location-Based Mobile Game in the Museum Visit: Evaluating Visitors' Behaviour and Learning," Journal on Computing and Cultural Heritage (JOCCH) Volume 8 Issue 3, 2015, Article No. 15.

[24] N. Yiannoutsou and N. Avouris, "Mobile games in Museums : from learning through game play to learning through game design," ICOM Education, vol. 23, 2012, pp. 79-86.