Musex: A System for Supporting Children's Collaborative Learning in a Museum with PDAs

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Abstract

Using handheld devices in educational environments has begun to be recognized as suitable. Due to the drastic revisions in Japanese curriculum standards for elementary school children, new theories, systems and practices to support children in their learning are required. Therefore, we focused attention on science museums, which are different learning environments from schools. In this paper, we propose a system called Musex, which is used to support children in learning and exploring collaboratively in a museum with two PDAs (Personal Digital Assistants). Through Musex, children can collaboratively challenge some questions which are related to exhibitions. Solving the questions let children pay their attention to exhibitions naturally and understand contents of exhibitions more. We evaluated the system in a Japanese science museum and confirmed its effectiveness.

1. Introduction

Handheld devices such as PDAs (Personal Digital Assistants) or Palms™ have some advantages compared to PCs, for example cheapness, mobility. Some recent researchers indicate that handheld devices can serve children not as organizational tools but as "ready-at-hand" tools, or tools to support children's learning activities[14]. It is highly expected that handheld devices will play an important role in children's learning.

In Japan, due to the drastic revision of National Curriculum Standards, *Integrated Courses* have been established in all elementary schools to further promote each school's unique educational activities. Elementary schools are required to devise interdisciplinary and comprehensive studies in Integrated Courses to achieve this goal. In order to meet this requirement, elementary schools have great interest in science museums, which provide different styles of learning from ones in schools.

Science museums seem to provide children with an ideal environment for this new learning style. However, several problems on science museums have been pointed out by school teachers and children. For example, some exhibitions in science museums are very popular for children, but some are not. Exhibitions which are not popular are often less-interactive, such as simple explanatory panels or VTRs (Video Tape Recorders), though they are very valuable educational materials. One approach to make these exhibitions more attractive to children is to redesign them for enhancing their interactivity. However, this approach often needs unaffordable costs for museums.

An orienteering game is one of the most popular educational activities in Japan. In an orienteering game, children are divided into pairs or teams in outdoors such as large parks or forests. The objective of this game is that they visit the points marked in the map in order as fast as possible. At each point, they are given a task such as answering a question, or playing a game. The challenge is usually related to educational topics. (for example, find out broad leaf trees and these names around here) When they complete the task successfully, they can get a direction to the next point. This kind of activities is mainly used in an outdoor, so we can apply this idea to children's explorations in science museums.

Children usually visit science museums with their parents, brothers, sisters, and friends. They explore museums together as they sometimes talk or discuss about exhibitions. This kind of discussions sometimes enhances their own experience in the museums. For example, in [15], it is shown that some kinds of child-parent interaction help children's learning and discovering activities. We think similar effects will occur not only between parents and children, but between children.

In this paper, we propose a system called *Musex*. Musex is used by a pair. Through a PDA, each child can challenge 13 questions which are related to exhibitions. Solving the questions let children pay their attention to exhibitions naturally and understand contents of exhibitions more. Their PDAs also support their partners' awareness visually and they can communicate with each other through transceivers so that children can solve questions collaboratively. We also made a website which reflects users' histories of answering the questions to review their performance and make further learning.

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In the section 2, we refer to some precedent works that are related to our project. The system architecture of Musex is presented in the section 3. We present an experiment of Musex and the results in the section 4 and 5, and make discussion about Musex in the section 6. Finally, in the section 7, we present a conclusion and a future work on Musex.

2. Related Works

There are several researches that brought handheld devices into a classroom[4, 9]. In WISE project[13], Palm Pilot technology is integrated into WISE inquiry curriculum to facilitate students' inquiry activities. In [12], it was examined how field laboratory experiences could be enhanced by using handheld devices as tools for a data collection.

Some systems have been proposed in order to construct collaborative learning environments with handheld devices. In [5], using small, communicating computers called Thinking Tags, students spontaneously participate in infectious disease simulations. In a similar way, Geney™ supports students in collaboratively exploring genetic concepts through the use of Palm™devices and a central PC[6]. And inspired by the concept of folklore, Folk Computing supports face-to-face communication and co-present community building[3]. These systems open up the potential for effectiveness of handheld devices in educational environments.

When it comes to handheld devices in science museums, several related predecessors also exist. These predecessors mainly focus on ubiquitous computing[1]. Recently, one research verified how a ubiquitous system can contribute to the enhancement of visitors' experience in an aquarium or a museum[2, 7]. These projects have investigated the use of handheld devices as guidance tools, but not as assistants of children's learning.

Systems which apply handheld devices to CSCW in a variety of locations or situations have also been proposed[10]. Several of them are supposed to be used in a museum. For example, Grinter et al. proposed Sotto Voce, which provides a collaborative portable audio guidance system in a museum. In [8], they discussed about users' activities and effectiveness of their awareness when Sotto Voce were used by pairs of visitors. Musex is different from Sotto Voce in a few points, such as aiming at supporting children's learning activities and realizing awareness by visualization in PDAs.

As noted above, there are few precedents which aim at enhancing children's learning activities through exploring a museum with handheld devices. Considering all the various factors together, including what will be needed for future education in elementary schools in Japan, we set our goal on building a system to support children's learning in a science museum.

3. Method

3.1. System Architecture

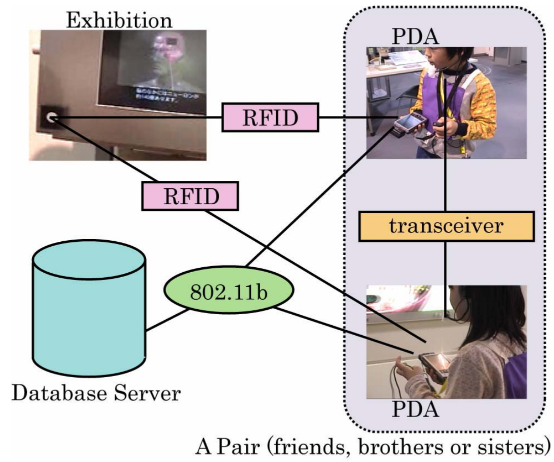


Figure 1. System Overview

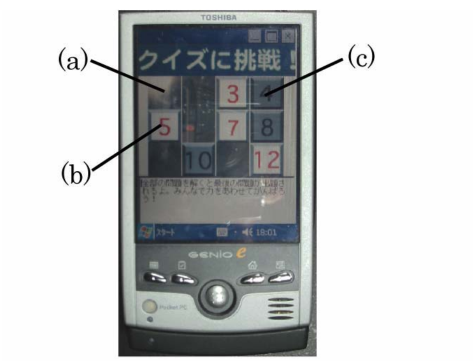
Figure 1 shows the system overview of Musex. Musex is used by a pair, such as brothers, sisters or friends. Each user is given a PDA and a transceiver. An RFID (Radio Frequency Identification) tag reader/writer and a wireless LAN card are installed in each PDA. An RFID tag is also installed in each exhibition. Each tag has an ID number that is uniquely allocated to each exhibition.

An RFID tag reader/writer is installed in a PDA so that it can read an ID number from the tag when a user lets his/her PDA close to the tag. When his/her PDA reads the ID number from the tag, it requests the server to send the corresponding question data. After the completion of receiving data, the question and the four choices appear which are shown in Figure 2.

The user reads the question carefully, and touches one of the four buttons in the bottom of the screen to select his/her answer. His/Her PDA then sends his/her answer to the server. The server logs his/her answer, and returns the correct answer data. If the answer is correct, the "Correct Answer" screen is shown, otherwise, the "Wrong Answer" screen is shown. In both cases, the explanation of the question is also shown so that the user can review the question at hand.

Figure 3 is the main screen of PDAs. The picture in the center of the screen is divided into 12 pieces. This picture is the key of the final question. Initially, the picture was covered with 12 white squares with numbers. If a user answers correctly, the white square where the number of the answered question is written is removed, and a part of the picture appears. If the user can not answer correctly, the white square will change to the gray one, and the user can't see this part of the picture. In order to finish the game, users have to answer the final question correctly by viewing the picture covered with the square. Users are motivated to answer correctly as many questions as possible in order to be able to see this important hint more clearly. It is expected that, therefore, users' engagement in solving questions will increase.

Figure 2. Screens of PDAs (left: question screen, center: correct answer screen, right: wrong answer screen)



(a) White panel: Not answered yet
(b) A part of the picture: Answered correctly
(c) Grey panel: Answered wrongly

Figure 3. The main screen of PDAs

Pairs' PDAs are linked to each other, and each pair shares each other's history of answering the questions. For example, if a user answers correctly, both users can see the part of the picture which the same number of the question is allocated. But, if one user answers wrongly, both users can't see the part of the picture. The hidden picture is different from the one in the partner's PDA, though these two pictures are related to the same exhibition. When one user answered a question, regardless of whether he/she answered correctly or wrongly, the pair can't challenge it again.

Through this screen, a pair can know each other's status. For example, by seeing one of the panels change, they can know whether the partner has answered correctly or wrongly. Or by seeing the pace of change, they can guess that the partner is challenging the questions continuously or that the partner is thinking them carefully. Such visualization as Figure 3, therefore, helps not only enhancing users' engagement in solving questions but supporting awareness between a pair, and then it is expected that more communication and collaboration will occur.

To talk with each other, two transceivers with headsets are given. Both users can talk or discuss about questions through their transceivers anytime and anywhere.

We also prepare a website for children to review their performance. After finishing all the questions, children will be given their own cards. An ID number is written in each card for the identification on the website. Therefore, children can revisit their explorations through a web browser after coming back to their home.

3.2. Design Principles for questions

We discussed about the design principles for exhibition-related questions with staffs in National Museum of Emerging Science and Innovation[11], where the experiment was held. As a result, we determined that (1) the difficulty level would be for elementary school students, (2) questions would contain the most important content about each exhibition, (3) answers are written in or can be guessed from exhibitions, and (4) we would provide questions to exhibition that are less unwatched but valuable for children's learning activities. In the experiment, we set up 13 questions (12 normal questions and one final question). There is no order for the questions, so children can challenge the questions in any order. There is also no time limit for each question and participation so that children can think about the questions and the exhibitions more deeply. Therefore, children can explore exhibitions and answer the questions at their own paces.

4. Experiment

Age	Number
Up to 5	4
6 to 9	21
10 to 12	10
13 to 24	0
25 to 34	3
35 to 44	6
Over 45	6
Total	50

Table 2. Age distributions of the participants

We evaluated Musex in National Museum of Emerging Science and Innovation in November 2002. 25 pairs (35 men and 15 women) participated in this experiment. 13 pairs are parent-child pairs, and 12 are brothers or friends pairs. They knew this experiment from posters or announcements in the museum, and they didn't know about us and our system. The age distributions of the participants are shown in Table 2.

We instructed children how to use PDAs and transceivers when they challenged a question for the first time. This instruction was not included any answer or hint on the questions. Children's activities were videotaped and questionnaires were filled out after their explorations. We also gave each child a card where an ID number for the website was written.

5. Results & Discussions

Through the experiment, we discovered several features of Musex. We will discuss about them by dividing into three kinds of interaction, interaction with users (especially children) and Musex, interaction with users and exhibitions and interaction between users. We also discuss about several points of Musex that should be more improved.

5.1. Interaction with users and Musex and with users and exhibitions

We list up several features of Musex by observing how users interacted with their PDAs or exhibitions.

- By using PDAs, children interacted with less interactive exhibitions: We observed that children looked at their PDAs and exhibitions alternatively and they reviewed their answers. Musex induced this kind of interaction, and children could pay their attention to less interactive exhibitions more naturally. Moreover, children interacted with exhibitions in front of them. For example, children traced explanations or pictures on the exhibitions with their finger. This kind of activities shows enhancement of children's engagement in less interactive exhibitions.
- Children explored more proactively: Except the case in that accidents occurred in their PDAs and users couldn't continue their explorations, nobody hanged up his/her exploration. Most children challenged the questions proactively. Even some children wanted to explore with Musex again after finishing their explorations.
- After their explorations, children revisited their explorations through the website: Some children visited the website and took a look back on their performance after their explorations in the museum. Therefore, there are some possibilities to support children's learning activities and learn more knowledge not only in a museum but also after visiting a museum.

5.2. Interaction between users

Next, we describe several unique interactions between users in Musex.

- Sharing the questions: One girl said to her partner through her transceiver, "I got No.5!" When her partner knew the partner's success, he tried to find a question except No.5. Another pair tried to find the questions collaboratively as they said with seeing their PDAs, "No.4, 7 and 10 are finished. So, we have to answer questions except them." Most pairs shared the questions by seeing the main screens of their PDAs or communicating through their transceivers.
- At the attempt at the last question, pairs collaboratively tried to find out the related exhibitions and answer correctly: Most pairs challenged the final question collaboratively. Some pairs met each other at first and then explored the related exhibitions together. Or some tried to find them individually as they sometimes communicated with each other through their transceivers. They also discussed about the final question in order to find the correct answer.
- Asking the partner for help: Some pairs, especially parent-child pairs, ask their partners for help when they met some troubles in their explorations. For example, one boy asked the partner (i. e., his parent) for help when he met unreadable kanji characters or felt difficult to solve questions by himself. They communicated through their transceivers at first, but if they couldn't make much progress, they met and tried to solve the questions together.
- Knowing the partner's status from the PDA: When they saw the picture, they could confirm their answer activities, but they also could know what numbers of the questions the partner challenged. For example, a mother whose daughter participated in the experiment said to her daughter, "Oh, sayaka-chan (her daughter's partner) has answered such many questions," as they looked at her PDA together. Then, her daughter said, "I've also answered so many!" It is interesting that they could communicate through not only their transceivers but also their PDAs.

5.3. For improvement of Musex

We also discovered about several points of Musex to be more improved.

- Some children skipped the comments of the questions: As shown in Figure 2, the comments of the questions were given children in text. Some children had tendencies to skip these comments. Enabling children to review their challenges on the spot is one of the characteristic advantages of Musex, and reviewing is an important learning activity. Therefore, some improvements for motivating children's reviewing are needed.

- Some children were puzzled by kanji characters: Some children, especially young children, couldn't read kanji characters which were used in exhibitions or PDAs. In this experiment, however, when children met difficult kanji characters, they asked the partner, their parents or staffs to show the readings of them, and they continued their challenges. It is interesting that children challenged the questions proactively even if they sometimes had difficulties.
- Some children couldn't use their transceivers enough well: All children understood how to use their PDAs easily, but some children couldn't understand how to use their transceivers. One of the reasons was that we used half-duplex transceivers which were not familiar to children. However, though they couldn't communicate with each other through transceivers, they could continue their explorations collaboratively because their awareness was supported by their PDAs.

6. Conclusions and Future Works

In this papar, we proposed Musex, which supported children's collaborative learning in a museum. Through the experiment, we confirmed that through Musex children are given opportunities to pay more attention to less interactive and less attractive exhibitions. We also confirmed that Musex is an effective system in enhancing children's engagement with learning activities. Moreover, visualization of users' status in PDAs supports awareness and interaction between users.

Through the experiment in the museum, we also found out that staffs in museums want to have more opportunities to communicate with visitors so that visitors can deepen their understanding of exhibitions. Explanations provided by staffs are described in plain words in face-to-face situations. Therefore, their explanations would be useful for children's learning activities and a system that supports interaction between children and staffs would be also useful. For example, we can add Musex to a function that enables children to ask staffs about questions, comments and exhibitions directly.

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8. References

[1] Abowd, G. D., Atkeson, C. G., Hong, J., Long, S., Kooper, R., and Pinkerton, M., "Cyberguide: A mobile context-aware tour guide," *Wireless networks*, vol. 3, no. 5, pp. 421-433, October 1997.

[2] Bellotti, F., Berta, R., Gloria, A., & Margarone, M, "User testing a hypermedia tour guide," *Pervasive computing*, vol. 1, no. 2, pp. 33-41, April 2002.

[3] Borovoy, R., Silverman, B., Gorton, T., Klann, J., Notowidigdo, M., Knep, B., and Resnick, M., "Folk computing: Revisiting oral tradition as a scaffold for co-present communities," *Proceedings of CHI*, pp. 466-473, Seattle, Washington, United States, March 2001.

[4] Chang, C., and Sheu, J., "Design and implementation of ad hoc classroom and eSchoolbag systems for ubiquitous learning," *Proceedings of WMTE*, pp. 8-14, Växjö, Sweden, August 2002.

[5] Colella, V., "Participatory simulations: Building collaborative understanding through immersive dynamic modeling," *The journal of the learning science*, vol. 9, no. 4, pp. 471-500, October 2000.

[6] Danesh, A., Inkpen, K., Lau, F., Shu, K., and Booth, K. (2001). Geney: Designing a collaborative activity for the palm handheld computer. *Proceedings of CHI*, Seattle, Washington, United States, 388-395.

[7] Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., and Spasojevic, M., "From informing to remembering: ubiquitous systems in interactive museums," *Pervasive computing*, vol. 1, no. 2, pp. 13-22, April 2002.

[8] Griner, R. E., Aoki, P. M., Hurst, A., Szymanski, M. H., Thornton, J. D., and Woodruff, A., "Revisiting the visit: understanding how technology can shape the museum visit," *Proceedings of CSCW*, pp. 146-155, New Orleans, Louisiana, United States, November 2002.

[9] Jipping, M. J., Krikke, J., Dieter, S., and Sandro, S., "Using handheld computers in the classroom: Laboratories and collaboration on handheld machines," *Proceedings of SIGCSE*, pp. 169-173, Charlotte, North Carolina, United States, February 2002.

[10] Luff, P., and Heath, C., "Mobility in collaboration," *Proceedings of CSCW*, pp. 305-314, Seattle, Washington, United States, November 1998.

[11] National Museum of Emerging Science and Innovation, http://www.miraikan.jst.go.jp/

[12] Rieger, R., and Gay, G., "Using mobile computing to enhance field study," *Proceedings of CSCL*, pp. 215-223, Tronto, Ontario, Canada, December 1997.

[13] Slotta J. D., Clark, D. B., and Cheng, B., "Integrating palm technology into WISE inquiry curriculum: Two school district partnerships," *Proceedings of CSCL*, pp. 542-543, Boulder, Colorado, United States, January 2002.

[14] Soloway, E., Norris, C., Blumenfeld, P., Fishman, B., Krajcik, J., and Marx, R., "Handheld devices are ready-at-hand," *Communications of the ACM*, vol. 44, pp. 15-20, 2001.

[15] Stanton, D., O'Malley, C., Hui, Ng, K., Fraser, M. and Benford, S., "Situating historical events through mixed reality," *Proceedings of CSCL*, pp. 293-302, Bergen, Norway, July 2003.