Evaluation of the New Outdoor Study Scheme Using Mobile Phone Based on the Zeigarnik Effect

Yuko Hiramatsu[1(✉)], Kumiko Kanbayashi[2], Atsushi Ito[3], and Fumihiro Sato[1]

[1] Chuo University, 742-1 Higashinakano, Hachioji, Tokyo 192-0393, Japan
{susana_y, fsato}@tamacc.chuo-u.ac.jp
[2] Kyowa Exeo Corporation, 3-29-20 Shibuya, Shibuya, Tokyo 150-0002, Japan
k.narita@isd.exeo.co.jp
[3] Utsunomiya University, 7-1-2 Yoyo, Utsunomiya, Tochigi 321-8505, Japan
at.ito@is.utsunomiya-u.ac.jp

Abstract. Many devices using ICT seem to bring students much information. They look up a lot of information and feel as if they already know the places or things using their PC. However, it is not all of the objects or is much for students to select high quality ones. Some cannot find interesting points among too much information. On the other hands, human beings take an interest in uncompleted or interrupted tasks. Using this human disposition, we create new application for outdoor studying in order to make some remarkable points using the Zeigarnik Effect. A little lack of information becomes a trigger to their interesting study. According to the effective results of our trials, we put it to practical use. In addition, we verified the safety mobile phone's usage during walking by EEG measurement for practical application.

Keywords: Outdoor study · Application · Mobile phone · Zeigarnik effect · BLE beacon · EEG measurement

1 Introduction

Many devices provide information through information and communications technology (ICT). Using Internet, ordinary life style expands into sightseeing areas by some navigation, SNS etc. Such information makes tourists safety. However, Some attractive points of the travel are beyond the ordinary life. Visiting unknowing place or finding new things makes us pulsate. It is a new experience. Therefore ICT always does not make trips attractive to people.

In addition, information on traditional themes information is not so enough. There is a huge numbers of information. However, many of them are written by new tourists who don't know the place well.

In Japanese schools, history and nature learning is supplemented by several day trips, which provide a more positive learning experience than the classroom. For this purpose, 87.3 % of junior high schools allow students to walk around the area by themselves in small groups [1]. Prior to the trip, students study the visited area in the

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classroom using books and the Internet. However, they find more information than what can be processed and remembered, and often fail to extract the important information. As a result, their interest may be diminished when visiting the area.

To overcome this problem, we have developed a new learning model for outdoor studies based on the Zeigarnik effect [2], i.e., the positive effect of incomplete or interrupted tasks on human interest. This paper examines our learning model for outdoor study, our original application system, and the practical evaluation of the system in outdoor trials.

To gratify teachers and parents, who are responsible for students' safety, we must also verify the safety functionality of the device. The learning tools are selected by teachers and purchased by parents. Therefore, the device must not only satisfy the students but also include safety functions that reassure teachers and parents.

We focus on two applications of our model. One is a Bluetooth low energy (BLE) Beacon system in Nikko, the world heritage site in Japan. And the other is an application using GPS. Both applications exploit the Zeigarnik effect. Section 2 of this paper presents some essential background, and Sect. 3 discusses related works. Sections 4 and 5 present our original system and the results of three trials, respectively. The third trial evaluates the safety of using a mobile phone while walking, and is accompanied by electroencephalography (ECG) measurements. In the concluding section, we discuss the effectiveness of our scheme as an outdoor learning tool and further issues of mobile studying.

2 Background

2.1 Mobile Phone Usage by Children in Japan

Japan's Ministry of Internal Affairs and Communications has stated the importance of incorporating ICT into the learning environment. When used effectively, the distinctive features of ICT are expected to foster the required abilities of children living in the 21st century, a period of drastic changes [3]. Governmental guidelines were enacted and digital contents and instruments are now being integrated into school curricula.

On the other hand, to halt the rising incidence of mobile phone crimes, the Ministry of National Education stipulated in 2009 that children should not bring mobile phones to school [4]. This rule remains valid in 2015. There are over 1 million mobile phone subscribers in Japan. According to the Internal Affairs Ministry of Research (2015), 94.5 % of Japanese households have mobile phones and 67.4 % of households have smartphones. Smartphones are especially popular among the younger demographic. 94.1 % persons from 20 to 29 years old have smartphones and 68.6 % persons from 10 to 19 years old have their own smartphones [5].

As an ICT instrument, the mobile phone is considered to be of dubious value [6]. Whereas the use of digital textbooks and tablets is encouraged, the use of smartphones is disfavored for several reasons. Therefore, despite being the most familiar ICT instrument, smartphones are not being used for learning in schools.

However, students sometimes contact their teachers through mobile phones during outdoor study. Before visiting the area, students learn the history, art, architecture and special features of the area in the classroom. Students conduct Internet searches on the

area through their personal computers, and record the important points in their note-books. They might create a leaflet for the school trip. When visiting the area, they are provided with a map and the leaflet, but they seldom consult this documentation. Students bring their mobile phones for emergency contacts.

After the large 2011 earthquake at Fukushima, Japan, many parents hoped that their children's schools would allow mobile phones with GPS during the school trip. Telephone numbers, e-mail addresses and location technologies on mobile phones provide essential information in disasters. However, such specialized use means that mobile phones are merely safety boxes while students are in school. We propose that mobile phones not only ensure students' safety, but could also enhance their formal learning.

3 Related Works

In 2009 the Ministry of Education, Culture, Sports, Science and Technology (MEXT) issued a notification forbidding school children to take mobile phones to elementary schools in Japan.

In a randomized study called Project ABC, Aker and co-authors investigated the effectiveness of mobile phone learning in Niger, Africa [7]. Besides the experimental results, they discussed the price and mobility of mobile phone learning. The results suggested that mobile phones can serve as an effective and sustainable learning tool. However, the study subjects were adult students rather than children.

Many schools have adopted tablets as a learning tool. For example, all secondary school students in Saga Prefecture (Japan) are required to use tablets. Some elementary schools in Takeo (a city of Saga Prefecture) have also introduced tablet learning [8].

We suggested that 21 skills can be acquired by mobile phones, the most popular instruments [9]. Mobile phone learning can be especially effective in outdoor study [10]. The present paper is a continuation of this study.

Evidence of the Zeigarnik effect was reported by Schiffman and Greist-Bousquet in 1992 [11]. The subject has also been studied from an environmental psychology and tourism perspective. Pearce and Stringer [12] investigated the Zeigarnik effect in physiology, cognition and individual variation. Similar studies were conducted by Fridgen [13], van Raaij [14], and Sasaki [15]. Sasaki proposed that a trip can be divided into 3 scenes: before the trip, during the trip, and after the trip [15]. Our new system focuses on the experiences before and during the trip.

4 Our Research and Original System for Outdoor Studying in the School Trip

4.1 Our Research About ICT Instruments at Junior High School and High School in Tokyo Area

We questioned teachers on the use of ICT instruments in junior and senior high schools in the Tokyo area, Japan. From 10th to 18th February, 2015, we disseminated questionnaires to 300 schools and received responses from 85 teachers (response percentage

28.33 %) and valid responses are 83. According to the results of these questionnaires, we found some characteristic points.

(1) During ordinary lessons
Teachers considered that ICT instruments should be used in classroom lessons. However, 42.17 % of the respondents felt uneasy about using ICT instruments in their own classes. PCs and projectors are the main learning tools at present, but many teachers would adopt digital texts and tablets for classroom learning. Despite the governmental guidelines, tablets were used by only 20.48 % of respondents. Some of the teachers, while understanding that ICT instruments will become mandatory learning tools in the near future, reported on the poor quality of ICT contents. Some teachers regarded paper and pencils as the best current learning implements, and did not feel competent in making ICT contents. Mobile phones are prohibited in public junior high schools, but are permitted in some private schools outside of class hours (for family contact purposes only).

(2) During outdoor study (school trips)
Neither teachers nor students do not use tablets at all on school trips. However, 59.04 % of the schools permit students to bring their mobile phones (future phones or smart phones) on the school trips, in order to contact to teachers when they walk around the area with 4–6 persons.

4.2 Our Original System for Outdoor Studying on the School Trips

Our aim is to develop an active learning system for students. ICT instruments inclosing smartphone are important tools to live in the 21th century. Students must appreciate the strengths and weaknesses of smartphone use.

According to our questionnaire results (Sect. 4.1), the majority of students take mobile phones on their school trips. Therefore, we considered that our mobile phone-based system would be widely accepted during school trips. Our system is described below and summarized in Fig. 1.

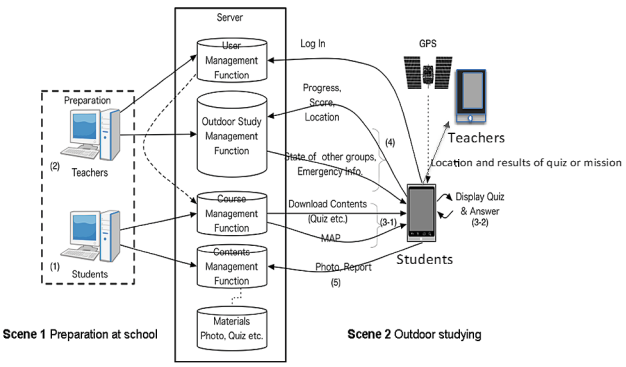

Fig. 1. Overview of our outdoor study system

There are 2 main scenes: before the trip and on the trip. Students prepare for their outdoor studies as an incomplete experience. Before the trip, they learn the history and specific arts in the area and prepare quizzes for their classmates on their PCs. The prepared quizzes are unknown to the other students. In other cases, teachers prepare missions for the students and inform them that the tasks will be completed at the visited site. Such incomplete experiences rouse human interest in the topic. One version of the Zeigarnik effect maintains that completed tasks are less well recalled than uncompleted tasks. Whereas some engineers have created detailed navigation systems for trips, we deliberately exploit the Zeigarnik effect to create incomplete experiences for students. During the trip, students undertake tasks using their smartphone or tablet. In addition, teachers can easily locate the students. The sense of safety of teachers is an important aspect of the system in practical use.

We created this system (Fig. 1). Then Kyowa Exeo Inc. attempted to create such system in practical stage. We collaborated this company and continued researches. In addition, we made a quiz course in the application of SCOPE (Strategic Information and Communications R&D Promotion Programme) project [16] in Nikko.

5 Trials Using the System

5.1 The Trial at a High School in Hawaii

(1) Summary of the trial
We had a trial with tablets at a high school class using new application by Kyowa Exeo Inc. In this application, the moving information of the present position can is captured by GPS accessible via the Internet. Students (n = 29) ordinary used tablets in their class and were issued with questionnaires before and after using the system. The functions of the application were map, mission, quiz, photo, video and chat.

- Before the school trip (November 2014)

Students learned about Hawaii and input their walking root by each group. In addition they tried to walk around the school using the application. Finally, they answered the first questionnaire.

- During the trip to Hawaii (December 2014)

Completing the missions specified in the application, students walked for half a day in Hawaii.

- After the trip (December 2014)

Students answered the second questionnaire.

(2) Results of questionnaires
The questionnaire results were evaluated on four-level scales. The missions and quizzes yielded very interesting results. Students favorably anticipated the mission and quizzes before the trip (3.1). After the trip, their evaluations were lower than before (2.9), but many of the students recorded their interest in the mission and

quizzes in their free comments. The contents of the missions and quizzes in the Hawaii trip may not have fully engaged the students, although the functions were interesting and they would like to write comments freely. These results suggest that we should reconsider the contents of the mission and quizzes.

Students rated Map high in Hawaii, too. Map with direction made students at ease in the first visiting place. Comparing before and after the trip, they enjoyed the application more in Hawaii. However, group cooperation was lower during the trip (see Fig. 2).

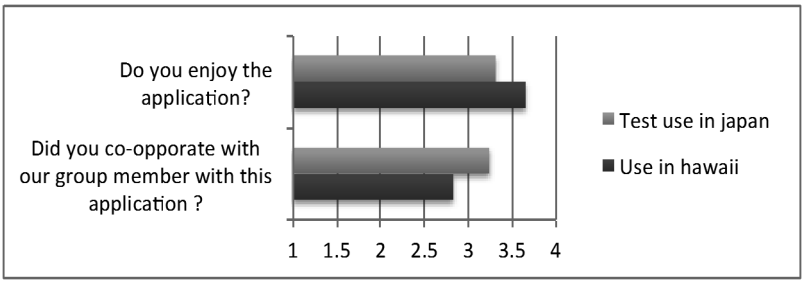

Fig. 2. Example of evaluations before and after the Hawaii trip

After the school trip, 26 students (90 %) assessed the application as useful. Although 16 students did not anticipate special use of the application before the trip, 28 students (96 %) answered that they would use this application again after the trip, and 28 students would highly recommend its use to juniors. However, some students and one teacher reported that the tablet was overly large and heavy.

5.2 A Trial in Nikko, the World Heritage Site in Japan

We implemented another trial in Nikko, a world heritage site in Japan. Setting BLE beacons on the poles by the roadside, we constructed course quizzes and applied them on iPhones on September 26–27, 2015. An application screen and a BLE beacon on a roadside pole are presented in Figs. 3 and 4, respectively. This system is designed not only for Japanese students but also for foreigners with limited access to Wi–Fi. The application can be installed at Wi–Fi-providing hotels and cafés, enabling its use without the Internet (see Fig. 5).

Twenty-eight students participated in the trial. Twenty-three students were required to complete 10 quizzes on the road, whereas 5 students walked without the application for comparison. Before looking at some important objects, students were provided with quizzes on the nearby locality, which they answered by viewing objects at the sites. Memory is thought to be largely visual [17]. Therefore, besides answering the questionnaires, students were requested to draw a map and to check some points on the map.

After the walking exercise, students answered the questionnaires and drew their maps of the area [18]. The answers of the application users were more concrete than those of the 5 students not provided with the application. On average, the application

Fig. 3. Beacon on a pole

Fig. 4. Map and quiz screen of the application

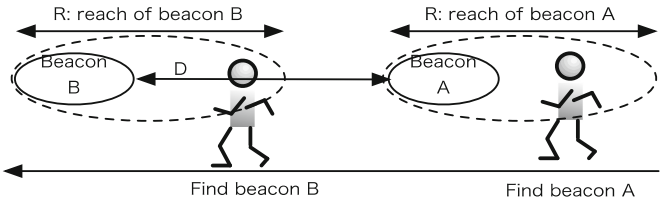

Fig. 5. Distance between beacons

users placed 9.18 objects on the map from the station to the shrine, whereas the non-application participants placed an average of 5.80 objects. The application users tended to remember not only the answers to the quizzes but also the shops around the beacons where they answered the quizzes.

After one month, the same students answered another questionnaires and checked 3 points in each photograph of the area walked in Nikko. We then constructed heat maps from the students' checks.

Figure 6 is a heat map of the way to the main shrine in Nikko. Architectures on the road were scarcely recalled by the students. Students recognized the street as the way to the main shrine and examined the local signs. A small BLE beacon, on which no letters were visible in the photograph, was remembered by the students. For comparison with

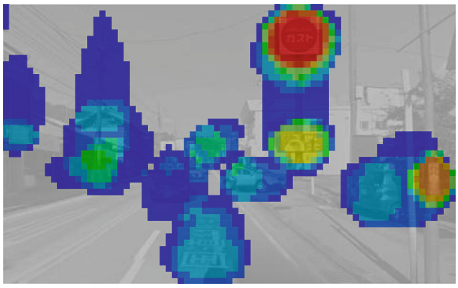

Fig. 6. A heat map on the way to the main shrine (by application users)

users viewing the same photographs without having visited the area, we also recruited unrelated third parties (n = 19). The heat map of the unrelated subjects exhibited no warm areas on the way to the main shrine.

As shown in Fig. 7, students noticed the architectures in the shrine, especially the upper right section, which was quizzed in the application.

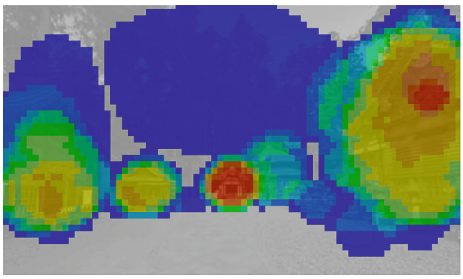

Fig. 7. A heat map in the shrine (by application users)

The same photo is used as Figs. 7 and 8. Figure 8 is a heat map of unrelated third parties. Comparing Fig. 7 with Fig. 8, we can conform that the application users remembered the quiz point. The unrelated students focused main structure as same as application users. However, they seldom paid attention to right one. The application users paid special attention to the section on which they were quizzed.

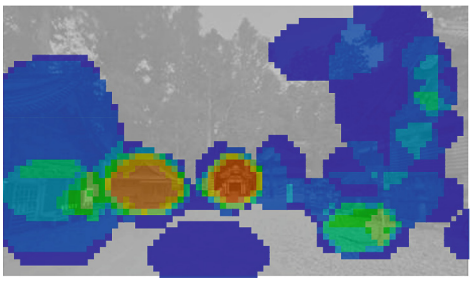

Fig. 8. A heat map in the shrine (by unrelated students)

According to the results, we confirmed that our quizzes' application using Zeigarnik effects is effective for memory. Students remembered BLE beacon and the object at the quizzes. The results confirmed that the use of the quizzes exploiting the Zeigarnik effect improves recall.

In addition, the evaluation of the questionnaires showed us important points. Students evaluated the quiz when traditional object in front of them linked to their daily life. Students who evaluated quiz contents kept higher score than students who evaluated interface of the application after 2 months. It is assumed as the Zeigarnik effect.

5.3 For the Practical Use -Safety-

(1) For safety in the case of disaster
Although learning is the most important purpose of the proposed application, its introduction to schools requires further consideration. In most cases, the purchasers are the parents, not the students. Therefore, the use of mobile phones on students' school trips is financed by parents and decided by teachers. The merits of mobile phone usage must be considered from the viewpoints of students, teachers and parents. The basic requirement of school trips is safety (Table 1).

Table 1. Targets and required functions

Target	*Important Factor*	*Function*
Perents	Safety asistance	Shelter information
Students	Study, Fun	Quiz, Mission, Map, Photo, Chat
Teachers	Location of students, Communication	GPS, Telephone, SMS

According to our research (4.1), tablets are not currently employed in school trips. Teachers need to know the locations of small groups of students separately walking around the visited area. The system must accommodate these demands. The system developed by Kyowa Exeo [19] has a new function that directs students to the nearest shelter when disaster strikes. This functionality has been recommended by parents and teachers. (See Fig. 9.) Students use the right side of the mobile as a chat space. The emergency announcements are indicated the space in the time of disaster.

(2) Safety evaluation of walking with a mobile phone by EEG measurement
Walking with a mobile phone may be dangerous. In addition, students and one of the teachers reported that tablets were large and heavy in the Hawaii trial. To assess the practical use of mobile phone learning, we experimentally tested the safety of mobile phone use using a simple EEG measuring instrument (head set type). We tested two differently sized tablets; an iPad mini (200 mm × 134.7 mm) and an iPad2 (240 mm × 167.5 mm). The subjects (2 male, 2 female, aged in their 20's) walked around an area in Tokyo for approximately 3 h, while using the application installed on the tablets. The experiment was conducted on March 12, 2015.

Fig. 9. The screen of emergency

Figure 10 presents the brain waves of one subject (male). When he arrived at the point, he was relaxed and carried out the mission with attention. There were sudden changes several times. When he walked across the road, walked in the crowded street, found the favorite things and arrived at the destination. Another 3 persons showed same tendency. However, the brain waves of 2 women were often lacked (missing value). The points of high attention and sudden changes indicate awareness of potential danger.

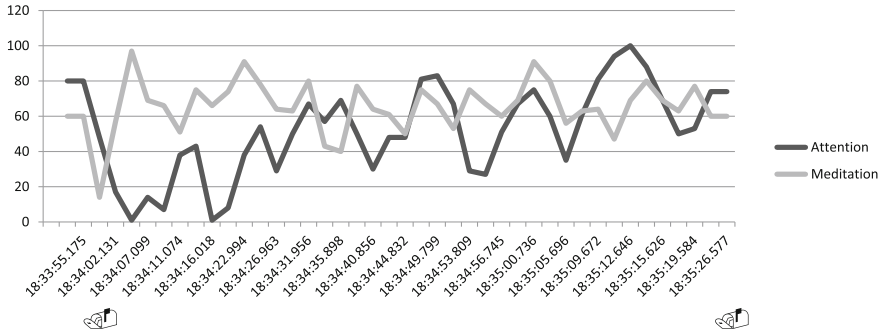

Fig. 10. A part of brain waves patterns of one subject

After the walking exercise, the subjects were presented with questionnaires. The questionnaire evaluations are summarized in Fig. 11. The usefulness and interest of the application were highly rated, but the safety was ranked lower than the other factors, especially on the iPad 2 (average rating 2.75 out of 5). Subjects judged that the iPad 2

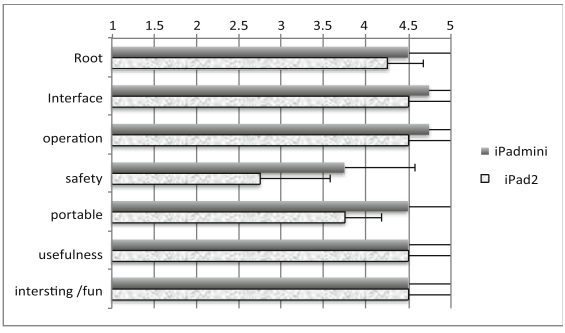

Fig. 11. Evaluation results of the 20th user trial (5-point Likert scale)

was too large for the exercise and compromised their safety.

According to the result, we have to consider about safety walking with mobile phone. To improve the safety of mobile phone learning applications, we could equip an accelerometer that notifies students of potential danger when walking with the mobile phone.

6 Conclusions

In several trials, we demonstrated the effectiveness of our outdoor study scheme based on ICT. Although ICT provides numerous information, much of that information is superfluous or uninspiring. We need to trigger students' interest in their studying. When students were required to seek unknown information, they became actively engaged with the target objects. Students using the application looked around the area, noted the architectures, and identified site-specific arts more positively than students not using the application. We hope to design opportunities for students to learn about and appreciate objects.

To realize such services, the functions and targets of the application must satisfy not only students but also their teachers, whose requirements may differ from those of students.

Our outdoor study scheme was highly rated in the trials, but several issues have yet to be resolved. For safety purposes, students could be equipped with an accelerometer that notifies them or switches off the screen in potentially dangerous situations. The small screen of the mobile phone narrows the viewing angle of users. We will also research the quality of the missions and quizzes installed in the device, and consider the suitability of ultra-modern functionalities, such as augmented reality (AR), for outdoor study.

Mobile internet use is increasing annually around the world. We intend to introduce Japanese culture to students in other countries, too. Mobile phone is suitable device to connect their classroom and real outdoor study.

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