Case Studies of Applications to Encourage Students in Cyber-Physical Environment

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Abstract. People became to have convenient lives in ICT society using the Internet. However, convenience is not the purpose to live. It is only the method to get something or know something quickly. Especially for learning, students have to overcome many obstacles actively to know and get knowledge. How we make an attractive point to be interested in the object? For active learning, we have researched applications to make some attractive points for students using psychological methods. Also, we had to arrange much information to make a point in cyber-physical environments. This paper explains about 2 kinds of applications. One is an application for inside studying using a Player versus Player (PvP) game. Another is for outdoor studying using Bluetooth Low Energy (BLE) beacon at the national park in Nikko. We developed applications of e-learning not for convenience but to feel beyond the smartphone screen. According to our experiments, such application makes students active to know about the subject.

Keywords: Computer aided education · Active learning · BLE beacon · PvP game · Cyber-physical environment

1 Introduction

1.1 Tools for Active Learning at the Convenient Society

Education level in Japan is high. According to the results of TIMSS 2015, which continues the long history of international assessments in mathematics and science conducted by IEA – the International Association for the Evaluation of Educational Achievement [1], Japanese students were in the grade of top 5 average score in the

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fields of mathematics and science both at elementary schools and at junior high schools. However, the research also told that they did not enjoy such works. For example, only 52% of Japanese students, the 8th grade, answered mathematics was joyful (cf. International average 71%). 66% of Japanese students answered science was joyful (cf. International average 81%) [2]. It is a problem that Japanese students have less motivation for learning. It is crucial to consider how we can improve students' ability and raise their motivation for learning.

Nowadays, people enclosing young students connect many intangible objects at the ICT society. However, it is difficult for young students to imagine intangible things. Many websites contain useful information for students. However, they tend to look over such information passively. What are the practical methods for young students to add information to their stock of knowledge? Make a point which students focus on, and they are interested in it. We have studied applications for that purpose. If students notice something that is not perfect (someplace is lacked), they urge to know complete one and would be attractive to know it. Human beings tend to be interested in something unfinished, and students tend to know about the lack points to finish their learning. We aimed to create applications to connect other place or other time using psychological approach. Then they can learn such expanse of space and time with our applications. Figure 1 shows the map of our case studies. There are two axes; one is "Space-Time," another is "active-passive."

In the following parts of this paper, we explain each case study. After explaining about related works in Sect. 2, we mention our two applications in Sect. 3. Then Sect. 4 tells the results of our researches. Finally, we mention conclusions and our research for the future.

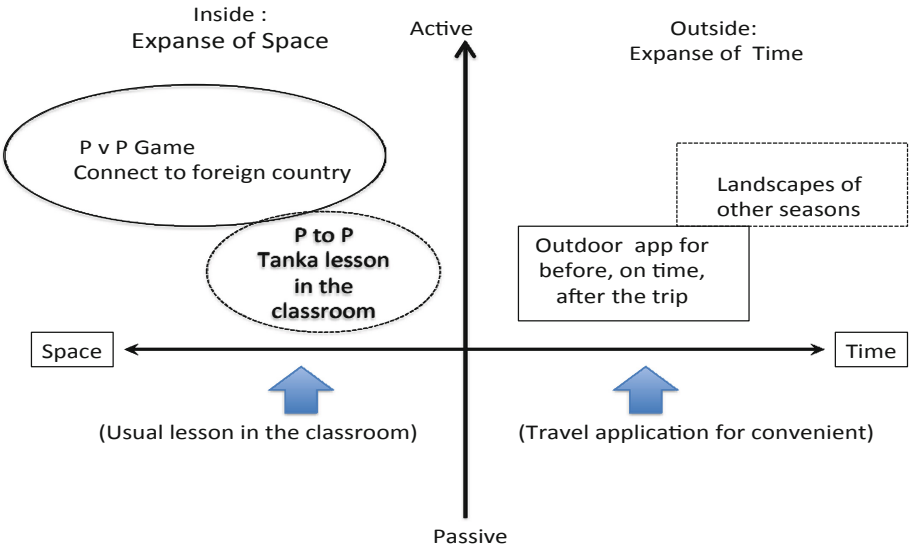

Fig. 1. Case studies of inside and outside

2 Related Works

2.1 Game (for Inside Studying)

We created an application for active learning in the classroom or house using a PvP (Player versus Player) game. The use of game thinking and game mechanics is getting more attention as a means of self-motivated and sustained behavioral change.

Gamification is not equal game. However, there are common elements. "Gamification Platform for Supporting Self-motivated and Sustained Actions" [3] indicates the effectiveness of the games. The Researchers had experiments at the elementary school [4]. In the paper, young students enjoyed the lesson using animation with a mission for them.

McGonigal told that the failures in the game are very light and players can make many failures in "Reality is Broken: Why Games Make Us Better and How They Can Change the World" [5]. Also, the success in the game is visible as some items such as a treasure, extraordinary powers that encourage players and make players active. Using these elements, we designed our application.

2.2 Psychology for Tourism (for Outdoor Studying)

Students visit famous places for several days with their classmates and teachers in Japan. We created another application using psychology in such few days outdoor studying. There are several works about psychology and tourism. Pearce and Stringer [6] studied from the viewpoint of physiology, cognition, and individual variation. Fridgen [7], van Raaij [8], Sasaki also studied this field. Especially, Sasaki mentioned that trip had three scenes: before the trip, during the trip, and after the trip [9]. It means that a trip is not only enjoying the trip itself but also planning to increase expectation before the trip and remember the memory of the trip after returning home.

3 Our Case Studies

3.1 Inside Use Case: Expansion of the Space

At first, we have developed an application for young students using SNS, which was a closed system in the school. Using this system, students talked to each other and created a lot of traditional Japanese poems, TANKA. Students created TANKA, and then they sent comments to other authors. Some comments were written with rhymes naturally. This process is similar to Japanese olden methods to write TANKA [10–12]. In the course of this experiment, it was found that young students who belonged to acquirement failed a lot to do their works. However, they learned how to use the system among making failures. We had to tolerate to make such mistakes for their acquirements. However, even the slightest mistake can be fatal in the ICT society. Then for usage in the classroom or at home, we created a PvP game for learning, named Fevordio, Sanze Learning System [13] (Refer to Fig. 2 and Table 1).

Students check the knowledge using the card game. They sometimes fail. However, it is not such a big problem to fail in the game. They can fail in the game. They study

the subject themselves and then remotely battles with the other members using questions which they choose. “the win and loss records” describes the battle score (Refer to Fig. 3). The characteristic points of this battle learning are as followings.

- Self-study: The results of each personal usage; accuracy rate and frequency of use, are recorded. The database is designed to follow the results and choose the degree of cards by AI to study low percentages of attendance.
- After using the card several times, students not only answer or choose the cards but also can make questions. They become positive parts of this battle.
- 3D database shows relations of cards visually. (Refer to Fig. 4). The cards are increasing and become big data because teachers and students create new ones using this application. Many data is arranged and became 3 databases by AI. For example, if the same word is found in 2 cards, they are connected in this database. By using this system, cross-curriculum learning becomes possible, and students can learn the subject multilayered.
- Create membership groups and members can sharing content within the groups.

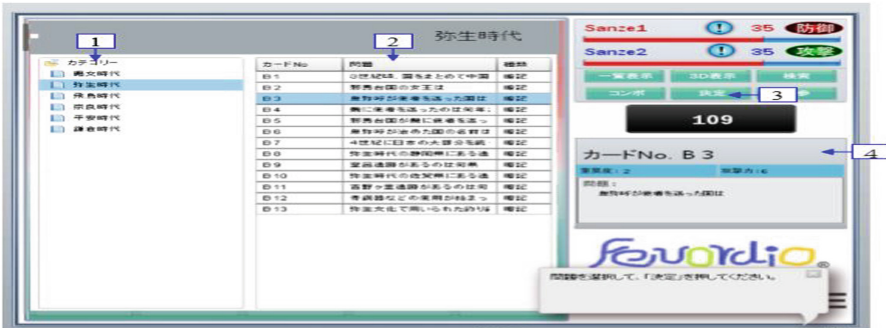

Fig. 2. The screen to choose the card (quiz)

Table 1. The explanation of numbers at Fig. 2

No.	Item	Description
1	Card list category	Click category name to display cards in each category
2	Card list	Display card information (card no., question and card type) of selected category. Click on list to select a card
3	OK button	Submit selected card to the sever
4	Card thumbnail	Display thumbnail of selected card

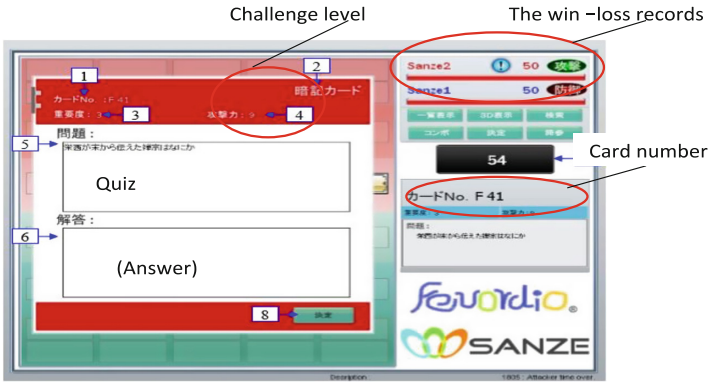

Fig. 3. Question & answer screen (on PC)

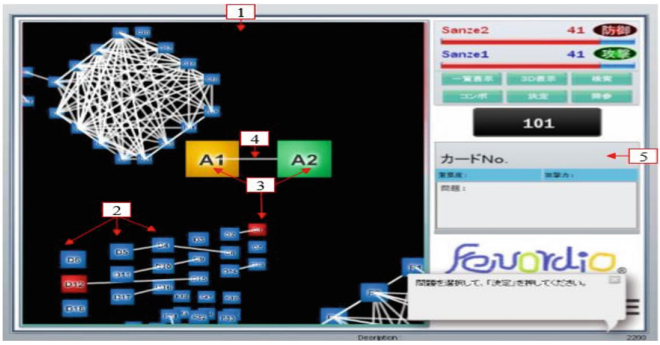

Fig. 4. The screen to choose quiz cards in 3D display

3.2 Outside Use Case

3.2.1 Our Previous Orienteering Application

We developed an application for outdoor studying using Bluetooth Low Energy (BLE) Beacon in Nikko, the world heritage site in Japan. At the quiz function in this application, we urged students to attend traditional objects actively. The quiz function made students look at one point in the landscape. This function provides a new learning model for outdoor studies using Zeigarnik effects; human beings take an interest in uncompleted or interrupted tasks [14]. Some desire or some stress, which includes the uncompleted part, can keep memory longer until the desire is fulfilled. In other words, the tasks that have been completed are recalled less well than tasks that have not been completed. In the case of school trips, if there is something uncompleted and know the answer, the memory of the point may remain longer. Students become active to the object using this smartphone application. For example, after answering the animal written in a famous picture, they looked up the building and ascertained the animal in the picture. The results of experiments students remembered the objects and evaluated

great history and culture in Nikko not only in Nikko but also after 2 months in 2016–2017 [15–18].

3.2.2 Application at the National Park

Based on the results of those experiments, we developed a new application (Refer to Fig. 5) Using BLE Beacon, students can get information just around the area. We set beacons in the national park in Oku-Nikko, where is the west of world heritage area with beautiful marsh registered under the Ramsar Convention [19]. Two psychological effects were used in our application for Oku-Nikko. One is the application of the Zeigarnik Effect [20], and another is Maslow's hierarchy of needs [21, 22].

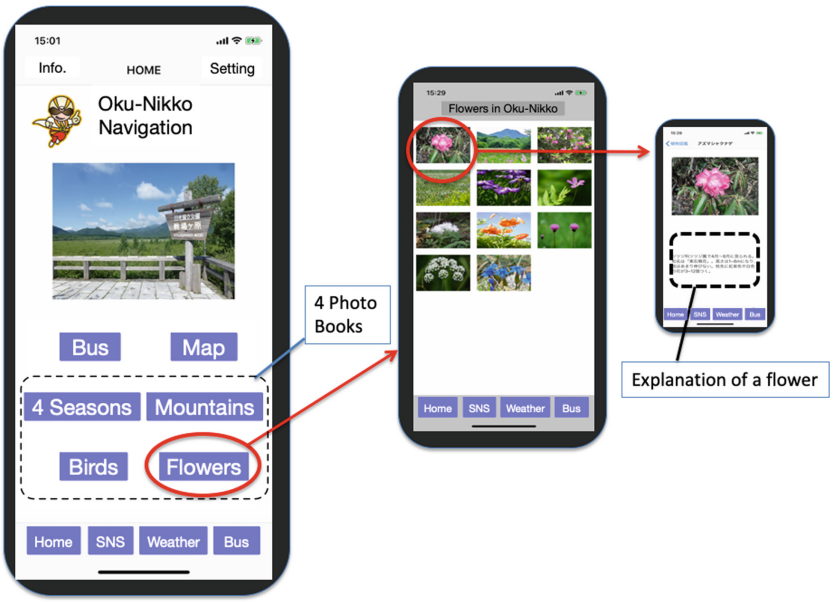

Fig. 5. Screens of Nikko application (top screen and an example of photo books. The details of the design process are described in [18].)

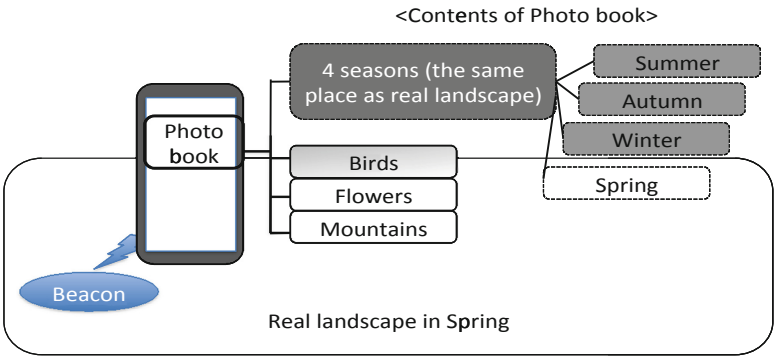

Fig. 6. Contents of photo book (the case in spring)

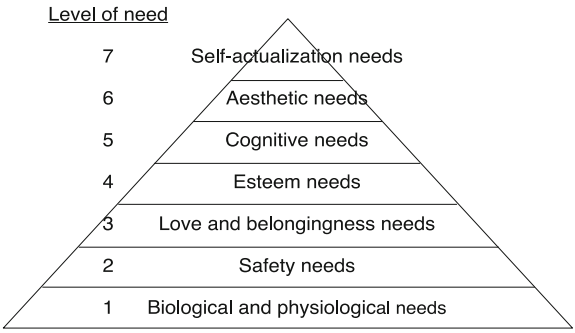

Fig. 7. Maslow's hierarchy of needs

We use the Zeigarnik Effect as followings. If students visit Oku-Nikko in autumn, the application display shows photos of scenery filled with cherry blossoms in spring or that covered by white snow with a footprint of a fox in winter, too. Those photos may attract the students, and it is expected that the memory of Oku-Nikko becomes stronger and the visitor becomes repeaters. Students may imagine other seasons. Figure 6 shows an example in spring. The white parts of the Fig. 6 are visible and the grey ones are invisible parts in spring. (Students are not always able to find the birds. So it is painted grey a bit) Looking at the beautiful landscape and know the objects around there using explanation of photos in our contents. Also, they look at photos of other seasons, they know there are other landscape which they have looked at them yet.

This application is used in nature. Information about map and timetables of an autobus is necessary for safe walking. Students are making groups, and they walked around the area within a designated time. Also, they collect photos and record their research.

A lot of information are set on the application. It seems that the developer sometimes set too many functions for users. Our most basic need is for physical survival, and it is the first thing that motivates the behavior. After one level is fulfilled, the next level up is what motivates us, and so on. The lower need is more critical and has higher priority. Maslow developed different types of the hierarchy of need such as five layers model and eight layers model. In our research, we used seven layers model (Fig. 7), since this model meets the classification of information required for outdoor studying. Having experiments as the next Sect. (4.2), we decided the arrangements at the interface of our application. Using Maslow's hierarchy of needs as the Cyber-Physical System (CPS). Maslow stated that people are motivated to achieve individual needs and that some needs take precedence over others.

4 Experiments and the Results

4.1 Fevordio, Application for Inside

We had questionnaires and experiments using mathematics battles in 2018.

(1) 23 on Nov. (A Festival at Minami-Ohsawa in Tokyo) 6 persons
(2) 5 on Dec. (houses Between Japan and Sri Lanka) 6 persons (3 each in Japan and Sri Lanka)

Total: 12 persons (male 5, female 7, from the 1st grade to 7th grade) and 9 parents of 12 persons answered questionnaires. Table 2 is the results about game use in their daily life.

Table 2. Questionnaires about games

Question	Answer		
Do you play TV or PC/Smartphone games?	Yes		11
	No		1
How many days do you play games (per week)?		4.95 days	(Average)
How long do you play games?	Week day	0.75 h	(Average)
	Holiday	1.29 h	(Average)

11 out of 12 children answered to play games every day (41%). The parents answered the same questionnaire as only 6 or 7 children play the game. (1 person had 2 children.) 4 parents answered that their children did not play the TV or PC game. The answers didn't match. Children, whom parents consider as no game users, did not have any rules for playing games with their parents.

Fig. 8. The evaluation by children using Fevordio

The answers after using Fevordio, children evaluated it was "joyful" as 91/100 points (average), "useful" 85/100 points (average). It was a high score. We asked them whether they liked Mathematics or not as the same way as Fig. 8, in advance. The scores of "like" were followings. Math class was 82/100 points, and Math drills were 66/100 points. They liked less drills than the subject itself. No children answered to prefer Math drills to Math class. However, they enjoyed our card battle named Fevordio, in spite of the same contents as Math drills. Children evaluated far higher this game than calculation Math drills (25 points higher). They answered this battle was "useful" and also was "easy". If it was useful for them to practice calculations, did we have to guess cards for the battle were too easy? Games are regarded to give players to feel happiness or well-being from easy battles. Sonija Lyubomirsky writes about such games, "We obtain maximum happiness when we take on flexible and appropriate goals" [22].

According to the data analysis, there was not a correlation between whether they liked Math drills and whether they enjoyed this card battle ($r = -0.08$). On the other

hands, there was a positive correlation between the question "How many days do you play games in a week?" and their feelings of "joyful" (r = 0.64). The difficulty level and "joyful" did not have correlation (r = 0.16).

Parents inclosing who answered their children did not play games, looked at their children playing the game, wrote comments as "Children look fun," "It is Interesting. Children are stimulated", "This concept is good" and "Good!". They evaluated this game positively.

At the Festival in Minami-Ohsawa on November 23, children sat next to each other in a single row and had the card battle. An elder child taught her opponent who couldn't answer the card. Though she met him for the first time then, it seemed to have friendly communication using the same game. This is a prosocial emotion named "naches". McGnigal explained the term "This is a Yiddish word for the bursting pride we feel when someone we've taught or mentored succeeds" [5]. Players sometimes feel a kind of vicarious pride from giving advice and encouragement to the opponent on games. Ekman also told, "it encourages us to contribute to someone else's success, and achievements from networks of support from which everyone involved benefit" [23]. This scene in festival at Minami Ohsawa was an example of naches and they studied together with communication.

On the battle between Japan and Sri Lanka on December 5, comments of the children both Japanese and Sri Lanka were "Joyful (n = 6)", "Useful (n = 1)" at the experiment. 2 children answered to be interested in Sri Lanka after playing the game in Japan. Also, a student at a higher grade of the elementary school became to notice news about Sri Lanka and remembered the long name of capital, "Sri Jayawardenepura Kotte". When children start to learn English as a foreign language at the elementary school, they connected directly using a Math game on the first hand. It is just a start point to communicate with each other. It is difficult to sense of foreign countries for young students in a stage of concrete operations. However, using such a system, they have chances to know other persons beyond the PC screen.

The results of our experiments, students made calculations (Math drills) with fin and also some of them were interested in opponents. They will learn each other using the game not only mathematics drills but also quizzes of cultural or historical subjects in future. We aim to develop the battle game, Fevordio, to bring up the feeling of real connection among the students. Young students feel the world and people in other countries directly and quickly. It is a game inside. However, students become to fell the extent of space.

4.2 Oku-Nikko Application for Outside

Setting BLE beacons in the national park of Oku-Nikko, we had an experiment from February 19 to 21 in 2018, at Utsunomiya University (n = 20).

We listed up required elements of trips at the setout and categorized into ten elements. Based on Maslow's hierarchy of needs, we added priority to the functions of a mobile phone application and designed it for Oku-Nikko. Students evaluated the effectiveness of our designs. For example, all higher priority functions are accessible from the home screen, and some of them are in the tab bar to be accessible from all screens of the application. We added a photo book of seasons on the home screen to

use the Zeigarnik Effect in order to encourage students to revisit Oku-Nikko in other seasons. We expected that the photos of nature (mountain, flower, bird) might cause a similar effect at the national park, too.

The results of the classification about the functions are as followings (Refer to Table 3).

Table 3. Mapping among elements of information, Maslow's hierarchy of needs

Elements of sightseeing (Oku-Nikko)	Hierarchy of needs						Function of App
	1	2	3	4	5	6	
Weather		O					Weather
New information (weather, disaster, bear, event etc.)		O			O	O	Information
Transportation, access		O					Bus (timetable and route)
Restroom, present location, model courses	O	O			O		Map
High light, guidance, transportation, food (shops)	O	O			O		Pop-up
High light, photos of seasons						O	Seasons photo
Guidance, origin, photos of animals, flowers, mountains					O	O	Photo books
Event					O		Stamp rally
SNS, "Like"			O	O			SNS
Multi lingual		O					Setting

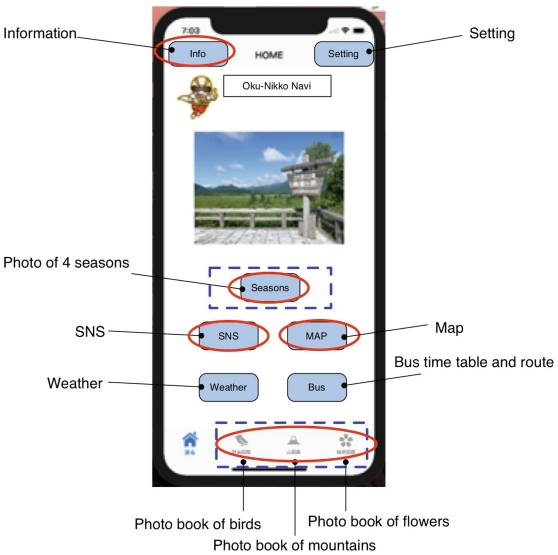

Fig. 9. New version user interface

The Weather, Map, Information (disaster, bear notification etc.) Bus routes and timetables were mapped as level 1 and 2. SNS was Level 3 and 4. Photo books and a part of information and a part of map were mapped as level 5 and 6. After basic needs (Level 1, 2) are fulfilled, human beings can think about higher levels. Therefore, after the experiments, the interface of our application was arranged mainly those basic needs (refer to Fig. 9.). Exceptionally photos of 4 seasons are not the basic needs. However, using basic information around the functions, we set "Seasons" in order to make students to be interested the other landscapes they cannot see real then.

After the experiments, the interface of our application was arranged as Fig. 9.

We had another test to use BLE beacon in the deep snow. In addition, we set a beacon by the pot spring source. The result of the test, it is possible to use beacon in a closed box in such areas. We have continued to research the condition of beacons in the forest or near hot springs. The reception of signals of a mobile phone is terrible in the forest so that it is not easy to get information about the direction. However, there are limited several paths that people can walk in the national park for the act of conserving nature. Therefore we can design the scene which people get signals of the beacon easily. We have an experiment in Oku-Nikko in 2019 to check the signals from BLE beacons and to know what kind of function is useful or joyful for people.

5 Conclusion

According to the researches, we concluded that the case studies about both inside and outside e-learning, studies in cyber-physical environments continue to urge students to have some active point for their learning. To connect some points invisible (Time or Space), young students imagine the objects beyond the PC or smartphone's screen and are interested in them. These applications express the expanse of time and space. Those applications are useful is not for convenience but imagination.

Why students have to learn foreign languages? Students may consider the reason for learning and get motivation for learning foreign languages. Connecting with foreigners is essential. One of the characteristic points of Fevordio is "Create membership groups, and members can share content within the groups" (Refer to Sect. 3.1). We try to bring up children's motivation. Also, such motivation brings them from virtual communication using games to real communication. Contents of Fevordio are increasing, and children would like to play card battles such as English, history, and science. Then 3D database's display has not used our experiments yet. We have other experiments using the function. That will make students learn multi-layered related subjects.

For outdoor studying, it is an excellent time to develop a new application in Oku-Nikko. The Ministry of the Environment has been promoting "the Project to Fully Enjoy National Parks [24]" at eight national parks in Japan since 2016, and the Nikko National Park is one of the selected areas. A mission of these projects is to support the national park by ICT. Our application will support it. We would like to have an experiment and evaluate the effect of our design method in the real field in Oku-Nikko before service-in.

Those 2 applications we developed have different systems and are used in different scenes. However, they have the same aim. These 2 applications make students to imagine some objects. They become actively imagine other persons beyond the screen or landscapes of other seasons. Students get not only some information positively, but also the information which they get, operates them beyond the space or the time. This effort is a step to active learning. In the ICT society, a great deal of information tends to make people passive. It is too much to be active users. We have to make some entrance points to focus on learning.

We continue to experiment for active learning both inside and outside to encourage active learning and bring up students' imagination.

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