Development of Experiential Learning System based on the Connection between Object Models and Their Digital Contents

Collaboration between Tangible Interface and Computer Interaction

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Abstract: Experiential learning is effective for educating children. However, there are many issues associated with this technique. In this study, we describe the development of a learning support system using which learners can experience touching and viewing in real and virtual environments. In the first stage of our study, we develop a larval mimesis experience system consisting of a Kinect sensor, larval models, and load sensors. The system is controlled using Arduino. Using the proposed system, learners can exercise full body interaction in the virtual environment; specifically, they can experience how larva models are observed in the real environment. The operation of this system was experimentally evaluated by learners from a primary school. The results indicate that the system is suitable for the use of children. In addition, the effectiveness of the learning support was evaluated by using a questionnaire. This paper summarizes the development of the proposed system and describes the evaluation results.

1 INTRODUCTION

The importance of natural experiential learning in educating children is well known. In this technique, emphasis is on teaching and learning by direct experience (Bueno, 2015). However, some things are difficult to experience directly, such as the habits of extinct animals and plants, time-consuming vegetation transition, and the habits of creatures with remote habitation environments.

Previous studies have conducted trials on simulating experience by reproducing the natural environment in a virtual environment. Yoshida et al. studied a learning experience related to extinct animals using full body interaction (Yoshida, 2015) (Adachi, 2013). Learning to move the body, as in a full body interaction, has a strong effect on learning (Yap, 2015). However, this experience is limited in the virtual environment. Learners do not experience real sensations, such as touching. This issue must be addressed to improve the quality of experiential learning.

In this study, we describe the development of a learning support system "OBSERVE," which allows learners to experience real and virtual environments. We use a tangible user interface that can handle information intuitively by using a combination of physical objects and digital information to simulate experiences in the real environment (Ishii, 1997). This combines the experience of using virtual and real environments (Ishii, 2008) and enables learners to learn based on experiences in both. We expect that this system will improve the learning experience.

In the first stage of this study, we develop a larval mimesis experience system that can be experienced in real and virtual environments. The proposed system consists of a commercial sensor, larval models, projector, screen, PC, and board-type computer. Using this system, learners observe larval models, perform interactions to identify larvae, and find latent larvae. We expect learners to observe the larval models and virtual environment attentively, as the

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larval models are palm-sized. In this paper, we describe the proposed system, its experimental evaluation, and the results based on information gathered using a questionnaire.

2 OBSERVE SYSTEM

2.1 Proposed System

In this study, we develop a system to realize experiential learning support. The flow of the system first requires learners to choose a larval model. We prepared models for 15 kinds of larvae—Biston robustus, Vespina Nielseni, Hypopyra vespertilio, Deilephila elpenor, Apochima juglansiaria Graeser, Celastrina argiolus, Cucullia maculosa Staudinger, Auaxa sulphurea, Neptis philyra, Thetidia albocostaria, Geometra dieckmanni, Xenochroa internifusca, Langia zenzeroides nawai, Neptis aiwina, and Sphinx caliginea caliginea. When a particular model is selected, its corresponding image is displayed on the screen. The larva is hidden in the display and learners play a game to find it. After finding the larva, the learners move their body and perform a motion to catch the larva. Then, the larva begins to move and an explanation of the mimicking action is shown.

Using this system, learners not only experience the observation of the larval model directly, but also observe them in the virtual environment. Realizing this requires us to implement the following two functions: (a) creation of a larval model as a tangible interface, and (b) operation using the learner's body motion. Function (a) combines the larval models and larva in the virtual environment, while function (b) allows us to implement experiential learning in the virtual environment. Figure 1 shows the setup of the system.

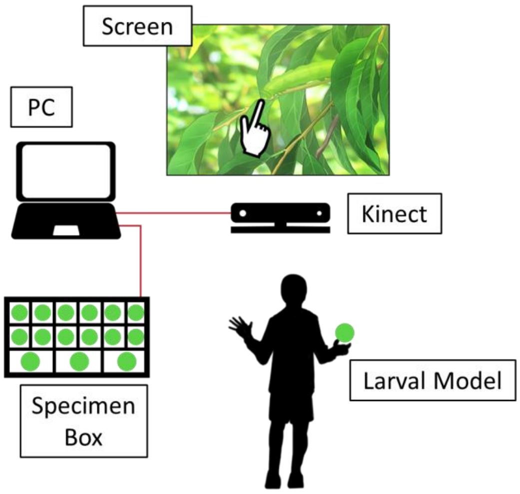

Figure 1: Setup of the system. Function (a) is performed in the specimen box. This consists of Arduino and FSR sensor. Function (b) is performed by the Kinect sensor.

2.2 Creating a Larval Model as a Tangible Interface

Displaying the chosen larva model in the virtual environment necessitates the development of a recognition function for the model. We use a board-type computer, Arduino, and load sensor, FSR(Force Resister Sensor), to recognize the model. Arduino is a single board-type computer using which various sensors can be controlled (Balogh, 2010). We use Arduino with control FSR, a sheet-like load sensor. The resistance level of FSR varies with the size of the added load.

We use FSR for two reasons. First, the value of the load is output in analog form. The system contains multiple larval models of varying weights, and hence the system must be adaptable to react to all of them. Second, FSR is not affected by illumination and temperature. In order to evaluate the proposed system, we carried out experiments in the laboratory as well as in a museum. Since the brightness of the illumination in the museum differs from that in the laboratory, the use of a sensor that remains unaffected by this characteristic is desirable.

We incorporate Arduino and FSR in a larval specimen box. Figure 2 shows the specimen box and PC. Figure 3 shows a larval model. The larval models are mounted on the FSR. When a learner picks up the model, it gets separated from the FSR, inducing a change in the resistance level. The system reads this change using Arduino, and recognizes that a learner has picked up the model.

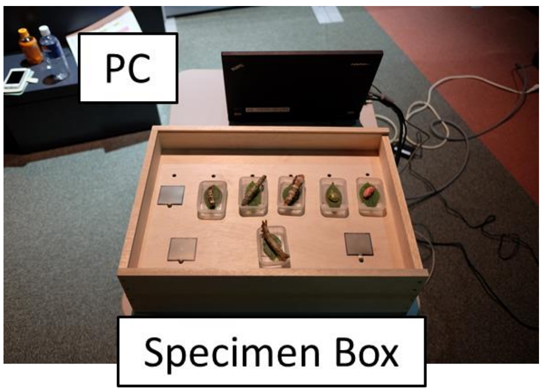

Figure 2: Specimen box and PC.

Figure 3: Larval model.

2.3 Operation using Learner'S Body Motion

The system requires real-time knowledge of the learner's movements to reflect this on the screen. This enables learners to experience the virtual environment by moving their bodies. We use a Kinect sensor to recognize the movement of the learner. This sensor is a range image sensor, originally developed as a home videogame device. It is highly cost effective and can measure distance with errors in the range of a few centimeters. Thus, the sensor can estimate user location precisely. Additionally, this sensor can recognize humans and their skeletons using libraries, such as Kinect for Windows SDK. This allows the Kinect sensor to estimate movements associated with human body parts, such as the limbs (Schotton, 2013).

The system enables learners to operate in a virtual environment by using hand movements. When a learner moves his hand, the hand pointer displayed in the virtual environment exhibits a similar movement. Figure 4 shows the flowchart of the procedure followed for seeking larva. Learners look for a larva and carry a pointer to a larva if they find it. A pointer in the virtual environment of the hand touches the larva when a movement is performed by pushing the hand forward. The animation of the larva moving on the screen is played when the system recognizes the movement of the learner's touch.

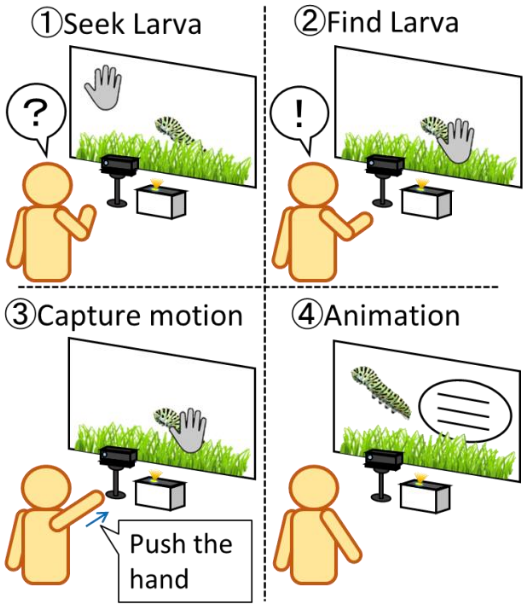

Figure 4: Flowchart of seeking larva.

3 EXPERIMENT

3.1 Methods

The proposed system was evaluated by 13 fifth-grade students (four boys and nine girls) from a national university-affiliated elementary school. The evaluation was conducted at the H Prefecture natural history museum. The participants tried out the system one-by-one. Six types of larvae were prepared as objects: Biston robustus, Vespina Nielseni, Hypopyra vespertilio, Deilephila elpenor, Apochima juglansiaria Graeser, and Celastrina argiolus. The participants used all the objects and experienced the system as described next.

The participants began by selecting and observing larvae from the six types of objects in the order of their interest. Figure 5 shows the scene. When an object is selected, animation that imitates the larvae of the selected object appears on a screen. Participants looked at the larvae and touched them with their hands. Figure 6 shows the participants seeking larvae. Once they found the larvae, the participants referred to information on the object that appeared on the screen, as shown in Figure 7.

Figure 5: Selecting and observing larval model.

Figure 6: Seeking larvae.

Each of the participants repeated this process for all six objects. For a chosen model, we recorded two types of data—whether the larva emerging on screen is right, and whether the animation shown after discovery is played correctly. We evaluated the system operation based on these parameters. After trying the system, the participants viewed related exhibits in the museum in groups of two and three.

Finally, we evaluated the system using a survey. Figure 8 shows the participants taking the survey. The survey comprised of 13 questions: three related to the overall experience of the system, four of them regarding the effect of the objects, three questions on the experience of physical movement, and three regarding the information provided by the animation. Each question was scored on a scale of one to seven, with one corresponding to "strongly agree" and seven corresponding to "completely disagree."

Figure 7: Referring to information.

Figure 8: Completing the survey.

3.2 Results

First, we analyze the operational evaluation. Table 1 shows the experimental results corresponding to the operational evaluation. We recorded the number of successes in recognizing the six kinds of larva for all the subjects. "A" represents the result of larval model recognition. The success rate for the total number of trials was 98.7%. For cases in which recognition failed, we observed that the model slipped from the load sensor. Thus, we assume that recognition failed because the sensor did not compute the load correctly. "B" represents the number of times the animation plays successfully when the learner touches the larva in a virtual environment. The success rate was 96.15%. We observed that for cases in which the animation failed, the leaners pushed their hand while moving their arm violently. This caused Kinect to recognize their movement incorrectly. From these results, we confirm that the system can be operated correctly by children in most situations.

Next, we describe the analysis of survey responses. We classified responses such as "strongly agree," "agree," and "somewhat agree" as positive responses, and "no opinion," "do not strongly agree," "do not agree," and "completely disagree" as neutral or negative responses. We then analyzed the number of positive replies and neutral and negative replies using a directly established calculation: 1 x 2 population rate inequality.

Three questions were about the overall system experience. The number of positive responses for "I developed an interest in larvae imitation," "I experienced the system and have a good understanding of the museum exhibits related to larvae imitation," and "The system experience was fun," exceeded the number and neutral or negative replies. Additionally, a significant deviation was observed between the various responses.

Four of the questions were related to the objects. The number of positive replies for “I was able to observe the larvae figures (objects) very well,” “I observed the larvae figures (objects) from several angles and understood some things about their ecology,” “I understood some things about the ecology of larvae by looking at the larvae figures (objects),” and “The larvae figures (objects) looked real; like they were actually alive” exceeded the number of neutral and negative responses. Additionally, a significant deviation was observed between the various responses.

Three questions dealt with the physical movement experience. The number of positive responses for “I developed an interest in larvae imitation through the game where I moved my body to look for the larvae,” “I would like to learn more about larvae imitation through the game where I moved my body to look for the larvae,” and “I developed an interest in other museum exhibits on imitation through the game where I moved my body to look for the larvae” exceeded the number of neutral and negative responses. Additionally, a significant deviation was observed between the various responses.

Finally, three questions were related to the information provided by the animation. The number of positive responses for “I developed an interest in larvae imitation by looking at the displayed animation,” “I would like to learn more about larvae imitation by looking at the displayed animation,” and “I developed an interest in museum exhibits on imitation by looking at the displayed animation” exceeded the number of neutral and negative responses. Additionally, a significant deviation was observed between the various responses.

Table 1: Experimental result of operational evaluation.

	The number of success	
Subject	A	B
1	6	6
2	6	6
3	6	6
4	6	6
5	6	6
6	6	6
7	5	6
8	6	6
9	6	4
10	6	5
11	6	6
12	6	6
13	6	6
Success rate[%]	98.72	96.15

4 CONCLUSION AND FUTURE WORK

In this paper, we discussed the development and evaluation of an experiential learning support system. Operational evaluation showed that the system could be operated correctly by children in almost all cases. The effectiveness of the system was evaluated using a survey that consisted of 13 questions. Out of these, three items were on systems, four on objects, three on the physical movement experience, and three on the information provided by the animation. For all of these, the number of positive responses exceeded neutral and negative responses. There was also a significant difference between the various responses. These results suggest that experiencing systems, using physical objects and physical movement, elicited the interest and attention of the participants toward the larvae and led to effective learning through museum exhibits.

Furthermore, we realized that system information provided through animation motivated the participants and supported viewing of the object larvae along with other related museum exhibits. In future work, we plan to increase the types of larvae. We will also consider a learning program that is not limited to the object larvae, but includes observation of live larvae outside the museum.

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