Effectiveness of a Cooperative Museum Learning Support System based on Multiple People Body Movements

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Abstract

Science museums play an important role for children as places to learn about science through conversation and experience. However, the main learning method in museums is passive: observing exhibits and reading explanations on text panels. Few opportunities to discuss experiences and engage in conversation exist. Therefore, it is difficult for young children to learn sufficiently and efficiently. We developed a cooperative immersive learning support system for a museum that enables children to learn through body movements and conversation. Children can learn by thinking while moving with people. We developed content that can be manipulated by the body movements of multiple people. For example, people can cooperate to observe a fossil in an exhibit and answer quizzes. We expect that this system could help children efficiently gain knowledge of fossils and enhance cooperation. This paper summarizes the current system and describes the evaluation results.

Keywords

Kinect Sensor, Education, Full Body Interaction, Radiolaria, Collaboration Learning

1 Introduction

Science museums play an important role in the science education of children (Gilbert & Stocklemayer, 2012: Falk, 2012). They are places where children can apply their own level of understanding without worrying about evaluation. In addition, they can tell whether their understanding is correct through experience and conversation with multiple people, which improves their motivation (Haneyman, 2007). Based on these experiences, children can efficiently obtain knowledge about topics like fossils. However, the primary learning method in museums is passive: observing exhibits and reading explanations (see Figure 1).

Figure 1: Learning method in the current museum

There are no opportunities for experiences or conversations. Therefore, it is difficult for young children to engage in learning and sufficiently understand a topic. In recent years, the difficulty of learning about the most important radiolaria in paleontology in museums has been problematic (O'Dogherty, Carter, Dumitrica, Gorican, & De Wever, 2009). Fossils, especially radiolaria, are difficult to learn about because they are observed with a microscope, which requires independent learning. A process that made fossils easier to observe could improve the quality of science education in museums.

Museums have developed various strategies to solve these problems. For example, a participatory workshop that observes fossils and provides commentaries and learning activities has been developed (Stocklmayer, Gore, & Bryant, 2001). While workshops offer opportunities for conversation with others, the process of observing fossils with a microscope is an individual activity. Therefore, the museum is not able to provide a fully collaborative learning environment, which makes it difficult to motivate learners because there is little difference from science class in school.

Various research has been conducted to improve the efficiency of collective learning. Some studies have found that group activities using mobile terminals are important in the field of computer-supported cooperative work (CSCW) because they can strengthen interactions with museum exhibits (Luff, 1998). For example, Papadimitriou, Komis, Tselios, & Avouris (2006) proposed providing two children with a personal digital assistant (PDA) equipped with a radiofrequency identifier (RFID) reader so that they can learn while searching exhibits. These studies allowed information to be obtained cooperatively from exhibitions, but observation with a microscope is different because only one person performs it. Moreover, the proposed means of learning support does not address children's need for real experience. Consequently, the fundamental problem of cooperative observation of fossils has not been solved. A solution would give children the opportunity to cooperate and encounter a true experience.

Sociality, cooperation, and knowledge cannot be obtained without actual experience gained from interaction with others to achieve a goal. Playing is a good opportunity for children to gain such experience. Studies have revealed that children develop deep understanding while cooperating and playing (Dau, 1999). When children use body movements while cooperating, the learning environment becomes more natural and they can retain more of the information being taught (Grandhi, Joue, & Mittelberg, 2011; Edge, Cheng, & Whitney, 2013).

We developed a system based on these ideas to solve the aforementioned problems with fossil observation. We developed a cooperative immersive learning support system that allows multiple people to collaborate and learn through body movements and conversation. Multiple people can cooperate to observe radiolaria; such collaboration leaves a strong impression and allows people to acquire knowledge efficiently.

The system involves multiple learners moving their bodies and talking to one other to learn about radiolaria.

The motion information of multiple people is simultaneously acquired via a sensor, and the contents are manipulated based on the information. Multiple screens are spread across the entire field of view, and learners can touch the virtual environment, which makes a strong impression.

In this paper, we describe this prototype and evaluate its usefulness as a first step towards implementing cooperative immersive learning support. In addition, we describe the technology used to create the proposed system.

Evaluation experiments were conducted at the Museum of Nature and Human Activities in Hyogo, Japan. In the evaluation experiment, we analyzed the effects of the museum workshop compared to the proposed system.

2 Cooperative Learning System

2.1 Current system

We developed a cooperative immersive learning support system that enables multiple people to collaborate through conversation and body movement to learn more efficiently with a stronger impression. This system allows fossil observation by multiple people simultaneously.

This system supports student learning of radiolaria. Radiolaria are zooplanktons; because they changed forms over time, their geological era can be easily determined. Radiolaria are very important because they are index fossils; radiolaria in each era have common features (O'Dogherty et al., 2009). However, when they are observed with a microscope in a museum, it is impossible for multiple people to collaborate efficiently despite the importance of the material. Furthermore, radiolaria are about 1/10 to 1/20 of the size of 1 mm, which makes them more difficult to observe with multiple people than normal fossils (O'Dogherty et al., 2009). For this reason, workshops are currently considered the best museum learning method.

We focused on supporting the learning of radiolaria. Our proposed system allows observation by multiple people. Multiple children can observe radiolaria and cooperate to find the characteristics of each era, which supports efficient learning. Observation with multiple people enables learners to gain new awareness from others' observations, apply knowledge to different problems, and notify others of their own awareness.

In our proposed process, when two learners stand in front of the system, the sensor detects the learners and the contents start. Radiolarian with features common to each of the Jurassic, Triassic, and Permian are displayed on the front screen, and the learners talk to each other about the characteristics of radiolarian. The learner selects what to observe from the radiolarian displayed on this screen. When the two people approach at the same time, the fossils of the radiolaria are enlarged. When they move away at the same time, the fossils are reduced. In this manner, the two learners communicate and decide on the radiolaria they want to observe, and the learner on the right takes action. As the two learners move forward and backward, they can observe the radiolaria together. Normally, a single person observes radiolaria with a microscope, but this approach allows two people to observe while communicating. After that, the students cooperatively answer quiz questions displayed on the front screen regarding to which era the radiolaria belong. To complete the quiz, learners need to share opinions and knowledge through conversation. In this way, the learners aim to acquire knowledge about radiolaria. Figure 2 shows the flow of the system.

Two functions are required for this system to succeed in achieving efficiency in science education:

(a) Operation using body movements of multiple people (efficient acquisition of knowledge)

(b) Fossil observation using multiple projectors (increases the impression of radiolaria)

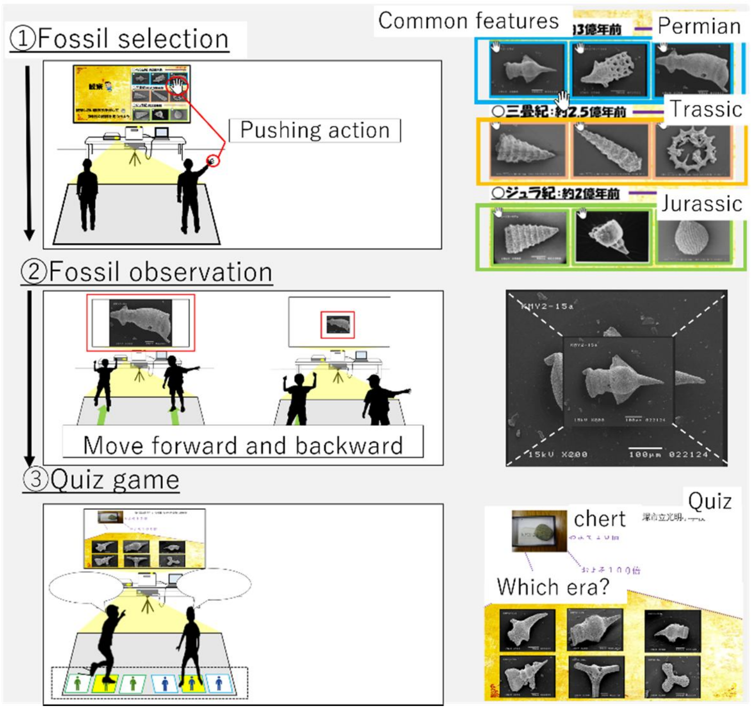

Figure 2: System flow

2.2 Operation using body movements of multiple people

We used the Kinect sensor to recognize the body movements of multiple people. Microsoft's Kinect sensor is a range-image sensor originally developed as a home videogame device. Although it is inexpensive, the sensor can record sophisticated measurements regarding the user's location. The Kinect sensor can measure the location of human body parts and can identify the user's pose or status with their function and location information. Twenty-five skeleton three-dimension coordinates can be measured (Shotton et al., 2013). By utilizing the function of recognizing skeleton coordinates, Enlargement and contraction of radiolaria on the screen are realized. Students move forward and backward as shown in Figure 3.

Figure 3: Operation using body movements of multiple people. In the picture on the left, learners move toward the screen, and the radiolaria are enlarged. In the picture on the right, learners move away from the screen, and the radiolaria are reduced.

2.3 Fossil observation using multiple projectors

In order to improve the immersive feeling of learners, we linked projectors (RICOH PJ WX4152NI) and surrounded the learners with images. The body movements recognized by the Kinect sensor were reflected on the two-sided projector, which made the still image and the animation change. Figure 4 shows the linked projectors.

Figure 4: Link of two projectors. Depending on the learner's movements, the images and animations of the two projectors change.

3 Experiment

3.1 Methods

Participants: The participants were 19 students at Kobe University Elementary School (13 fifth graders and six sixth-graders; 10–12 years old; 11 boys and 8 girls).

Location: The experiment was performed at the Museum of Nature and Human Activities in Hyogo, Japan.

Evaluation method: For evaluation, a word association method was implemented. The word association method is an evaluation method in which a learner writes a word associated with the word "radiolarian" and calculates the number of words. We count correct words for radiolaria as one. We do not count words not related to radiolaria.

Procedure: First, participants took the first word association test to confirm how much advanced knowledge they possessed about radiolarian. After that, the participants participated in a 30-minute workshop led by museum curators of the Museum of Nature and Human Activities in Hyogo. Participants touched sedimentary rocks and charts and observed them with a magnifying glass. Participants learned that information about radiolaria was included in charts, such as the size of radiolaria and the places they can be seen. The workshop is held daily at the museum. After the workshop experience, the participants took the second word association test to confirm how much knowledge they obtained in the workshop experience. After that, participants experienced our proposed educational system for radiolaria described in Section 2. Initially, the participants were divided into two groups, with two people talking to each other to find the characteristics of radiolaria seen in each era, and estimating the eras of the radiolaria. There were five questions for the students to complete, and the answer choices for all questions were Permian, Triassic, and Jurassic. After experiencing the proposed system, participants took a third word association test to confirm how much knowledge was acquired by experiencing the proposed system. Figure 5 shows the experimental procedure.

Figure 5: Experiment procedure

The word association test was administered three times: before the workshop, after the workshop, and after the system experience. This experiment evaluated how much correct knowledge was acquired for radiolarian in each scenario. We also compared the learning effect of the actual museum workshop and the proposed system.

4 Results

Table 1, 2 summarizes the results of the word association tests of all subjects administered before the workshop, after the workshop, and after the system experience. In the word association method, we counted the number of correct words relating to radiolaria such as "Permian" and "Jurassic." Table 1 shows that students wrote the most words related to radiolaria after the workshop and system experience. We analyzed the word association test data before the workshop, after the workshop, and after the system experience using the Friedman test. A significant difference (p <. 01) was observed. Furthermore, multiple comparisons were performed using data from the three word association tests, which yielded the following results:

・There was no significant difference (p> .05) in the number of words before the workshop and after the workshop.

・There was a significant difference (p> .01) in the number of words between the workshop and after the system experience.

・There was a significant difference (p <. 01) in the number of words before the workshop and after the system experience.

These results indicate that knowledge was improved through the proposed system experience.

Subject number	1	2	3	4	5	6	7	8	9
First time (First knowledge)	0	0	0	0	0	0	0	0	0
Second time (After workshop)	0	0	0	0	0	0	0	0	0
Third time (After workshop +System experience)	3	1	3	3	3	4	3	0	2

Table 1: Results of all subjects (subject number 1-9)

Subject number	10	11	12	13	14	15	16	17	18	19
First time (First knowledge)	0	0	0	0	0	0	0	0	0	0
Second time (After workshop)	2	0	0	0	0	0	0	0	0	0
Third time (After workshop +System experience)	3	4	6	1	3	3	4	0	4	3

Table 2: Results of all subjects (subject number 10-19)

One could infer that the connection between radiolaria and knowledge of geological age was formed by cooperating and experiencing the proposed system. In addition, learners were able to acquire knowledge more efficiently than in workshops. Figure 6 shows that learners acquired the most knowledge through the experience of the system.

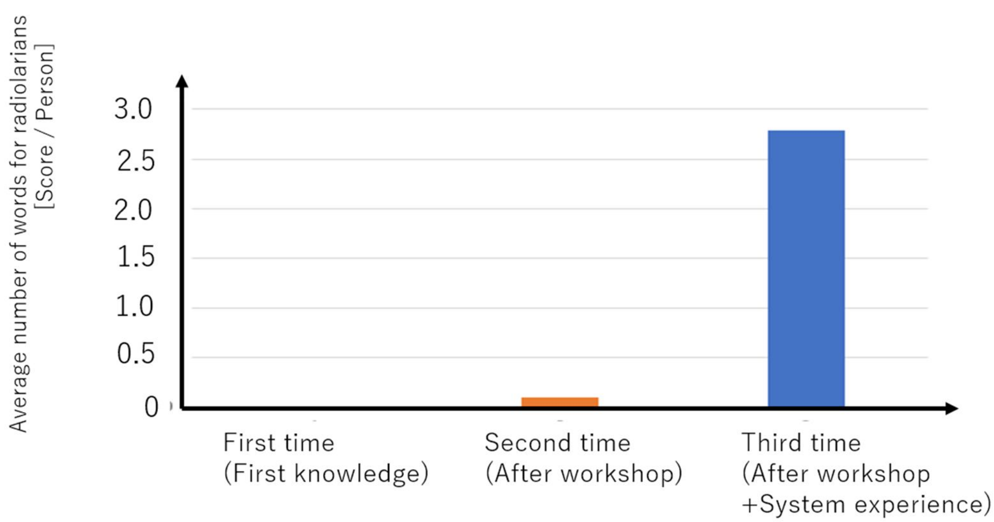

Figure 6: Experimental result of word association method

5 Observations and future issues

In this first step towards implementing a cooperative immersion learning support system for children, we proposed a system for children to learn about radiolaria using a Kinect sensor. We evaluated the proposed system through an experiment and word association method to determine whether children were able to learn cooperatively. We compared the learning effects of the workshop and the proposed system. The results of our evaluation clearly showed that learners acquired more knowledge about radiolarian through the experience of the proposed system,

In the future, we aim to gather further knowledge and implement improved learning strategies in the museum. Future research could explore the correlation between system experience and knowledge understanding and methods to improve cooperation.

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