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Externalization Support for Hypotheses Creation Process of Discovery Learning in Biology

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Abstract: Discovery learning is a learning method for understanding knowledge through repeated process of observation, hypothesis generation and verification. However, some students cannot generate hypotheses or verify generated hypotheses because such activities are usually done implicitly. In order to engage in the activities, to be aware of insufficiency of the activities by grasping the process of them explicitly is effective. This research proposes the discovery learning support system of biology by providing the interfaces for externalizing the processes.
Keywords: Discovery learning, learning support system, externalization, hypotheses generation support, hypotheses verification support, biology

1. Introduction

In recent years, various styles of active learning are introduced in the primary/secondary school education. One of the styles is a fieldwork type class. An example of such class in biology is that students go to ecological gardens such as zoos and botanical gardens to discover the natures of animals or plants before learning about them. Such learning method for discover the knowledge from the experience is called discovery learning. In discovery learning, students observe objects and make hypotheses based on information obtained from observation. In making hypotheses, they need to check the validity of their hypotheses and modify them. In order to discover important natures as hypotheses, they at least need to repeat these processes until derived hypotheses can explain all observation results.

Balım et al. (2009) stated that discovery learning has an effect on enhancing interests of students by grasping phenomena from various aspects. However, current discovery learning held in a fieldwork type class, especially in Japan, emphasizes only on practicing the class in the field, such as outside of the school. Since it is difficult for teachers to handle the activities of all students at once, they are often not able to check the hypotheses that students made and also the processes of how they derived them.

Most of studies supporting fieldwork activities in biology focus on promoting observations by asking questions that can be solved by observation (Hwang et al. 2008, Ohsugi et al. 2016). These studies do not support activities for generating hypotheses from observation. Nishio et al. (2016) proposed a system that supports learners to organize the observation results for making presentations. However, this system does not promote the process of deriving hypotheses. Although these studies could partially support discovery learning, there are almost no studies that promotes activities of generating hypotheses from the observation in the fieldwork type class.

This study aims at proposing a system that encourages students to proceed the processes of discovery learning, such as deriving candidates of hypotheses and checking their validities. One of the reasons that students cannot actively conduct these activities is that they usually do it implicitly and do not intentionally promote them. If they are aware of insufficiency of the activities, they can execute the process of discovery learning actively. For the awareness, students need to explicitly grasp their understanding contents corresponding to results of each activity in discovery learning. This study constructs a system where students can externalize their understanding contents in activity during the discovery learning. It also provides the information which triggers students' activity.

2. Activity in Discovery Learning of Biology and its Supporting Framework

This research focuses on the discovery learning in biology where students try to discover the natures of animals. The objective of such learning is to find the unique characteristics of target animals, such as unique behavior and body parts. “A mane of lions” and “a wash gesture of raccoons” are some of the examples. Therefore, hypotheses are the unique body parts and behaviors that can be grasped from the observation. In order to derive the hypotheses, following four activities are needed.

Step 1 “Observation”: To observe body parts and behaviors of target animals from various viewpoints,
Step 2 “Creating hypotheses”: To detect the remarkable body parts and behaviors from the observation results as hypotheses,
Step 3 “Verifying rationality of hypotheses”: To find the correlation between unique body parts and behaviors,
Step 4 “Verifying uniqueness of hypotheses”: To compare body parts and behaviors with other animals.

Observation is a step where students obtain information for creating hypotheses. Since most of unique characteristics are seen in detailed body parts and behaviors, observing from not only large-scale viewpoints but also detailed viewpoints is desirable. Candidates of unique characteristics are chosen from observation results in the step for creating hypotheses. The body parts of animals are developed to allow them to act in favor of survival, so unique behavior should have corresponding unique body parts that are used to do. Therefore, to check the correlation between detected body parts and behaviors is one of the methods for verifying the validity of the uniqueness of them. In addition, unique body parts and behaviors are those that cannot be seen in other kinds of animals. Therefore, to compare the body parts of behaviors with other animals also promote to verify the uniqueness.

Since these four steps are needed in the discovery learning of the biology, this study proposes the support system that has the functions for supporting externalization of each steps and also for promoting them. This system consists of three interfaces; observation record interface, body and behavior correlation interface and animals comparison interface. Observation records interface focuses on the steps 1 and 2, and allows students to record what they discovered through observation and create hypotheses from them. Body and behavior correlation interface is for executing step 3. It allows students to make relations between observed body parts and behaviors. Animals comparison interface is for step 4. It provides an interface for comparing observation results of two different animals. By using the body and behavior correlation interface and the animal comparison interface, students are able to check whether the body parts or behaviors are unique to the target animal.

3. Prototype System of Discovery Learning Support System

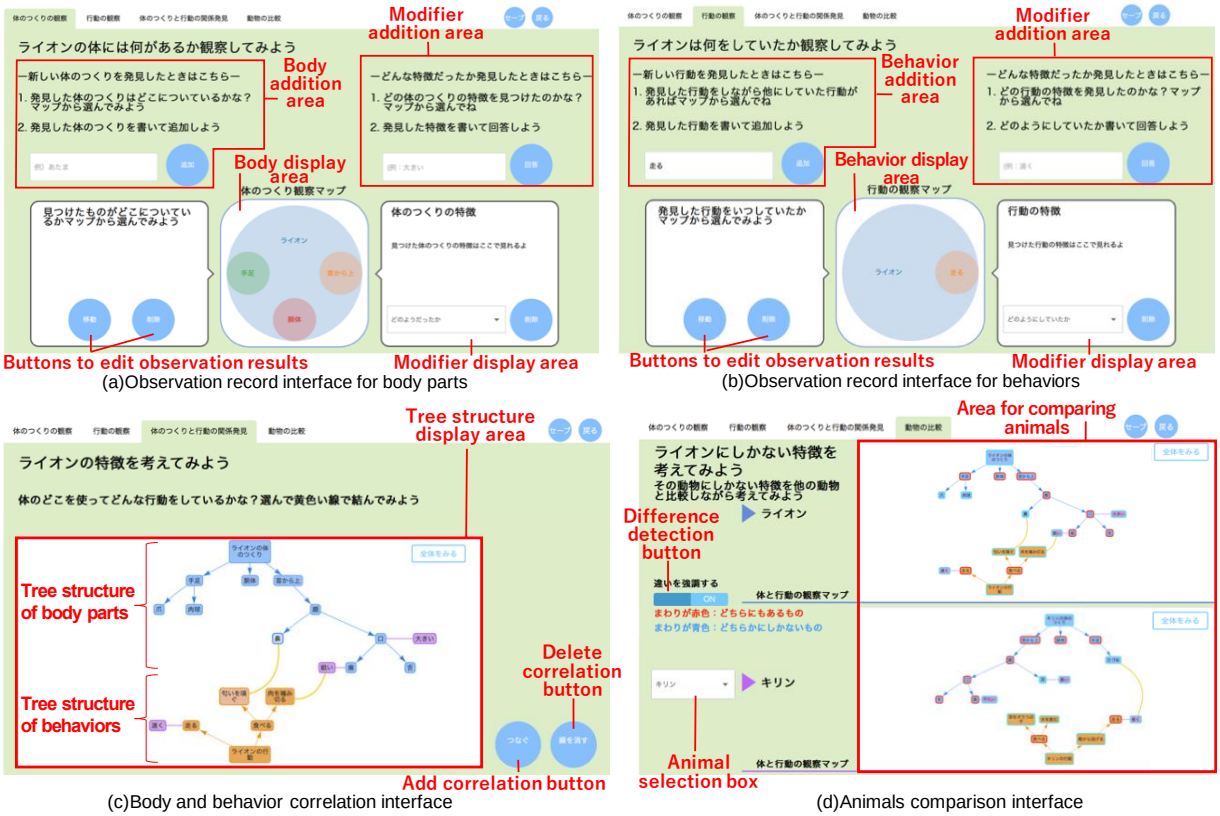
We have implemented the discovery learning support system by HTML and Java Script.

Observation record interface consists of two part. One is the interface for recording body parts shown in Figure 1(a) and the other is the interface for recording behavior shown in Figure 1(b). In body/behavior display area, inputted body parts or behaviors are represented by circles. When the new body parts or behaviors have been discovered, students need to select body parts or behaviors that the newly discovered one is included by body/behavior display area, and input the name of the discovered one in the body/behavior addition area. If students find the attributes of the body parts and behaviors, they can input it from modifier addition area and check it on modifier display area.

Figure 1(c) shows body and behavior correlation interface. In tree structure display area, tree structures of body parts and behaviors are displayed. Blue nodes and directed links shown in the upper half part of the tree structure display area are the tree structure of the body parts, and orange nodes and directed links shown in the lower half part are that of the behaviors. The tree structure of the behaviors is represented in the opposite way to that of the body part, namely the root node of the behaviors is in the bottom while that of the body part is in the top. Purple nodes show modifiers and are connected by links to nodes of body parts or behavior. By selecting a node of the body part and a node of the behavior and push the add correlation button, yellow links can be added and selected nodes are correlated.

Figure 1(d) shows the animals comparison interface. It shows the results of the body and behavior correlation interfaces for two animals. The upper half displays the current target animal. When the name

of the animal to compare is inputted in the animal selection box, the observation results of the selected one is appeared in the lower half of the interface. By clicking difference detect button, common nodes of the two animals are detected and are colored by blue, and other nodes are painted by red. By observing the colors, the uniqueness of the body parts of the behaviors of the current target animal are grasped. When the body part and the behavior of the hypothesis are found as unique, the hypothesis is verified as appropriate. If either of one is found as not unique, other behavior / body part should be found to form the hypothesis.



(a)Observation record interface for body parts

(b)Observation record interface for behaviors

(c)Body and behavior correlation interface

(d)Animals comparison interface

Figure 1. Interfaces of the system

4. Conclusion

This study proposed a system of activating the process of the discovery learning of biology. The system provides the interface for externalizing the process, such as observation, hypotheses creation, and verification. In the future, we need to evaluate the effectiveness of the system through experiment with primary/secondary school students.

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