

# Marine Science Education from the View of Functional Morphology and Comparative Morphology of Sea Turtle - The Quiz of Morphology for Marine Science Education

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## ABSTRACT

Recently, the necessity of marine education is associated with the conservation of the marine environment. Accurate knowledge of marine organisms is essential for their preservation as well as that of their habitat. In the education of living things, a functional-morphological viewpoint with high visibility is very useful. We created functional-morphological quizzes of sea turtles and conducted a marine education course for elementary school students and their parents and verified its usefulness. Students were given hints regarding the functional morphology of sea turtles and tortoises, the correct answer rate was analyzed before and after the hints were given. Regarding the relationship between the entire silhouette and the habitat, the correct answer rate was high when no hints were given. However, the correct answer rate for questions about the forms of limbs and carapaces was higher after the hints were given. In questionnaire of the impression and comprehension for the course, most participants indicated that the course was excellent or good, and that the subject was easy to understand. Further, we were able to raise awareness of conservation through the course. It was inferred that the functional-morphology quiz about sea turtles was useful for marine science education.

**Keywords:** functional morphology, marine education, quiz

## INTRODUCTION

In recent years, the necessity of marine education has arisen (Andersen & Miller, 2006; Kohno, Yatabe, Kase, & Saito, 2016). Japan is one of the world's largest fish-eating countries, and the developing sustainable fishery resources is a problem (Kohno et al., 2016). For that purpose, oceanic education for the next generation is necessary for sustainable development, as Japan exists by the sea as a maritime country.

Accurate knowledge of marine life is indispensable, especially for its conservation and that of the environment (Andersen & Miller, 2006; Hassan, Kamalia, & Mui, 2017). An interest in living things without accurate knowledge creates the possibility that actions intended for conservation would conversely exacerbate the environmental problems. For that reason, marine education for young children is crucial (Kashio, 2016).

Sea turtles are one of the most familiar marine lives for children since sea turtles appear in fairy tales (Tokita & Akino, 1974). There are seven species of sea turtles in the world, and they have all been on the red list (Kamezaki, 2012). The conservation of sea turtles is needed (Gilman et al., 2006; Hassan et al., 2017; Mazaris, Schofield, Gkazinou, Alpanidou, & Hays, 2017) Many countries are promoting conservation (Hassan et al., 2017), but Japan is regarded internationally as a country that harms sea turtles (Spotila, 2004).

**Article History:** Received 5 March 2019 ♦ Revised 5 May 2019 ♦ Accepted 6 May 2019

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The conservation of sea turtles is a global effort, and Japan is also participating in conservation activities (Kamezaki, 2012). However, it is difficult to verify whether anthropogenic conservation activities have a positive influence on living organisms; thus, it is necessary to devise countermeasures with a good understanding of the ecology of living things (Kamezaki, 2012). Sea turtles are released during the daytime in the event for educational purposes, but since the wild sea turtle swims toward the sea at night after hatching, there is a possibility that sea turtle releasing event may have a negative influence on sea turtle ecology (Kamezaki, 2012; Okuyama, 2010). Also, for learners to have the motivation to learn, it is necessary to clarify the significance and purpose of learning (Sakai & Fukuyama, 2018). Therefore, to raise motivation for future learning, it is important to tell that correct knowledge will also be useful for future conservation of marine organism and thinking measures. For that reason, it is very important to communicate to children the current situation and convey the importance of having correct biological knowledge.

When developing science educational course contents and teaching materials, to attract the interest of learners is needed (Okazaki, 2017). Therefore, it is useful to incorporate games and quizzes in order to interest primary scholars and give them the motivation to learn (Fujioka, Kaji, & Mihira, 2011; Okazaki, 2017). Beyond just explaining the meaning of the form, creating quizzes to distinguish the form and its function should encourage active learning (Sunaga, 2010). However, quizzes of marine organisms from the functional morphological view have rarely been conducted.

To recognize nature, the method of observation was used (Omura, 2016; Saiki, 2017). Learners recognized the living creatures by observing their shapes (Omura, 2016). In particular, functional morphology is a study that makes it easy for non-experts and first-time scholars to understand based on the strength of their observational powers (Arima, Honda, Hirose, Shimoe, & Satoda, 2012); thus, it is extremely useful in marine education. Functional morphology is an academic field that unravels the answer to, “what is the purpose of that form?” Morphology is closely related to habitat (the environment) and movement style, and it reflects its function in each part and overall form (Arima et al., 2012; Sakashita, Uchinuno, Kirimura, & Kaji, 2004). It is reported that students who hate science increase from elementary school to junior high school (Saijoh & Ohashi, 2018). The reason of increasing students who hate sciences is suggested that in elementary school, science curriculum is mainly observations and experiments, but in junior high school, students have to consider the natural phenomenon (Saijoh & Ohashi, 2018). However, to learn science, students need to think about why the phenomenon has occurred regardless of their age (Shimada, 2009). To eliminate of gap between elementary school and junior high school, there is a need to tell phases that there is a reason for the phenomenon from the time of elementary school students. Therefore, it is thought to be necessary for elementary school students that the opportunity of the learning of the reasons for the natural phenomenon. In the marine life education seen from the morphological point of view, there is a need to not only explain the organism name but also to tell students that there is a reason for the shape.

However, marine science education programs focusing on reasons for the functional morphology have been a little. Because the shape is related the creature’s ecology (Omura & Endo, 2014; Omura et al., 2015a; Omura et al., 2015; Omura et al., 2015b), it is very important to not only know but also to think about why a creature has a certain shape to understand the relationship between the sea environment and living things.

The method known as “comparative morphology” extracts its features from comparisons with other species (Omura & Endo, 2014). The object for comparison varies according to its purpose, but closely related species are mainly used (e.g., Omura et al., 2015). Therefore, to understand the shape necessary for living in the sea, educators can compare the tortoise with the sea turtle; observing them visually promotes understanding.

In this research, we aimed to make the shape of a living creature and the importance of oceanic conservation more understandable. Therefore, we created quizzes from a functional-morphological point of view, provided practical applications in the marine education course, and verified the effect of the educational method.

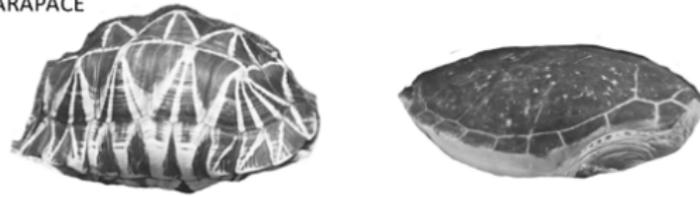
## MATERIALS AND METHODS

### Participants

In terms of the differences between the sea turtle and the tortoise, we developed a quiz-style teaching material and delivered a lecture. The summer course for parents and children (1-2 grades of elementary school students) was held in August 2018. We analyzed the effect of functional-morphological quiz for marine and science education from participants; 16 children and 16 parents.

## Which is a sea turtle ?

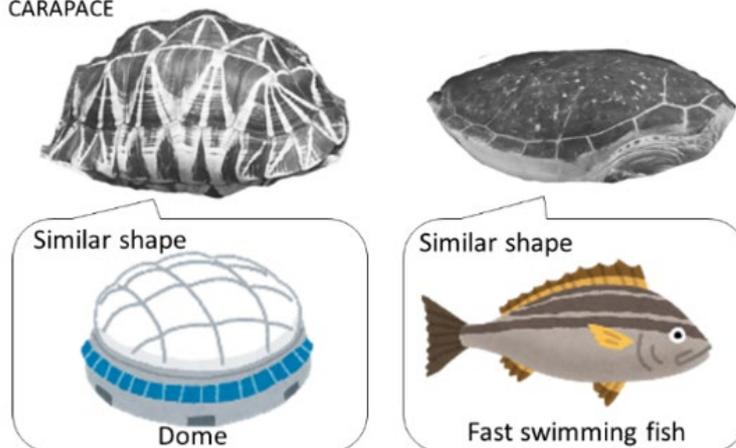
CARAPACE



**Figure 1.** The slide of quiz without the hint of carapace's shape in power point for this lecture

## Which is a sea turtle ?

CARAPACE



**Figure 2.** The slide of quiz with the hint of carapace's shape in power point for this lecture

## Context

In order to investigate one's recognition without prior knowledge, we first showed the black-and-white photographs of carapaces (**Figure 1**) and limbs of the sea turtle and tortoise and the black whole silhouettes of the sea turtle and tortoise and examined the number of students who answered correctly for identifying the sea turtle by counting the raised hands. After that, hints were added about the noticeable morphological differences between land and ocean areas (**Figure 2**). After the hints were given, the number of students who answered correctly was examined again. Then, we explained that the sea turtle is an endangered species and presented the necessity of possessing accurate knowledge about conservation via PowerPoint.

As a hint, we showed an illustration and its functional significance in a similar shape (the same functional significance of a specific form). For the carapace, a sea turtle's carapace with illustrations of streamlined fish attached was shown to portray high-speed swimming, and a dome illustration was used for a tortoise carapace (**Figure 2**). The hint regarding the sea turtle's limbs was a set of paddles for maneuvering through water, and the hint for a tortoise's legs was an illustration of an elephant which has robust limbs and walks on land (**Figure 3**). For the whole silhouettes, a sea turtle's silhouette with illustrations of streamlined fish attached was shown to portray high-speed swimming, and a dome illustration was used for a tortoise silhouette (**Figure 4**). Then, a commentary was rendered. A sea turtle has streamlined carapace that reduces the viscosity resistance of water and allows it to swim with speed (Sfakiotakis, Lane, & Davies, 1999). The limbs are shaped like fins and oars, which are also conducive for swimming. When attacked by predators, a sea turtle can get away by swimming swiftly, but it cannot withdraw its head or limbs into the carapace (Kamezaki, 2012). On the other hand, the tortoise has thick limbs that can support its heavy weight (Kamezaki, 2012). When attacked by predators, it retracts its head and limbs into the dome-shaped hard carapace.

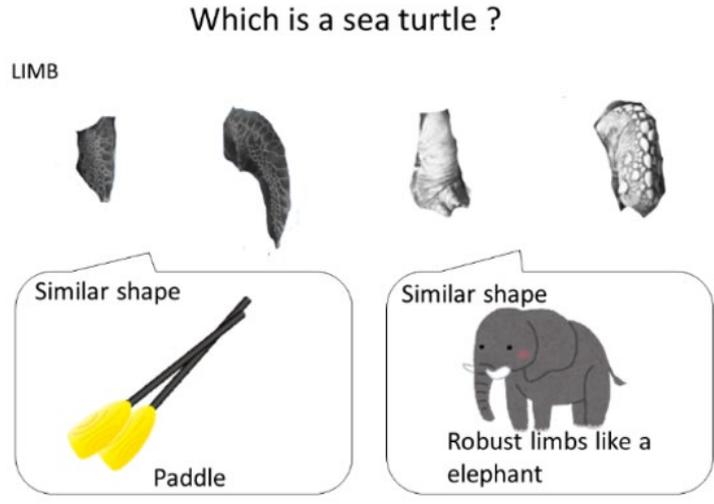


Figure 3. The slide of quiz with the hint of limb's shape in power point for this lecture

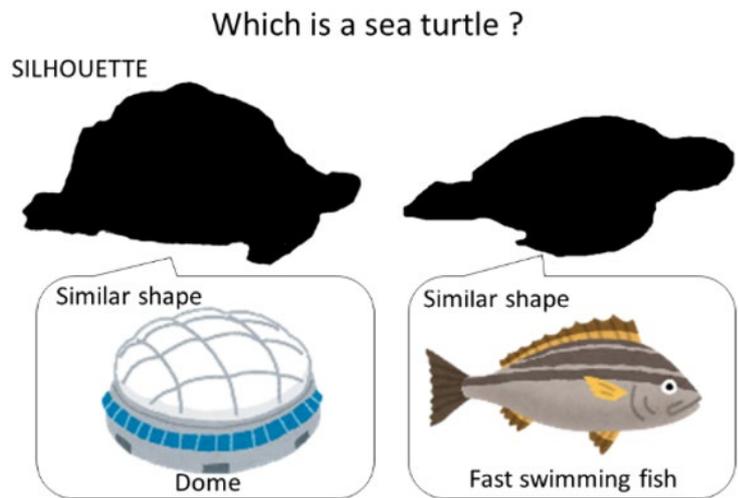
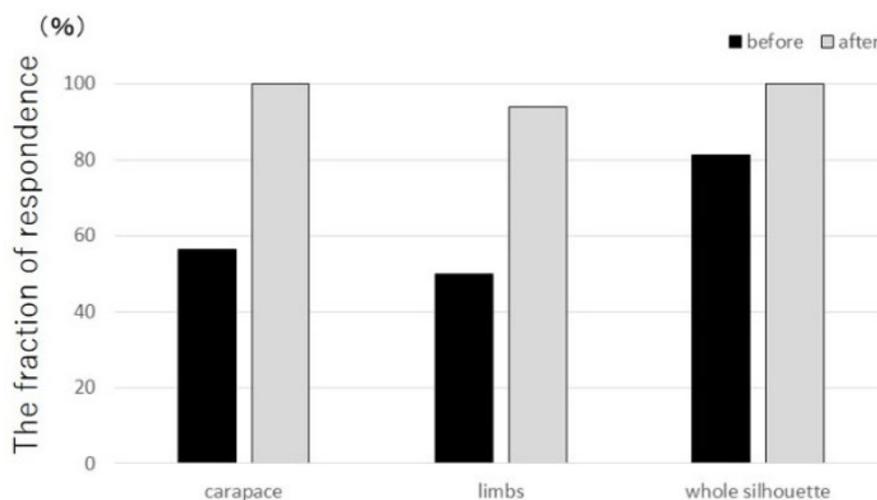


Figure 4. The slide of quiz with hint of whole silhouette in power point for this lecture

### Analysis

To verify whether the hint of functional significance is useful for understanding the formation of a living organism, the number of students who answered questions correctly before being given hints to the quiz and the number of people who gave correct answers after being given hints were measured by raised hands. The correct answer rate was the ratio of the number of people answering correctly to the total number of students, and the difference in this rate before and after hints were given was evaluated with the Wilcoxon Signed-Rank Test.

To confirm the usefulness of the course, a questionnaire was distributed after the course. For children, respondents were given five choices per question regarding impression and comprehension about the course. In addition, a free response section was provided for other opinions. For parents, respondents were given five choices per question regarding impression and difficulty level for children, and a free response section was provided for other opinions.



**Figure 5.** Correct answer rates of children for the quiz of the sea turtle. Black bar: before giving hint. Gray bar: after giving hint

## RESULT

### Correct Answer Rate and Children's Situations

**Figure 5** shows the correct answer rate of quiz. Regarding the morphology of the sea turtle, a change in the correct answer rate was observed before and after hints of similar shapes were given. Regarding the form of the carapace, significant difference was shown between before hints were given and after hints were given ( $p < 0.01$ ). The correct answer rate of the form of the carapace was 56.3 % (9 out of 16) before hints were given and 100 % (16 out of 16) after they were given. Regarding the morphology of limbs, significant difference was shown between before hints were given and after hints were given ( $p < 0.01$ ). The correct answer rate for morphology of limbs was 50.0 % (8 out of 16) before hints were given and 93.8 % (15 out of 16) after hints were given. Finally, regarding the entire silhouette, no significant difference was shown between before hints were given and after hints were given ( $p < 0.01$ ). The correct answer rate was 81.3 % (13 out of 16) before hints were given about the entire silhouette and 100 % (16 out of 16) after they were given. A positive result was that children raised their hands and answered questions in a participatory fashion. Some even raised their hands to answer a question before the educator could announce the correct answer.

### Survey Questionnaire

Results of the questionnaire of the impression and comprehension given to children are shown in **Figures 6** and **7** respectively. Impressively, 87.5 % (14 of 16 people) expressed that they were excellent with the methodology, and 12.5 % (2 out of 16) answered that it was good. Further, 93.8 % (15 out of 16) said that the course material of understandability was excellent and 6.3 % (1 out of 16) answered that it was good to understand. In the free response section regarding understandable content, comments included the following: "I understood the difference between a sea turtle and a tortoise," "The quizzes were fun," and "It was fun trying to understand the meaning of the shapes." Opinions about conservation were also positive: "I was thinking of preserving sea turtles" and "It was the first time to know that sea turtles are an endangered species."

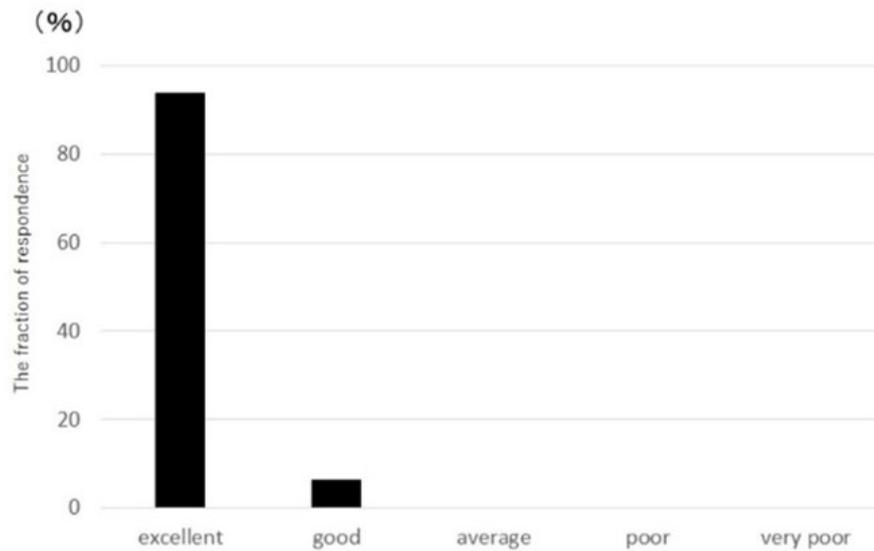


Figure 6. Children’s answer to the questionnaire in the impression of the course

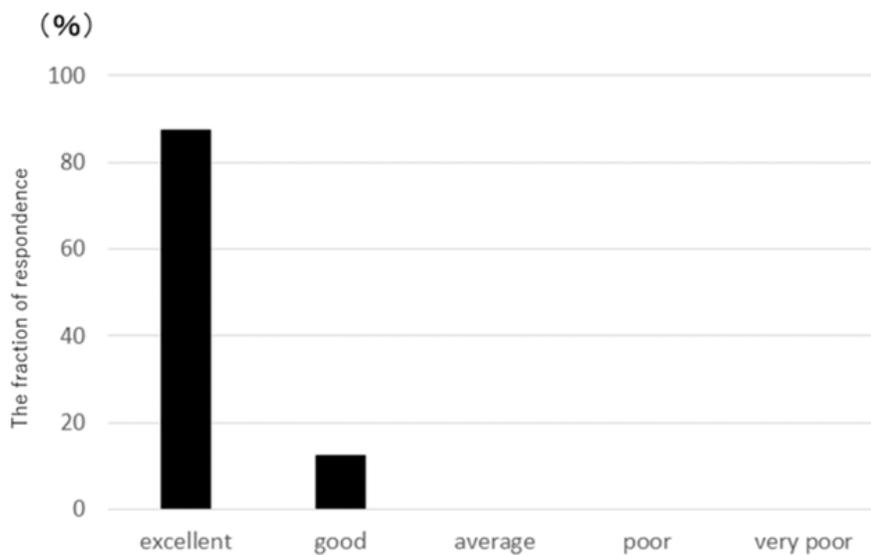
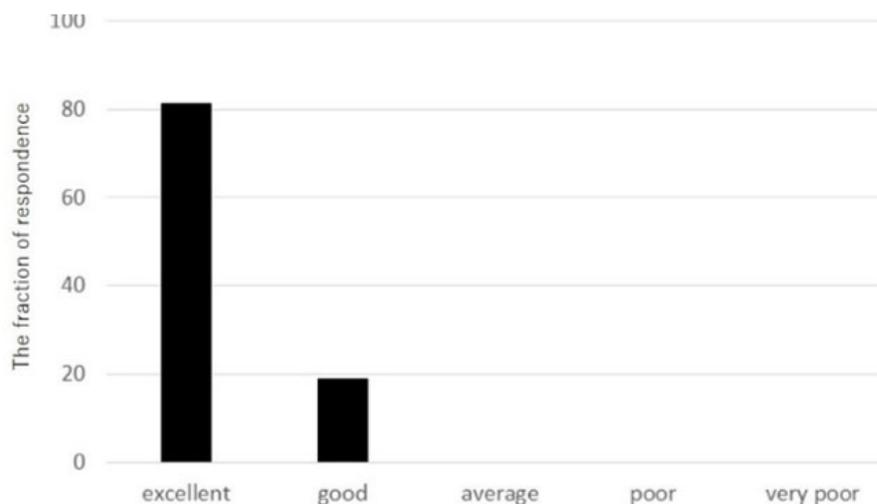
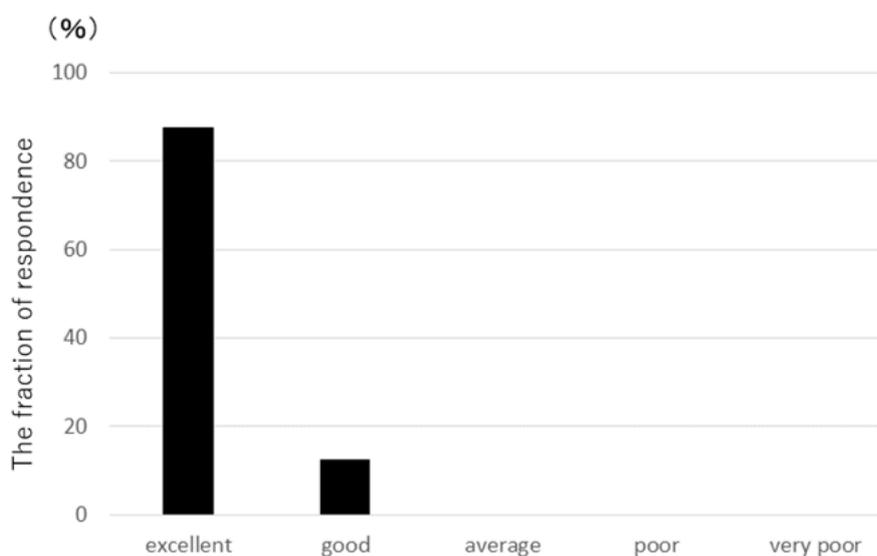


Figure 7. Children’s answer to the questionnaire in the comprehension of the course

Figures 8 and 9 showed the results of questionnaire for parents, impression and difficulty level for children respectively. Parents also viewed the course favorably, with 81.3 % (13 out of 16) stating that it was excellent and 18.8 % (3 out of 16) responding that it was good. In addition, 87.5 % (14 out of 16) described the material is excellent for children to understand and 12.5 % (2 out of 16) said it was good. Free responses included the following: “It was good to learn in an easy-to-understand manner, even at the elementary school student’s level,” “It was good that the quiz form was devised,” “I was able to raise the consciousness of conservation,” and “Teaching about the importance of learning was good.”



**Figure 8.** Parents' answer of the questionnaire in the impression for children of the course



**Figure 9.** Parents' answer of the questionnaire in the difficulty level for children of the course

## DISCUSSION

In this course, quizzes were created from a functional-morphological point of view, and marine education was conducted. In terms of the quiz about the sea turtle, an increase in the correct answer rate was observed after giving morphological hints. Regarding the entire silhouette, a correct answer rate of 81.3 % was obtained even before hints were given (Figure 5). Students had many opportunities to observe marine creatures in the aquarium (Kamezaki & Nakamura, 2017), and various educational materials were used. In contrast, regarding the limbs and carapace, the percentage of correct answers rose considerably after hints were given (Figure 5). The lower answer rate before students received hints indicated that they were not generally aware of how each part of sea turtle is used or is useful. Although there were many opportunities to grasp children's impression of the whole form, it is presumed that they had no experience observing each part or considering the respective functions. By giving hints about the function based on something that functioned similarly, the correct answer rate rose dominantly, indicating that the function of each body part can be inferred from illustrations of things with reflecting functions. The form of an organism often reflects the function of the whole and each part (Omura & Endo, 2014; Omura et al., 2015). It is suggested that the quiz for identifying habitats based on shape is useful in functional-morphological education.

Various contents are being implemented in marine education programs (Kashio, 2016; Kohno et al., 2016). Lectures focusing on the shapes of living things tend to convey their names and ecology (Kashio, 2016), but few mention the relationship between shape and function (Iwama, Hatogai, Matsubara, Yamagishi, & Shimojo, 2008). It seems important to communicate which form is appropriate for living in the sea, as this knowledge is helpful for understanding marine life and the marine environment, since the form is related their adaptive strategy of life in habitats (Omura & Endo, 2014). Therefore, it can be concluded that it is useful to educate students about marine life and how it differs from land. Especially, the functional-morphological viewpoint seems to be highly useful because it facilitates understanding among first-time learners because of the highly visibility (Arima et al., 2012).

There are many reports on the importance of incorporating games in teaching materials (Fujioka et al., 2011; Okazaki, 2017), and it is said to be useful for motivating learners (Okazaki, 2017). In this course, learners raised their hands and answered questions positively; thus, active learning efforts were observed. Many answers to the questionnaire distributed to learners indicated that quizzes were more useful than unilateral lectures. Most children participated the course answered that the course was excellent or good (**Figures 6 and 7**). In addition, results of the questionnaire for parents indicated that the degree of impression and degree of difficulty level for children were excellent or good (**Figures 8 and 9**) and answered the quiz format was appropriate. Therefore, it is suggested that using quiz of functional morphology is effective for marine science education. In recent years, the importance of active learning has been stated, and it is significant that two-way communication (not one-way lessons) engages learners (Koyama & Mizokami, 2018; Sunaga, 2010). Though real experience in nature is optimal for interacting with it (Furihata, Miyano, Nojo, & Fujii, 2009), teaching materials for enhancing interest regarding creatures that cannot be easily seen (e.g., sea turtles) are helpful (Okazaki, 2017). Therefore, it is inferred that the quiz format of this study is very effective.

In this course, we introduced sea turtles from the functional-morphological perspective and lectured on biology and conservation. According to the questionnaire given to children in participants, consciousness of conservation increased in this research. All seven species of sea turtles are in danger of extinction (Kamezaki, 2012). Therefore, conservation activities for sea turtles are being carried out around the world (Cruz, Shillinger, Robinson, Santidrián, & Paladino, 2018; Hassan et al., 2017; Spotila, 2004). Also in Japan, the conservation activity have been done and many research studies have conducted for conservation of sea turtles, such as an investigation regarding the development of a net to prevent bycatch by longline (Matsushita, 2000). However, Japan is lagging behind in the conservation of biodiversity, and it has been portrayed as the country with the most negative impact on the sea turtle worldwide (Spotila, 2004). Although sea turtles are released for marine education programs presented to the general public in Japan, it is reported that this activity exerts a negative influence on the ecology of the species (Kamezaki, 2012). This situation still remains unchanged and releasing the sea turtle in the daytime has a high possibility creating an adverse effect (Okuyama, 2010). Therefore, it is needed for educators to not only provoke children's interest in living things but also to communicate that conservation and countermeasures for marine lives must be done from the "correct" knowledge (Okuyama, 2010). This course will generate interest in the sea turtle and its habitat, and it will be beneficial for future conservation activities and studies related to the marine environment.

In this research, we developed quizzes from a functional-morphological point of view, conducted marine science education, and examined its usefulness. Marine education seems most effective when conducted in nature, but some contents can only be taught in the classroom (Kohno et al., 2016). Teaching materials also can be delivered to children when they cannot participate in outdoor activities such as in hospitals (Taniguchi, 2005). The development of teaching materials is also important, and efforts in the future should include cooperation with diverse organizations to ensure that a variety of teaching materials are designed to meet the needs of diverse groups.

## ACKNOWLEDGEMENT

To promote this research, we would like to express appreciation to the Gakushuin Sakura Academy staff who have been working on the course. We would like to thank Pr. Masashi Kimura for giving us the useful guidance of making the illustration in the teaching materials, and Dr. Takanori Maehara for giving us the useful advice of the statistical test.

We would like to thank Sunshine Aquarium for giving us permission of using the tortoise's photos in the teaching materials. We would like to thank Editage ([www.editage.jp](http://www.editage.jp)) for English language editing. Moreover, this work was supported by the Sasakawa Research Grant under Grant <number 2018-8027>.

## Disclosure statement

No potential conflict of interest was reported by the authors.

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