

Touch national monument: web-based AR application of *Taniwhasaurus mikasaensis*

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Mosasauroidea is a group of aquatic lizards living in the Late Cretaceous sea. They are found worldwide. *Taniwhasaurus mikasaensis* Caldwell et al. 2008 is a species of Mosasauridae and was found from the Kashima Formation, the Santonian-Campanian boundary interval, the Upper Cretaceous. This type specimen was chosen for Japan's National monument on July 16th, 1976 for the first discovery of terrestrial carnivorous dinosaurs (at the time of discovery of the specimen, it was identified to Tyrannosauroidae).

Including the holotype of *T. mikasaensis*, only four fossils are registered as Japan's National Monument. In addition, the other fossils of National Monuments are registered with its localities. Namely, the holotype of *T. mikasaensis* is an only fossil alone registered National Monument. Therefore, there is no opportunity to touch by non-experts and to see in another museum for special exhibition or fossil replica because the change of existing condition is strongly restricted by the law. In addition, the Holotype of *T. mikasaensis* is housed in a local museum of Japan and then it is difficult to touch or research that for "foreigners".

To change this situation, firstly, we made 3D data of *T. mikasaensis* for the original specimen available for various uses such as research and educational outreach. This model, obtained through a simple and cheap procedure, accurately describes the whole bony structure of the mosasaurid skull, sutures, and teeth. We made some types of outreach tools of *T. mikasaensis*. First, we made some sizes of replicas by using 3D printers (AFINIA). These replicas were changed "untouchable" situation of the national monument. Second, we made a web-based AR application using this 3D model and surface texture data. The web-based system does not need special equipment or APP for display AR model. We used A-frame and AR.js for making an AR system. AR.js are generally used marker for showing 3D models in smartphones.

Then, we verified the educational effect of these 3D data of *T. mikasaensis*. On July 13th, 2019, we carried out a hands-on education program for *T. mikasaensis*. Experiment peoples were general visitors from teens to the 50s. First, they viewed an exhibition room where the holotype of *T. mikasaensis* was put in, and then they moved to the hands-on booth. In this booth, the followers were exhibited; a photo of *T. mikasaensis*, two 3D printed replicas, a whole-body skeleton and a reconstruction illustration of *T. mikasaensis*, and some sets of a QR code and a marker for the web-based AR application. Visitors experienced AR with their own smartphones or the arranged tablet PC. A curator explained the outline and importance of *T. mikasaensis* and then, visitors touched models and AR freely.

Questionnaires by visitors show this hands-on experiment improved their interests for *T. mikasaensis*. In addition, visitors often asked the curator about how 3D models and AR made. These hands-on experiments aroused interests to visitors for not only paleontology but also advanced technology. We concluded these hands-on experiments have a good interdisciplinary effect.

The holotype of *T. mikasaensis* was one of the rare mosasaurid skulls in Japan. This specimen was difficult to move because of legislatively and physically (about 22 kg in weight). In contrast, 3D printed models or

AR enable them to observe accurately everywhere. Therefore, in the future, it was expected to provide more research chance to worldwide researchers with our digital contains.

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