DINOSAU IN 3D

Institute for the Study of Mongolian Dinosaurs (ISMD) team and 2019 summer workshop participants.

Dr. Bolor Minjin (bottom left), Gabriel Santos (top middle left) and Michael Ziegler (top middle right).

DINOSAURS IN 3D

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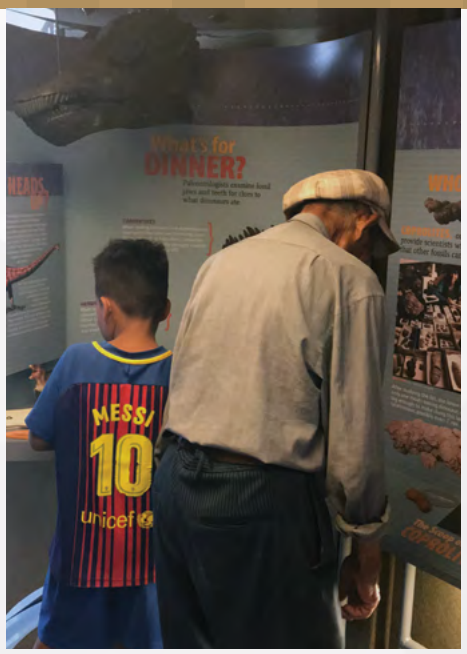
For decades, dinosaur fossils have been taken from their ancient resting grounds in Mongolia, and transported to museums, research facilities, and illicit private collections outside of the country. Recently, however, thanks to the collaboration of Marston Engineering Librarian Jean Bossart, Florida Museum of Natural History Paleontologist Michael Ziegler, and Mongolian Paleontologist Dr. Bolortsetseg 'Bolor' Minjin, a set of 3D-printed dinosaur models recently made the 7,000-mile trip between Marston Science Library and their rightful home.

Mongolian educator and participant of the ISMD summer workshop taking measurements of 3D-printed Velociraptor mongoliensis *skull.*



Mongolian family explores the interactive exhibits on the ISMD Moveable Museum and listens to information from a student leader.

Mongolian students lining up to enter the ISMD Moveable Museum.

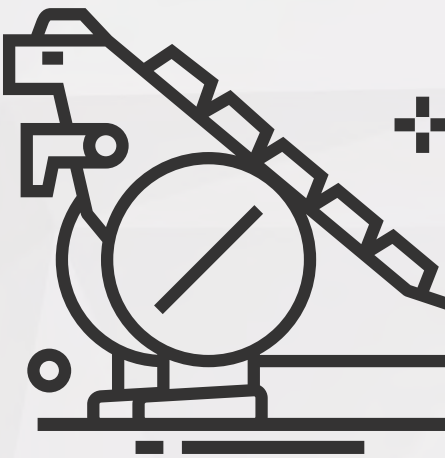
The Gobi Desert, within Mongolia, is host to some of the most exciting and impressive paleontological discoveries. However, the history of paleontology in Mongolia is defined by international scientists and fossil hunters visiting to do fieldwork and removing the fossils from their home country. Dr. Minjin recognized that her country's treasure of dinosaur fossils was being steadily lost to this illicit fossil market. She led efforts to reverse these losses by founding the non-profit Institute for the Study of Mongolian Dinosaurs (ISMD). The ISMD focuses on repatriation of dinosaur fossils from the scattered corners of the globe to its own Central Museum of Mongolian Dinosaurs in Ulaanbaatar. They also seek to build the next generation of Mongolian paleontologists, through educational outreach and professional training, who can lead

Mongolian students tour the ISMD Moveable museum and ask Dr. Bolor Minjin questions.

"Fossils can be rare or delicate and are often housed in research universities or museums.

Printing high-fidelity models of these discoveries allow fossils to be, in a way, rediscovered and enjoyed by educators and students worldwide."

- Michael Ziegler



The Smathers Libraries' 3D service printed 16 copies each of the Psittacosaurus *and* Velociraptor *skulls to share with K-12 educators in Mongolia.*

their own in-country field work instead of leaving the task to foreign researchers who will continue to spirit away the evidence of Mongolia's rich natural history. The ISMD holds training workshops for K-12 teachers, and even hosts a mobile museum bus that visits schools across rural Mongolia, inspiring an interest in paleontology in the next generation. This can be a challenge, however, as the removal of most of the fossils from Mongolia means there is little to show the students.

Michael Ziegler is a partner with the ISMD and recently visited Mongolia to assist with the education of K-12 teachers. Before he left Florida, Ziegler contacted Jean Bossart and Sara Gonzalez to see if the Smathers Libraries 3D service could collaborate in printing 32 copies of 3D scans of the skulls of *Velociraptor mongoliensis*, more commonly known as the ever popular *Velociraptor*, and *Psittacosaurus amitabha*, a newly discovered species of *Ceratopsian* dinosaur from central Mongolia. These prints would provide the children in Mongolia with real, tangible examples of their native dinosaur fossils.

3D printing is a manufacturing process that uses super-heated plastic filament to build physical models layer by layer. The Smathers Libraries has offered 3D-printing services since 2014, and it has become incredibly popular in the years since it was first introduced. Anyone, from UF student and staff to unaffiliated members of the public, can use the service if they have a 3D model.

Ziegler's models of the *Velociraptor* and *Psittacosaurus* skulls were created by 3D scanning existing fossils, which allowed for a high degree of accuracy and realism. Moreover, the fossils were just the right size to fit on the bed of the 3D printers. However, the Marston 3D printers typically deposit layers of plastic in 0.02 mm thickness. Each layer being meticulously added by the machine, one after another, with such a minute attention to detail, meant that each dinosaur head took approximately 14 hours to complete. The 3D team knew that Ziegler would be leaving for Mongolia in only ten days. So, determined to complete the project in time, they set up a system to leave the printers running all through the night, almost nonstop, in order to finish enough copies of the dinosaur skulls in time. They successfully finished in time for Ziegler to package the fossil models and carry them in his luggage to Mongolia.

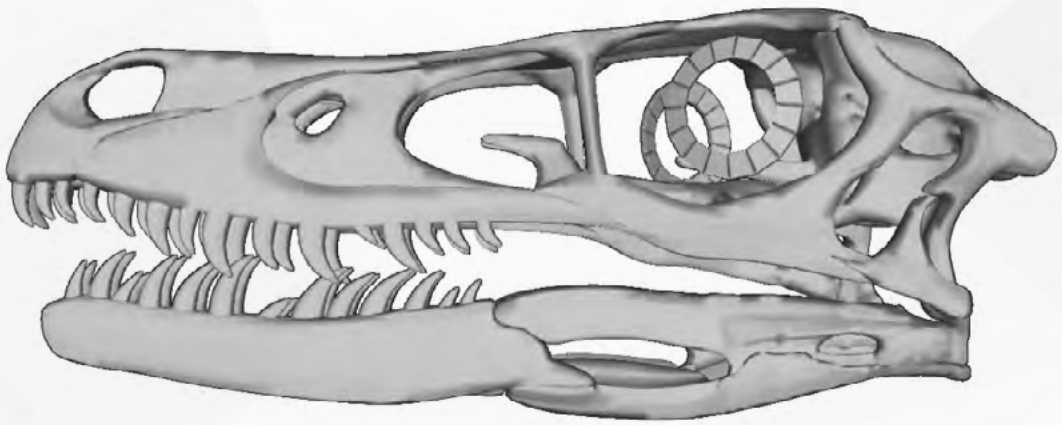
The models were enthusiastically received by the educators in Mongolia. Lessons were designed that allowed students to measure the length of a *Velociraptor* skull and use this to estimate how large the dinosaur's whole body would have been. Many expressed surprise to learn how small these dinosaurs actually were in life, usually no higher than a human knee. Another lesson compared the formation of the teeth on the *Velociraptor* and the *Psittacosaurus*. Students were encouraged to guess from the shape of their teeth what these dinosaurs would have eaten while they were alive, using the teeth of modern animals with known diets as a point of comparison. The skulls were also used in the mobile museum, allowing not just children but entire families who had never seen fossils before to experience their country's rich natural history.

3D model of the *Herbivorous* dinosaur, *Psittacosaurus amitabha* skull

(lateral view), from the early Cretaceous Period (around 125 million years ago) of Mongolia. 16 full-scale replicas were printed out and used in an ISMD lesson plan geared towards analyzing what diet of a dinosaur would be based on the shape of their teeth.

3D model of the carnivorous dinosaur, *Velociraptor mongoliensis* skull

(lateral view), from the late Cretaceous Period (around 75 million years ago) of Mongolia. 16 full-scale replicas were printed out and used in an ISMD lesson plan aimed at calculating the mass of a Velociraptor *if it were alive.*



And these projects were just the beginning. When asked about the potential applications of 3D printing to paleontology, Ziegler was enthusiastic and insightful. He explained that one of the best facets of 3D printing was its ability to scale a model perfectly without losing the integrity. This "allows researchers to create 3D models of any size, from giant extinct bison (*Bison latifrons*) to microscopic single-celled organisms called *Foraminifera* and resize them to print out for educational use."

Education and outreach are important aspects of the Smathers Libraries' mission, and those objectives were well and truly achieved by this project. Ziegler explains, "Fossils and 3D models are gateways into STEM and help highlight larger concepts like what makes a fossil a fossil, the process of science and deep time. 3D printing often captures the attention by taking abstract concepts or fossils of unimaginable size and putting them into the hands of learners as a tangible object." By collaborating with Dr. Minjin, the ISMD, and Michael Ziegler, the 3D print team has contributed not just 32 plastic printed dinosaur skulls, but an example of a history that is being lost, and an inspiration for generations of Mongolian paleontologists to come.