Bringing biological sounds to the classroom: 3D printing the creatures of the earth and the oceans

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Summary

This project entails the development of 3D printed animal models to enable the incorporation of active learning into bioacoustics and vibroacoustic teaching within the school of environmental sciences (SoES). Beginning with an inter-disciplinary competition, students were tasked with researching sound-producing animals, finding recordings of their respective sounds, supporting the 3D printing process, painting, and finishing of the various models. This approach promotes opportunities such as utilising the models to demonstrate acoustic 'masking', where a biological signal is inaudible due to a noise signal and teaches students aspects such as noise impacts and pollution. Additionally, this approach was found to develop student confidence and increase digital skills, as students learn about the 3D printing process and sourcing the appropriate animal sounds from research leaders and repositories from around the world.

Please briefly describe the activity undertaken for the case study

Many animals, aquatic and terrestrial, make sounds and vibrations to communicate. Some sounds are very well known, such as elephant trumpets or cricket songs. However, there is a whole world of biological sounds that most people have never heard or thought about. For example, have you ever heard a fish "*grunt*"..? One way to increase student and public engagement is to use active learning techniques. Acoustics is well adapted to this mode of engagement since we can 'play out' sounds to listeners. Additionally, recent technological advances mean that we can now 3D-print objects to produce hands-on learning tools quite readily. Combining these techniques here we used an innovative educational approach to bring biological sounds into the classroom by 3D printing animal models, with loudspeakers associated. The models played out their respective sounds, and therefore acted as hand-held visual, tactile, and aural educational tools for student engagement.

How was the activity implemented?

In an inter-disciplinary competition, students were tasked with researching sound-producing animals, finding recordings of their respective sounds, and helping with the 3D printing process. Miniature 'test' prints of the chosen animals were printed on campus in the Central Teaching Laboratory with assistance from staff there. For the full-size prints we utilised a local independent 3D print shop* for the prints and chose a compostable biodegradable plastic polymer.

Animals were chosen which have 'unusual' sounds which we thought people may not have heard before. Overall, we printed 6 extra-large [c.a. 25 – 30 cm] animal models: long snout seahorse, cane toad, African elephant, killer whale, American alligator and haddock (Latin names: *Hippocampus reidi; Rhinella marina; Loxodonta africana; Orcinus orca; Alligator mississippiensis; Melanogrammus aeglefinus*). We also had a medium [c.a. 15 – 20 cm] set printed of all the above, plus eastern kangaroo, red drum, shoebill bird and cockchafer beetle larvae (latin names: *Macropus giganteus; Sciaenops ocellatus; Balaeniceps rex; Melolontha melolontha)*.

We recruited three students to assist with the painting process, who primed, painted, and varnished all the models. Audio recordings for each model were sourced directly via the leads research contacts or by contacting the authors of papers. The sources of the clips included researchers at Oxford university, East Carolina University, Hochschule Geisenheim University, Cornell University, and the State University of Paraiba. We purchased Bluetooth speakers, one per model, to play out the recordings at the press of a button.

We hosted an exhibition in the Sydney Jones library on campus to display the models. Attendees could press the buttons on the loudspeakers to listen to the sounds, plus read information about the project itself and details of the contributing sound researchers and artists. Students and staff from across campus came to interact with the materials.

The animal models are currently on display in the Nicholson building on the 3rd floor.

Has this activity improved programme provision and student experience, if so how?

Models can be incorporated into bioacoustics and vibroacoustic teaching within the school of environmental sciences, with varying levels of complexity. As an example, we can utilise the models to demonstrate acoustic 'masking', where a biological signal is inaudible due to a noise signal (in the marine environment, boat engine noise, for example); and teach about noise impacts and pollution. Now that the models are ready, we also plan to use these at ADD applicant discovery days and open days in a 'guess the sound' type activity. Several staff members suggested that we take the exhibition out to local schools. Various activities can be designed according to the age group of the cohort targeted.

Did you experience any challenges in implementation and if so how did you overcome these?

Animal choice was in part dictated by how delicate the resulting model would be. For example, insects and crustaceans have thin legs which are more difficult to reliably reproduce at the size we required. Additionally, the original idea of the project was to embed speakers within each animal model, however, it soon became apparent that it was better to have the speakers next to the models, since the body cavity volume of the animals chosen was highly variable.

The intended plan for this project was that students would liaise with the 3D printer technicians to learn about the 3D design and print process. Students seemed less willing to engage with that side of the project (preferring the essay side of the task instead). Perhaps that aspect of the task seemed too daunting and could have been made more approachable with a little more project time.

How does this case study relate to the Hallmarks and Attributes you have selected?

This project is linked to the LCF Hallmarks of:

- **Research-connected teaching:** this grant relates particularly to the lead's own expertise of bioacoustics. This is a new area which the Ecology and Marine Biology group, hence this project has been a first step in introducing students to the topic. This grant also provides a hands-on active teaching method to the topic.

- **Active learning:** instead of asking students to read about sound production and animal behaviour, these models stimulate the imagination by bringing these aspects to life in 3D representations. Students and staff enjoyed pressing the buttons and playing the audio clips and were clearly interested in engaging with the exhibition. This active learning tool will hopefully remain in the students' minds, so that they continue to think about animal bioacoustics.

This project is linked to the LCF attributes of:

- **Confidence:** We were impressed at how engaged the students who were specifically involved were. The various tasks were new to them, and they approached them with relish. We encouraged students who were involved with this project to add the tasks to their CV, to show they have experience in other skills aside from their direct topic of study.

- **Digital fluency:** (finding information, critical evaluation, managing digital practises): students engaged with this project engaged with digital platforms to research the animals, to collect audio files and to connect with researchers worldwide.

How could this case study be transferred to other disciplines?

Although the acoustic aspect of this activity is somewhat specific to aural disciplines, the use of 3D printing can be extended to almost any discipline where an in-person model would be helpful. For example, printing of 3D molecules for chemistry, or of structures for engineering. Sets of models could also form parts of outreach activities or displays, as well as being utilised on campus.

If someone else were to implement the activity within your case study, what advice would you give to them?

The print process itself, which involves finding (or creating) suitable .STL or .OBJ files to be sent to the printer, needs some time. It is helpful to have assistance with this either via print technicians or by 3D-modellers. We do have on-campus expertise to help with this. For this project we utilised existing animal files sourced from online repositories, but other projects with more specific requirements would need to create bespoke model files and should build in time and budget to do this.

Examples of Models

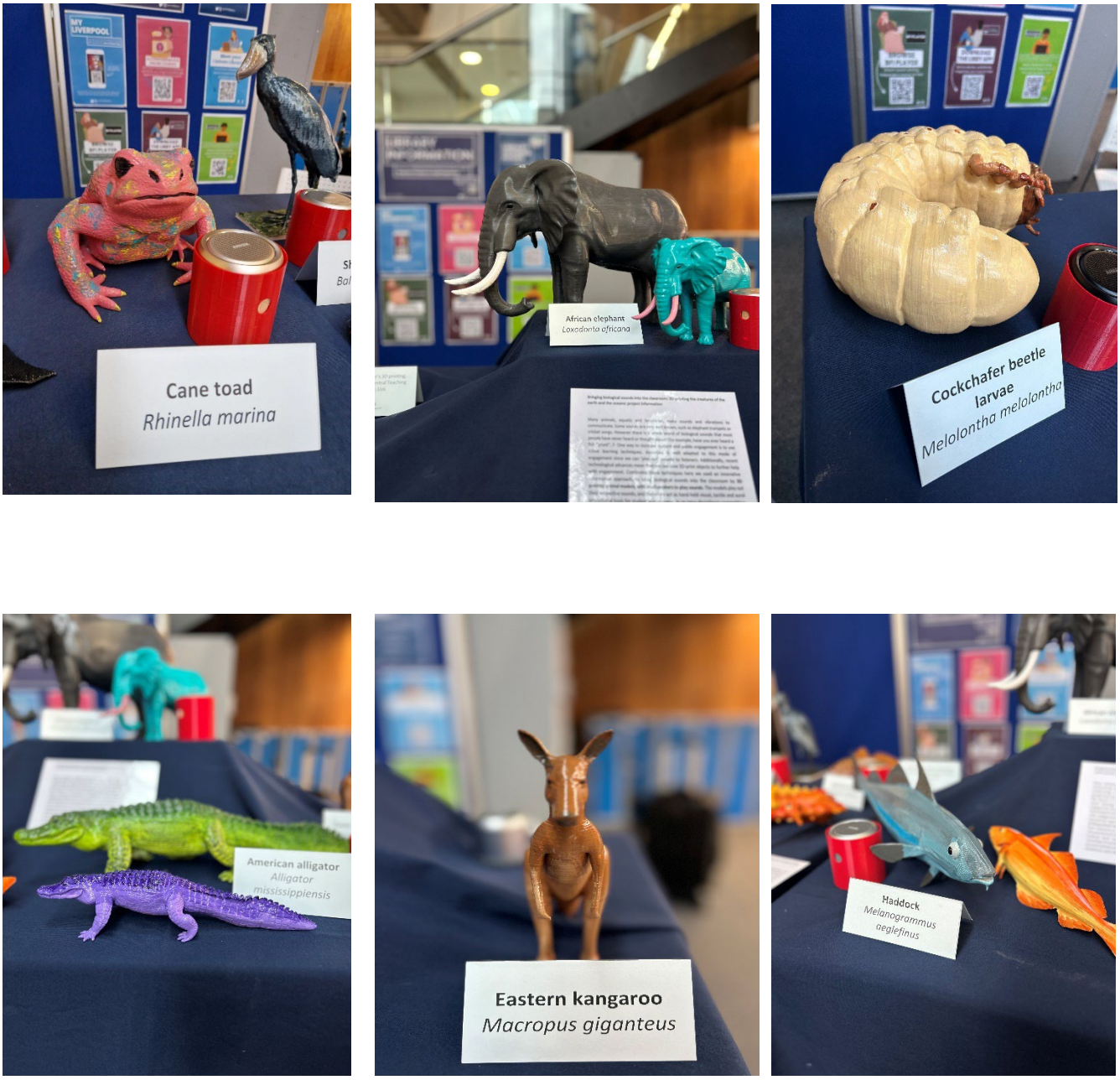


Fig.1 - A selection of photographs taken at the November 2023 exhibition at the library on campus. Image credit: CIE photographer/Rebecca Atkinson CIE.

Fig. 2 - A selection of photographs taken at the November 2023 exhibition at the library on campus, project leader (LR) shown right. Top image credit: CIE photographer/Rebecca Atkinson CIE; Bottom image credit: Roger's 3D printing.

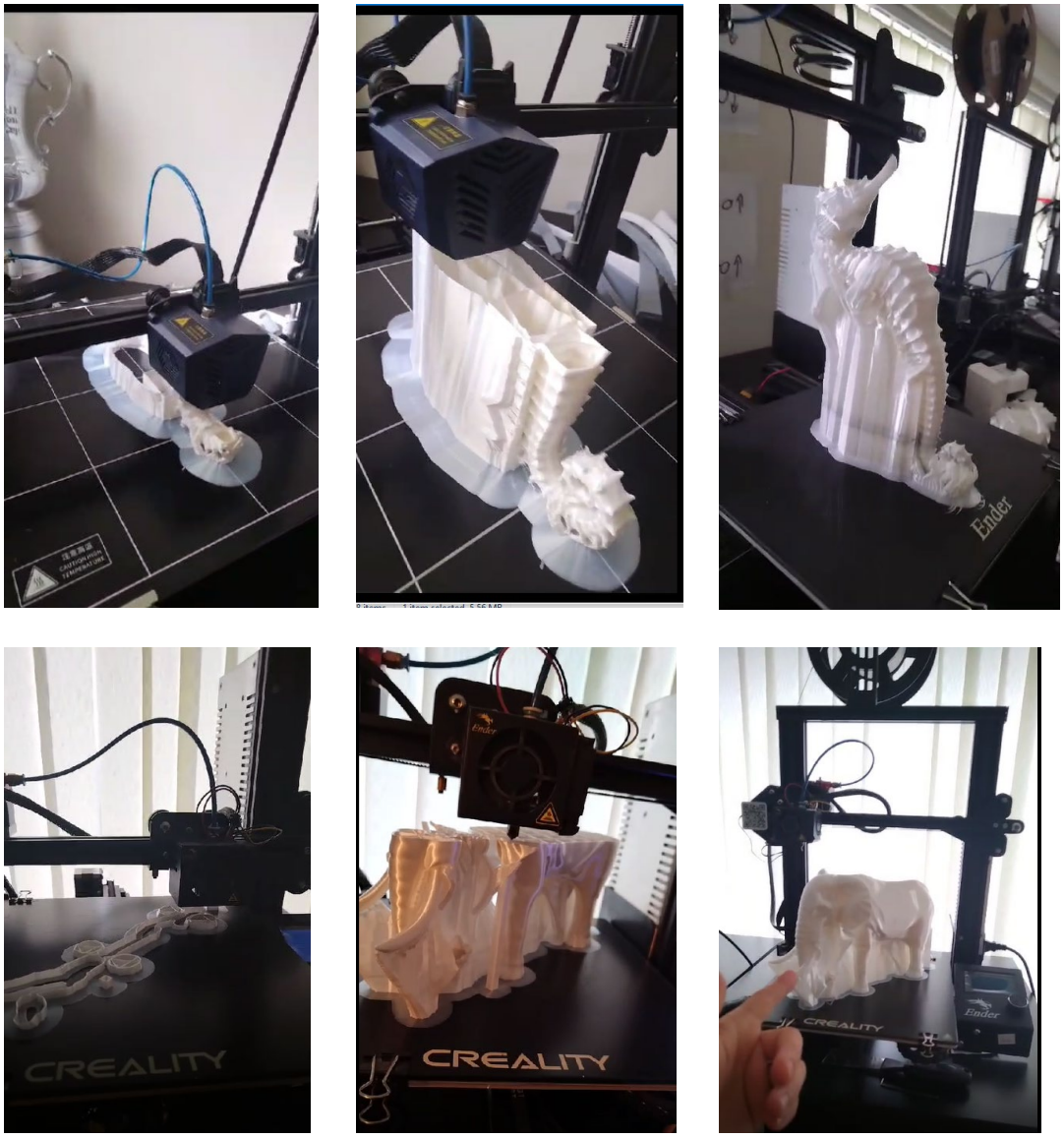
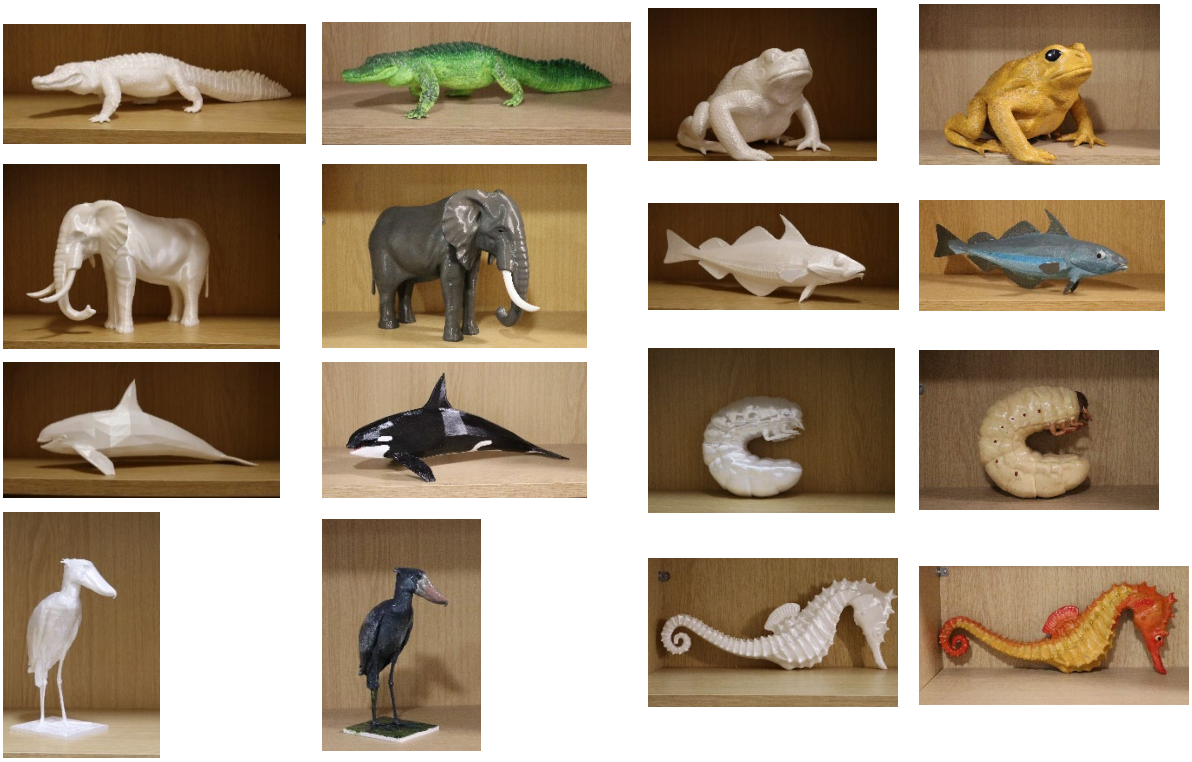


Fig. 3 - Video stills showing the 3D print process. Top - the seahorse print on the printer, with the left being the beginning stages and then the far right being nearly finished. Bottom - the elephant print, again showing the progression of the print from left to right. Each model is printed with added supporting structures, which are then removed after printing. Video credits: Roger's 3D printing shop.

Fig. 4 - Photograph of three of the 3D printers at the chosen print shop during the printing process. Photo credits: Roger's 3D Printing shop.



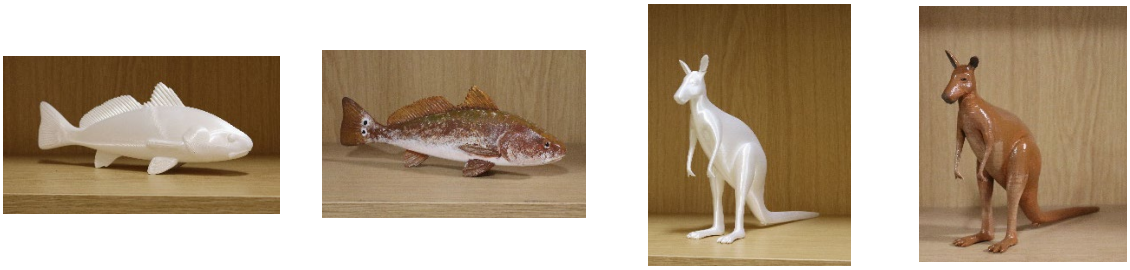


Fig. 5 - A selection of the completed models, before (in white) and after student painting (coloured); From top row left to right: American alligator; Cane toad; African elephant; Haddock; Southern killer whale; Cockchafer beetle larvae; Spoonbill bird; Long snout seahorse; Red drum; Eastern kangaroo. Photo credit: Jack Walker.

Fig. 6 - All the completed models, which were printed in white polymer and then painted in colour my student helpers. Photo credit: Jack Walker. The models are currently on display in the Nicholson building, 3rd floor corridor opposite room 306. The exhibition name plates, and the printed information about the project are also displayed there.

References

Roger's 3D-print shop; Gateacre, Liverpool; www.rogers3Dprinting.com