The University of Edinburgh
Principal's Teaching Award Scheme

Project Final Report

Where Art Meets Science: Development and Evaluation of Innovative 3-D Models for Undergraduate Education

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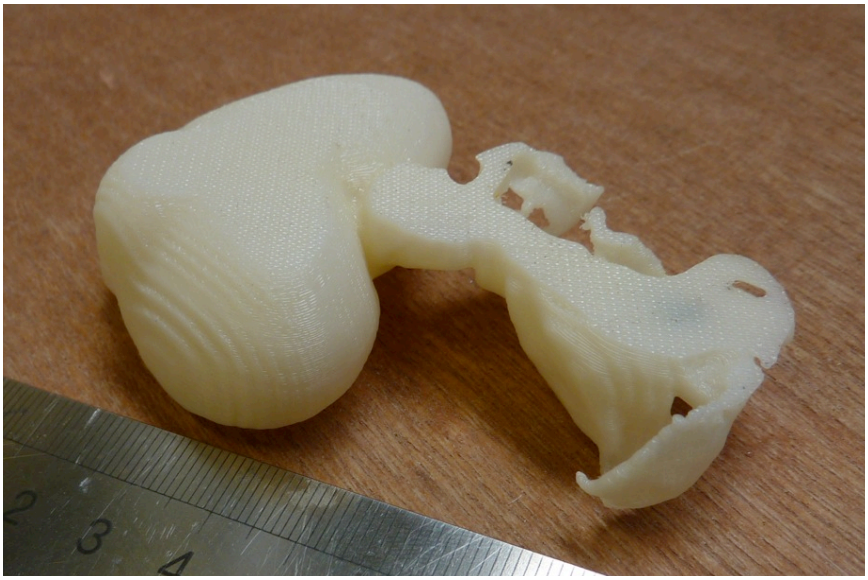
This report outlines the outcomes of our PTAS-funded study on the use of 3D printed models of animal body parts for undergraduate education of veterinary and art students at the University of Edinburgh.

Veterinary students need to develop a deep understanding of the anatomy of the entire body of numerous species to be able to diagnose and treat diseases effectively. Given the detail required and large variation between species this is a daunting task to achieve in a 5-year-curriculum. In the recent past, other important subjects had to be incorporated into the limited veterinary curriculum, making anatomic learning ever more challenging and demanding. To link theory into praxis physical anatomical specimen are essential. This allows students to gain a three-dimensional comprehension of anatomy, gain insights into structure and function, distinguish normal from abnormal and make their first steps to surgical planning. For art students learning about the anatomy of the body is also an essential part of their curriculum, albeit from a different perspective. The animal kingdom is an attractive area of interest for many artists.

The Royal (Dick) School of Veterinary Studies and the Edinburgh College of Art have good ties and have collaborated successfully in the past. The recent purchase of a 3D printer by the Edinburgh College of Art and the skills and expertise they developed opened a new avenue of collaboration with veterinary educators. In the diagnostic imaging department of the R(D)VS we generate many CT scans of a variety of species that lend themselves for 3D printing. A joint project was designed to develop 3D prints from CT scans and digitised specimen, to involve students and staff in the generation of these 3D prints and to use them in different ways.

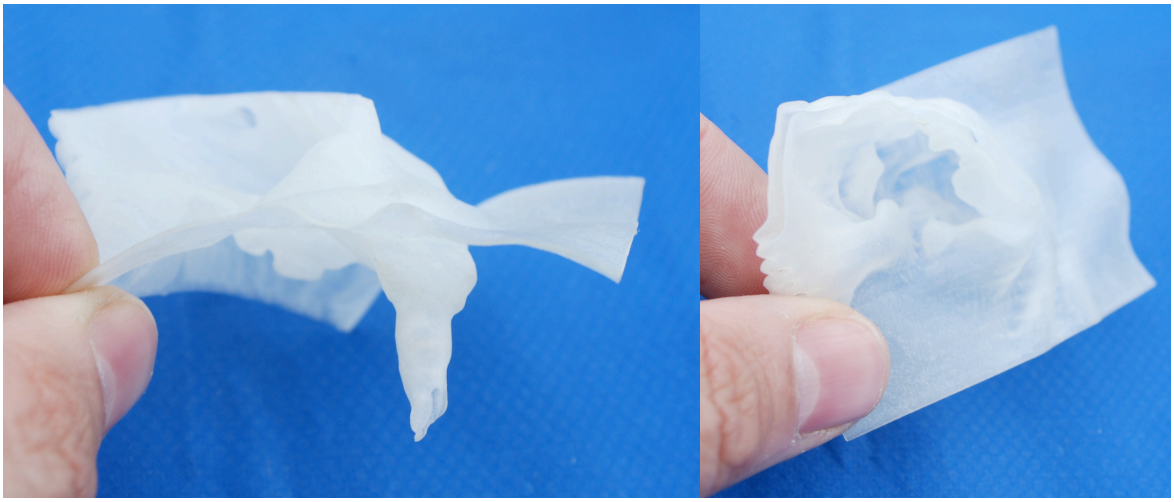
In the first part of the project 3D prints were generated from CT scans of animals and animal body parts, such as skulls, teeth, vertebrae, long bones but also soft tissue organs like spleens and kidneys. Normal and pathologic specimen were scanned and



3D print of a diseased feline kidney, based on a CT scans of a formalin-fixed specimen.

printed. Two veterinary students were involved in assisting to generate the 3D prints as part of their self-directed study project. Tests of several trial versions software were done to find software that is easy to use for a non-expert to make a CT generated 3D model print ready. Based on this the hardware specifications were established and two computers were purchased and loaded with the software to generate the 3D files and to make them print ready. Two main projects evolved out of this project. One was to determine the optimal CT settings for 3D printing of specimen. For this a canine lumbar vertebra was CT scanned with different technical settings and 3D prints were generated and anonymised. The data collection part of this study is now finished and we will soon evaluate the print quality using objective criteria. We anticipate manuscript submission at the end of 2014. The other project involves the generation of a 3D model of the canine ear. This model should be used by students to learn the techniques of doing a visual ear examination including the tympanic membrane (otoscopy) and to properly perform external ear cleaning. The canine ear canal is angled and the technique requires some bending of the ear canal with the instrumentation. Initial prints in ABS plastic provided an excellent anatomic model of the external ear, however the material is too rigid. The ECA recently acquired an additional, more advanced 3D printer that can also print elastic material and trials of an elastic external ear print are currently on-going. We also have the anticipation to finalise this project by the end of 2014 and to create an otoscopy/ ear cleaning station with this model at the Clinical Skills Lab of the R(D)SVS.

Other projects included 3D prints of canine angular limb deformities, the skull of dogs and cats for surgical procedure planning, equine bone specimen and the skull of a Babirusa pig. We have also printed out objects enlarged or minified, with selected cut-surfaces to allow visualisation of the internal anatomy. We have printed over 50 objects as part of this project so far, exceeding our initial expectations of 10 objects by far. Veterinary clinicians have used these models for small group teaching



3D print of a canine external and middle ear using elastic translucent material.

with veterinary students in their final year rotation.

Another part of the project was to generate 3D images of objects that were also 3D printed, using an application on an Ipad. Three Ipads were purchased and three students are currently generating 3D images of these objects. Within the next three months we anticipate performing the questionnaires and gather the results of this part of the study.

We had several meetings with groups of veterinary and art students and educators both at ECA and the R(D)SVS including a large exhibition of 3D prints and an interactive workshop which included painting of 3D prints. Students and staff were excited about the potential of 3D printing. The possibility to magnify small structures, to see the intricate anatomical detail, to assist in creating a spatial awareness of complex structures were all viewed as very positive and inspiring.

In the last two months we have worked hard on creating an infrastructure allowing a wide participation in the generation and use of 3D printing and intensify collaboration between our colleges. The R(D)SVS has purchased from internal funds a simple 3D printer that can print PLA material. ECA is hosting in collaboration with the medical school a top-of-the line 3D printer that can print specimen in multiple colours and with stiff and elastic material. We hope to continue our collaborative effort and sharing of experiences and resources to make 3D-printing a widely used teaching, research and clinical tool.

The project is being presented at 3 different congresses so far (presenter underlined)

Schwarz T, Collins R (2013):
Practical considerations in 3D printing in biology.
Centre for In Vivo Imaging Sciences (CIVIS) 2013 Annual Scientific Meeting
Little France Campus, The University of Edinburgh, UK, 28.11.2013.

Schwarz T, Smith J, Roe A, Collins R, Bell C, Gardiner A, Clarkson E Paterson J, Mather B, Rhind S (2014):
Where art meets science: development and evaluation of innovative 3D models for undergraduate education.
Veterinary Education Symposium, Bristol, UK, July 10-11, 2014
(poster) abstract in: *Proceedings* p. 62.

Schwarz T, Bell C, Collins R, Rhind S (2014):
Generation of 3D printed models from animal CT scans for clinical and teaching purposes.
2014 EVDI Annual Meeting, Utrecht, The Netherlands, August 27-30, 2014
(oral presentation) abstract in: *Proceedings* in press; *Vet Radiol Ultrasound* 55 (2014), in press.

Our project has been a great success, in that it has brought 3D printing to the attention of a range of University of Edinburgh students, teaching staff and researchers. We are enormously grateful for receiving this grant and will continue our commitment to 3D printing.

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