DOMAIN 1b: Development of Enduring Educational Materials Do not exceed 2 pages.	
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1. Educational Product: Identify the impactful educational material you've select to focus on.

Virtual Animal Anatomy

2. Your role(s): Describe your role(s) and specifically what you contribute.

Started in 2005, CSU's Virtual Veterinary Education Tools (VVET) team known for best for the Virtual Canine Anatomy (VCA) and Veterinary Neurologic Exam programs. I joined VVET in 2012 to expand the virtual anatomy species offerings to include feline, equine, and bovine anatomical resources, as well as secure extramural funding for this work. I became VVET Program Lead in 2018 and am responsible for the for VVET software development and distribution.

3. Learners and amount of contact: Describe how the material is being utilized – i.e. specifically where, when (*duration/frequency*), and by whom (*the types, levels and numbers of learners involved*).

Use of the suite of Virtual Animal Anatomy (VAA) software has depended on program distribution strategies. From 2015-2018, there were more than 337,000 users in 198 countries who accessed a free website hosting VCA. In 2018 I initiated conversion of the software from Adobe Flash into HTML5 and restricted access to either software download of the Adobe Flash version of the programs ($40ea) or learning management system (LMS) secure subscription as service (SAS) access to the HTML5. From August 2018-March 2020, there were more than 600 Adobe Flash software downloads and four 12 month SAS contracts ($3,000ea), with 3 veterinary technician programs (San Joaquin Valley College, Medialle College, Georgian College) and one professional DVM program (University of Pennsylvania). From March-July 1, 2020 the SAS VAA is freely available in response to COVID-19 and is in use by more than 100 schools (K-12, undergraduate, and professional veterinary and technician programs) worldwide.

4. Goals and learning objectives: List goals and learning objectives of the educational product. If these are extensive, provide just a few illustrative examples.

1) VAA Program Goals: a) to enhance student learning and b) increase the availability of instructional materials for anatomy teaching.
2) VVET Program Goals: to establish sufficient program income by 2023 to sustain the VVET development team and program growth. VVET has been heavily subsided by the College of Veterinary Medicine and Biomedical Sciences (CVMBS) at CSU with support for two part-time instructional technologist/software developers and an annual operating budget of $25,000 to support student employees.

5. Methods: Briefly describe the product / materials – i.e. the methods used and how these align with objectives.

1) VAA is the only virtual animal anatomy software tool that utilizes photographic capture of real cadaveric dissection. Osteology, surface anatomy, and radiology are coupled with cadavers dissected layer-by-layer using a regional approach. Each layer is captured photographically to create a 360° point cloud of the specimen for three-dimensional (3D) rendering, then coupled with structure identification and text to inform the user of the structures in each layer.
2) VVET was issued an Invention Disclosure (INV18-084) in 2018 for the Adobe Flash version of the VAA and we began licensing VAA as a software download. I began working with CSU's technology transfer unit, CSUVentures, and took VVET through their Research to Market program improve my understanding of the VAA value proposition, target market, and potential. VAA was converted to HTML5 because Adobe Flash will become obsolete by December 2020. The HTML5 version can be hosted through an LMS via an Learning Tool Interoperablilty (LTI) or within an LMS. These SAS distribution models prevent piracy of the program content and streamline software delivery updates.

6. Rationale: Describe why and how you chose the method(s) you used.

1) Instruction in gross domestic animal anatomy is challenging to deliver as it requires preserved specimens from a variety of species, a specialized laboratory with specimen storage and sufficient air exchange to remove the toxic fumes from those specimens, and access to specimens for embalming. Providing students with unlimited access to a cadaveric laboratory for self-study is not feasible, nor is having professionally dissected specimens (prosections) of all species for student study. VAA provides users with access to cadavers without having to step in to the laboratory. Once in the laboratory, VAA becomes a resource to guide dissection or as reference during self-study. 2) Continuous intramural

support for VVET is not feasible. Changes in software require continuous development and new species offerings are necessary to support the wide array of gross domestic animal anatomy that is taught at CSU and in other programs. Development of new strategies for developing true 3D, VR objects creates opportunities to explore new avenues of anatomical instruction and strategies to enhance student learning.

7. Results and impact: Describe evidence of learner satisfaction (*e.g. student ratings of teaching/course*), learning outcomes, application of knowledge in other settings at your institution, impact on educational programs within the institution, and/or teaching awards.

1) Previous studies had demonstrated that VCA enhances student learning (Linton et al., JVME 2005). To apply a more qualitative assessment of the impact of VCA, my underlying hypothesis was that early and frequent student use of VCA in undergraduate anatomy positively correlate with student performance outcomes. High performing (A-B grade) students in my BMS305 course self-reported VCA as an essential learning tool, specifically before a laboratory session (Magee et al., TILT PDI 2015). In a follow-up study evaluating VAA learning management system usage statistics in high (A-B grade) vs. low (C-D grade) students in BMS305, program access (n = students, mean total VCA page views) was significantly (R=0.28) higher among high performing (n = 79, 44.8 ± 3.4) vs. low performing (n = 22, 30.7 ± 3.4) students at the end of the course. Student performance on the first laboratory examination was correlated to VCA page views as early as week 1 (R=0.42) and the sum of VCA page views by week 3 (R=0.46) (Magee et al. AAVA 2019). These findings demonstrate the value of VCA as an anatomy learning resource and the potential to use VCA page views as an instructor intervention tool within the first 3 weeks of a course. In the dissection environment the hypothesis to be tested was that VCA improves teaching efficacy. Dissectors (n=19/group) were given the same canine pelvic limb dissection task and access to teaching assistants, but only one group had VCA access which significantly reduced the number of visits and the amount of time that the TAs spent with each dissector (manuscript submitted to ASE January 2020). VAA can enhance learning both in and out of the anatomy laboratory.
2) Licensing of VAA Adobe Flash has generated >$25,000 since 2018 and university licensing resulted in $12,000 of program income in 2019. A single user subscription mechanism will launch August 2020. While not yet financially independent of CVMBS, the income generated in the last 2 years will allow VVET to continue development of new species offering as well as true, 3D Virtual Reality learning tools in a resource scarce environment post-COVID-19.

8. Reflective critique: Describe your reflections, what went well and plans for improvement. If applicable, briefly explain how the information obtained through development and assessment of this teaching activity changed your overall educational practices.

Of all the hats that I wear, Program Lead for VVET is one for which I have no formal training and the learning curve has been steep. I am a veterinarian running a software company within an academic institution. As an anatomist, I strongly believe that cadaveric dissection is essential for instruction of professional veterinary students; nonetheless, I believe there is a place for learning tools such as the VAA to improve the quality of anatomy learning for all learners. Taking the VAA through the CSUVentures Research to Market program and collaborating with individuals at CSU and at other institutions to conduct research related to VAA has been essential for me to understand growth and development of the VAA, including translation of the VCA to Spanish and Japanese. I am a veterinarian running a software company within an academic institution. I still don't know how to code or use stereophotogrammetry to create 3D objects. When software development and VR programming became critical for the future viability of VVET, I pivoted our development and distribution strategies and I trusted my team to help me make informed decisions about VVET's future. As Program Lead, I am attentive to the needs of my team as well as the academic community. VAA was essential for my delivery of anatomy instruction Spring 2020 and making VAA freely available in response to COVID-19 was the right decision to support anatomy learners around the world. Social distancing has created an uncertain future for anatomic laboratory instruction, but has likely created a greater opportunity for continued VAA use.

9. Dissemination: If applicable, describe how your efforts have been recognized by others externally through peer review, dissemination, use by others, or teaching awards nationally.

In addition to what is described above, the VR version of the VAA is the only animal anatomy VR product in the Mars Petcare “Future of Technology, Pet Health and Innovation” space at Mars, Inc. headquarters. The VAA is also recognized as a humane alternative in education by the International Network for Humane Education (InterNICHE)