Building a Better Donkey: A Game-Based Layered Learning Approach to Veterinary Medical Education

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Teaching veterinary students the practice of anesthesia is fraught with many of the same concerns associated with teaching medical students, certified registered nurse anesthetists, and anesthesia residents. In fact, some would argue that teaching general anesthesia skills to veterinary students is even more daunting than introducing such skills to clinicians that will eventually take care of human patients, because the veterinarian is expected to enter practice with a much broader breadth of skills and often works in solo practice settings.

Theory

This project advanced along two parallel tracks, which included the development of a manikin-based donkey simulator, SimDonkey and a game-based mobile application, iDonkey.

In this way a layered learning approach is used to reinforce didactic components of the curriculum, while simultaneously providing authentic situated learning opportunities to move students towards eventual clinical practice and competency. The layered learning model, Figure 1, illustrates how a multi-medium approach scaffolds educational activities while preparing clinicians for real world experiences.

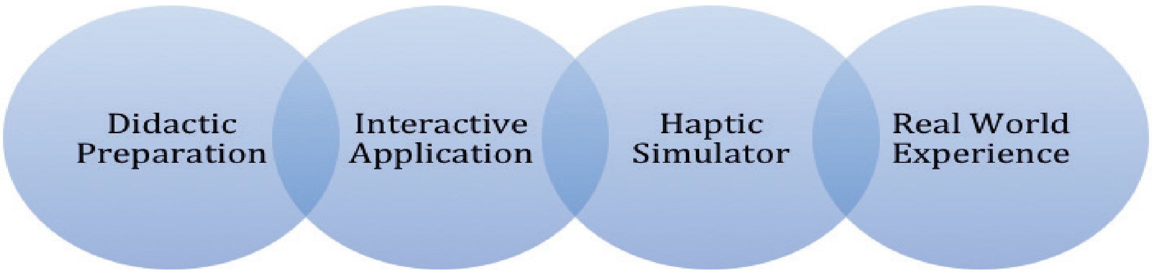

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Figure 1: Layered Learning Model

The layered learning model recognizes the importance and relevance of traditional facets of education. Students must take time to prepare themselves for more interactive components of the educational process, whether those processes take place in a classroom, digital environment, laboratory, or in the real world. In the layered learning model students still engage traditional didactic preparation, such as reading assignments. However, this didactic preparation prepares students for and overlaps with interactive situated learning activities that represent and portray clinical practice.

For the purposes of this paper, digital games and simulations represent interactive applications found within the layered learning model. Students continue to develop content and process knowledge though game-play, which in turn prepares them for supervised learning opportunities with physical simulators existing in created spaces (Bauman, 2007; Bauman 2010). Created spaces represent and replicate various aspects of actual clinical settings. Student experiences with physical or haptic simulators in created spaces unfold as designed experiences (Squire, 2006). Designed experiences taking place in environments that produce sufficient fidelity to allow for the suspension of disbelief encourage learning to take place as performance (Bauman, 2007; Bauman 2010; Bauman, 2012; Bauman and Ralston-Berk, 2014). Learning that leverages digital interaction and interaction taking place with haptic simulators prepares students for supervised clinical education in actual clinical environments where students interact with real patients.

Mobile digital application: iDonkey

The mobile digital application developed for this project, iDonkey was developed in partnership with the Institute for Research and Clinical Strategy, Ross University School of Veterinary Medicine, and the Learning Games Network. The iDonkey mobile application introduces veterinary students to the process of large animal anesthesia. The application objectives were derived from and map back to the existing curriculum. The iDonkey application was designed to meet challenges and gaps found within the existing curriculum. iDonkey strives to prepare students for actual high stakes live animal laboratory experiences related to the safe delivery of anesthesia in the preoperative or surgical environment.

Introducing games into the curriculum must be seen as value added in terms of return on investment. The iDonkey application is intended to provide an orientation to and preparation for a live animal laboratory experience. Live animal laboratory experiences are expensive to facilitate. Further, they pose inherent risk to laboratory animals and students who are unaccustomed to working with large animals. By providing an interactive simulation or game to orient students to the live animal laboratory solves several challenges and gaps in clinical veterinary education. Students arrive to live animal clinical laboratories with more experience on which to draw from. Further, the game experience allows for an interactive orientation to the laboratory in terms of animal and clinician safety, as well as a lesson plan orientation to drive the depth of the learning that is taking place. Games should be seen as integrative rather than additive and provide situated supplemental opportunities that are seen to have intrinsic value for learners (Bauman and Ralston-Berg, 2014; Deterding, Dixon, Khalid, and Lennart, 2011).

Game Design

The current iteration of iDonkey focuses on one particular practice case involving a donkey with a leg laceration that must be sutured. In a fully 3D, photorealistic environment, the game guides students through the entire procedure of checking the animal's health, preparing the animal for surgery, sedating and inducing anesthesia the animal, and finally waking the animal and guiding it back to it's feet.

Bringing the physical interactions of working with a large animal to a virtual environment involved replicating many of hands-on tests a student would use on a real patient. During the preoperative exam, a student is able to check pulse and capillary refill time, which are both important measures of health and faithfully recreated with appropriate visual feedback. In this case, pressing on the donkey's exposed gums turns that area white and slowly fades back to pink, allowing the player to measure the blood return time to gauge health. Similarly, clicking on accurate pulse points displays a visual indicator of what would be felt in the artery, again allowing the student to measure and record the pulse rate.

As the student progresses to the induction phase, drug knowledge begins to play a major role in the success of the procedure. Students must select the proper sedative and anesthetic agents, and be able to provide correct dosage in order to continue. Here, failure is caught immediately and corrected, indicating that a different medication or dosage should be used. Dosage specifically is corrected with proper proportions, helping the student become more familiar with the medications, and the math behind properly administering the medication.

Once the donkey is anesthetized, a set of randomized scenarios play out simulating either a "normal" case, or one where complications arise. The player is instructed to triage the situation accordingly, testing their knowledge of how a patients vitals indicate their level of anesthesia. For the duration of the anesthesia, the player has the ability to watch a simulated monitor, check pulse and other indicators of health, and in turn adjust medications appropriately.

This iteration of the game finishes successfully on every play through, though future cases will include more severe consequences for incorrectly dosed medications and improper procedure. These simulations generally mimic real-world scenarios that the student is likely to encounter, and help prepare them for manikin based simulation and real patient interactions.

SimDonkey: The manikin-based simulator

To this end the SimDonkey project seeks to develop a donkey anesthesia simulator appropriate for pre-anesthesia assessment, induction of anesthesia and perioperative care. A donkey was chosen for the simulator medium because the affiliated veterinary school uses donkeys to teach large animal anesthesia. Just as simulation has become an important and viable option for teaching clinicians caring for humans, we believe the ethical concerns for animal patients and students caring for them are relevant in the context of veterinary medicine.

The SimDonkey was created by heavily modifying a second generation Laerdal SimMan and a life sized stuffed donkey toy. The Laerdal SimMan is a human manikin simulator used for clinical education in the human health sciences. In essence the stuffed donkey was stripped down to a steel frame and the SimMan was stripped down to component electronic and pneumatic modules (circuit boards, pneumatic distribution block, speakers, breathing, pulse and airway modules). These components were then mounted on the steel frame, and a plastic case was created to protect them and provide structure for the donkey's chest and abdomen. The heart and lung sound speakers were located in anatomically correct position on the outside of the case and the airway was mounted and extended using simulated bowel. The donkey was then recovered with fur and stuffed.

This initial design process however presented two primary technological challenges for several of the donkeys "physiological" systems.

Cardiac/Electrical

Challenge

To accommodate the retrofit of the electrical and pneumatic components into the donkey model; the vast majority of the physical mounting and electrical housing components were removed. This created two related issues first remounting the components without their intended physical support structures and second, "re-housing" the electrical components to protect them from contact with moisture, dirt, or the stuffing used to fill the donkey model.

Solution

The components of the simulator could be broken down into 2 main categories: central control (the computer main board, pneumatic control and pneumatic distribution block) and peripheral accessories (electronic pulse motors, touch sensors, speakers, EKG/Defib cables). The central components were hung along the upper steel spine of the model donkey using a series of zip ties, and the original mounting hardware. These were then rehoused in an internal plastic case.

The case was custom built using construction silicone to bond the upper edge of two plastic flowerpots together to make a closed "egg". The "egg" was then sectioned into 3 pieces (right side, left side, and upper spine). The upper plastic spine section was mounted onto the upper spine of the steel frame using zip ties. The right and left sides were then mounted to the spine creating an articulating joint at each side. The bottom of the right and left section were then joined together with Velcro and a sheet of vinyl plastic, cut from an industrial shower curtain, to create and expanding collapsible joint between the right and left side. The entire case was then cover in additional vinyl sheeting to prevent the cotton-poly stuffing from contacting the electrical components.

Several holes were cut into the case to allow wires from the peripheral accessories to be connected to the main computer board. The cabling was run through flexible electrical conduit and the conduit was mounted sealed on the inside of the outside of the case to maintain the "stuffing proof" seal.

The electrical conduit was run mounted the steel structure of the model. The corresponding peripheral accessory (pulse point, touch sensor, speaker) was mounted in anatomically appropriate locations with Velcro or zip ties using the steel frame or conduit as a mounting surface.

Respiratory/Pneumatic

Challenge

The standard pneumatic breathing apparatus from the human manikin is designed to operate while the manikin is in a supine position. The pneumatic control system uses a combination of air pressure and gravity to inflate and deflate a plastic air bladder. This causes a chest plate move up and down. While this design is effective to recreate the physical appearance of human respiration it presented several challenges when applied to the equine model. First and for most, the physical motion of human respiration is vastly different from that of equine respiration. The human chest moves primarily up and down with limited lateral expansion during inspiration. The equine chest however expands almost entirely laterally with extremely limited up and down movement. Secondarily, the SimDoney was designed to be operated with the donkey model was standing or lying on its side, additionally to accommodate the shape and size of the equine model the human chest plate was totally removed. This meant we could not use gravity and the chest plate to compress and deflate the bladder.

Solution

The lung bladder and pneumatic tubing supplying it were removed and replaced with a "Y" connector, two new supply lines, and air bladders that had been removed from the human manikin but would not be used in the equine model (the pneumothorax bladders). These were then placed between a series of three plastic electrical boxes fastened together with elastic bands. The two exterior boxes were then mounted transversely to the bottom section of the plastic case, and the center box was mounted to the steel frame.

When the bladders are inflated the exterior electrical boxes are pushed away from the center section, causing the side of the case to move outwards. Once the bladders are fully inflated the pneumatic control stops the air supply and the force of the elastic bands causes the bladders to deflate and the sides of the case move inwards.

Alpha Build Results and Moving Forward:

The completed simulator underwent beta testing by faculty at a veterinary school. Some modifications were recommended and have been included in the ongoing build and design of the Beta simulator.

The first and foremost criticism of the alpha SimDonkey was that it was far too small. The initial donkey build was based on a "life-sized" toy donkey. Ultimately it proved to be several times too small. This resulted in several of the pulse points and physiological features being anatomically incorrect and/or difficult to appropriately assess.

As a result the beta version of the donkey has been scratch built on a custom designed steal frame comprised of ½" and ¼" rigid and flexible gas pipe that has been reinforces with semi rigid PEX plastic piping.

A related but secondary criticism was that the simulated gut and human manikin jaw that were used to create the airway in the initial model were anatomically and functionally inappropriate. To correct this, the skull, jaw and airway of the beta build are based on a molded replica of an equine skull with teeth. However, a replica donkey skull was not available. Custom building a molded replica donkey skull was cost prohibitive and using a real skull presented ethical, health, and safety concerns. As a result a replica zebra skull was used as a proxy model. While there are subtle differences in the skulls of donkeys and zebras the size and functional differences are minimal. The new soft tissues of the airway are currently being designed and will be scratch built using commercially available moldable silicone and medical imaging as a reference.

The design plans from the initial build will otherwise remain identical to the initial build with the exception of scaling for the new size.

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