roduction:

The benefits of immersive simulation are well documented in human medicine, and a robust industry producing a range of high fidelity human patient simulators (HPS) has resulted. HPS can be programmed to progress through a series of states determined by learner interventions, providing a realistic clinical environment in which trainees can explore treatment options, receive direct feedback from the HPS, and learn from mistakes in a safe environment. There are no comparable simulators on the veterinary market, and HPS are expensive.

Materials and Methods:

A Veterinary Clinical Simulation Platform (VCSP) was designed using open source software development tools and off-the-shelf hardware components and implemented with a commercial foam-core canine mannequin. The design goals were to provide the following functionality:

- Normal and abnormal heart and lung sounds auscultable at multiple locations on the thorax
- Palpable pulses with programmable strength
- Bilateral chest rise to simulate spontaneous respiration
- Detection of positive pressure breaths and chest compressions
- Simulated patient monitor with ECG, pulse oximetry, non-invasive blood pressure, ETCO2, and temperature
- Interactive instructor interface for on-the-fly changes of all parameters
- Pre-programmed scenarios with transitions between physiologic states dictated by learner actions.

The VCSP was implemented using open-source software and inexpensive, off-the-shelf hardware as documented in the figure below. It was designed to be flexible and to encourage extension and refinement.

Results:

All design goals were achieved. An overview of the hardware is provided in table 1 and Figure 1 below. The instructor interface is programmed in Javascript and served up as an HTML5 compliant web page that can be viewed and interacted with by any device with a web browser, including tablets and phones.

The Sim Manager software on the Simulation Server is written in C++ and PHP, and the Sim Controller code running on the microcontroller in C++. The open source Gnu C++ compiler was used to compile all C++ code.

Scenarios progressing through a branching series of physiologic states determined by learner interactions are developed using a standardized XML schema that can be shared as standalone files.

Figure 1: Hardware design of VCSP

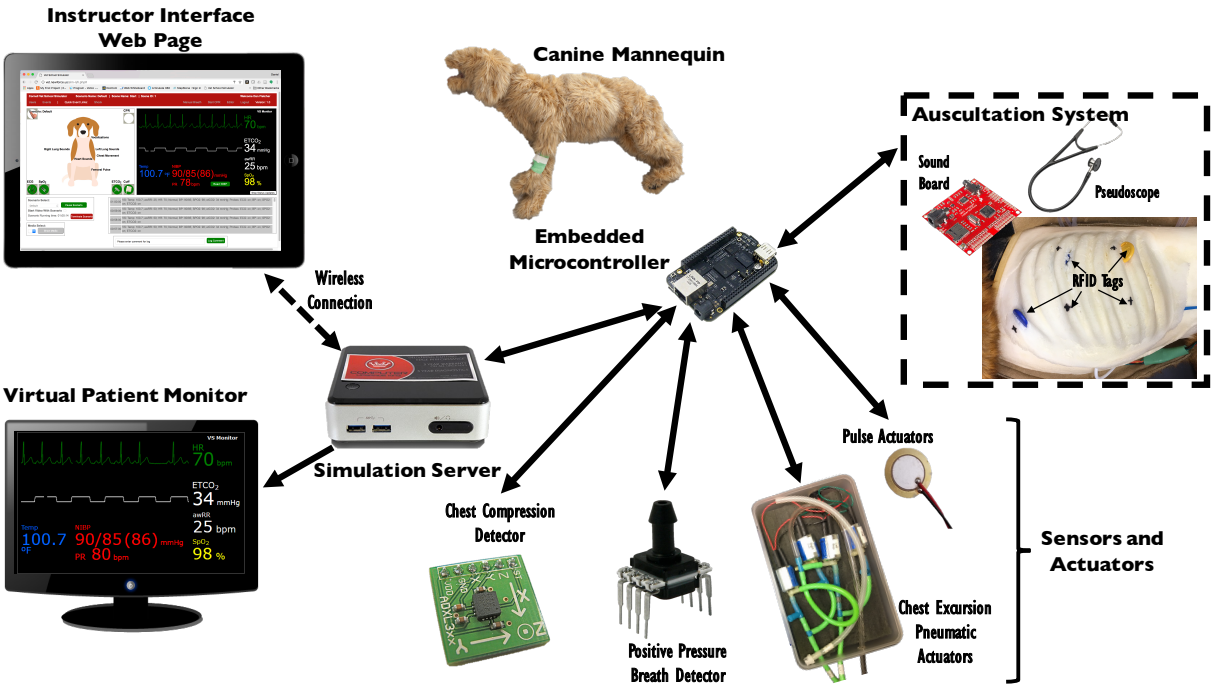

Table 1: Hardware requirements and costs of VCSP

Component	Cost (USD)	Details
Simulation Server	$600	Intel Next Unit of Computing (NUC) Core i5 Mini PC running the free, open-source LAMP server (Ubuntu Linux, Apache web server, MySQL, and PHP).
Embedded Microcontroller	$55	BeagleBone Black running open-source Linux OS
Auscultation System Sound Board RFID Tags RFID Antenna	 $50 $3x10=$30 $30	Wav Trigger board, Robertsonics
Other Sensors and Actuators	$500	Accelerometer (chest compression detection) Pressure sensor (positive pressure breath detector) Linear resonant actuators (pulse) Solenoid valves and compact air compressor (chest rise)
Canine Mannequin	$1650	RescueCritters!® Advanced Airway Jerry

Next Steps:

Construction of the first 2 simulators is nearing completion and they will be deployed at Cornell and SUNY Delhi by the end of September 2017. The proposed efficacy study will be carried out in the Spring of 2018 at both SUNY Delhi and the Cornell College of Veterinary Medicine, with manuscript submission expected by September of 2018.