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Bridging medical simulation with computer science and engineering: A growing field of study

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ABSTRACT

Background: Medical simulation has become an essential educational tool in the curricula of healthcare professionals. A literature review revealed a knowledge gap in healthcare simulation education with respect to the technological expertise required to operate highly sophisticated simulation equipment. With this motivation, a case study was designed to determine if implementing on-site technological expertise allows for the facile navigation of high fidelity manikins. Next, a research study was conducted to evaluate engineering students understanding of simulation, and their interest to attend a program in medical simulation.
Objectives: To determine if on-site technological expertise lifts barriers associated with manikin use and to assess levels of understanding and interest among engineering students following exposure to the technology used in healthcare simulation.
Design: A prospective, descriptive study with pre-post surveys.
Settings: The Nursing Skills and Simulation Center at a New England University campus.
Participants: Engineering students attending 6 different engineering programs (Computer Science, Computer Engineering, Mechanical Engineering, Biomedical Engineering, Electrical Engineering and Technology Management) and having different educational levels (undergraduate and graduate).
Methods: Two assessments were applied to engineering students attending a class on technology used in healthcare simulation. A pre-test measured the understanding and interest of students in the engineering/computer science courses before attending a simulation class. A post-test assessment measured their improvement in understanding and interest to learn more about simulation technologies.
Results: Statistical analysis and comparisons of pre-and post-test assessments show a 23% gain in understanding of this field following exposure to the healthcare simulation class. Furthermore, post test results show greater than 67% of those surveyed have an interest in attending a program in healthcare simulation.
Conclusions: The results indicate the collaboration of nursing and engineering has lifted known barriers to simulation education, and reveal engineering students have an interest in the field of medical simulation.

1. Introduction

Medical simulation has become a necessary learning methodology for healthcare professionals who can simulate cases they cannot always find during real-life patient care (Lavoie and Clarke, 2017). The learning technology used in the simulation process has improved through time, starting from a doll-like manikin with simple functions to a realistic manikin which is enhanced by new advanced technologies including robotics, embedded systems, and virtual and augmented reality. Some of these systems are hybrid systems to simulate a real patient or hospital environment. Some of the advanced technology is developed through university research, especially from engineering schools, to enhance and push the limits of these simulation tools. At the same time, several companies developed products based on these research technologies to create a comprehensive environment for realistic medical simulation.

Although there is a general agreement that integrating simulation technology into nursing curriculum is essential, there is currently no documented educational approach for preparing faculty to expertly operate and manage the differing types of simulation technology. Many

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faculty state they did not receive training in their graduate programs and most of the learning is achieved on their own (Roney et al., 2017). Additionally, the technological complexities have become a barrier for nurse educators to operate human patient simulator manikins (HPSMs) in the clinical laboratory setting and overshadow the attractiveness of this technological learning tool. Simulation based-education (SBE) is growing rapidly and is an expensive educational offering that millennial learners are preferring as a learning strategy and have come to expect this state-of-the-art technology in their nursing programs (Parker and Myrick, 2009).

In order to deliver a successful SBE program, a team of professionals knowledgeable in business management, education, and technical skills must work collaboratively in the simulation center (INACSL, 2017). Based on this knowledge, we hypothesized that the incorporation of on-site technological expertise that allows for the facile navigation of HPSM's in the School of Nursing will lift barriers that interfere with the maximization of the intended educational experience.

2. Background

Use of high definition simulation has been shown in the literature to provide robust learning opportunities for students while meeting the particular learning needs of millennials. (Lavoie and Clarke, 2017) With the rapid expansion of technology, there is a shift in the pedagogical approach in nursing educational programs that is supported by the millennial expectation that state of the art technology is imbedded in their nursing curriculums (Parker and Myrick, 2009) Evidence exists which supports the expansion of simulation within nursing programs to increase competency and critical thinking of nursing students (Hayden et al., 2014). Use of simulation-based education (SBE) has even been shown in the evidence to increase students' specialty exam scores (Sarasnick et al., 2017). Despite evidence that simulation is a potent contributor to the success of students in health care fields, barriers to its implementation continue to exist.

Although many faculty members realize that integration of technology into curricula is important, they are uncomfortable with its use due to lack of training and inadequate technological support (Roney et al., 2017). Many faculty report a lack of confidence in relation to the technology of high-definition manikins utilized in simulation scenarios (Abell and Keaster, 2012; Jansen et al., 2009). An integrated review by Al-Ghareeb and Cooper (2016) revealed numerous evidence of faculty barriers to the integration of simulation technology as being due to the complex technologies inherent in the engineering design of the high-fidelity manikin**s,** inadequate training, and insufficient access to quality technicians.

Within the standards for use of simulation in nursing education is the tenet that simulation is facilitated by individuals who possess exemplary knowledge and capabilities to make the educational offering seamless (INACSL, 2016). An integrative review of healthcare literature between 2000 and 2015 related to the use of HPSMs in nursing simulated learning (Al-Ghareeb and Cooper, 2016) identified the need for dedicated simulation coordinators and technological support as a method of reducing faculty discomfort.

Although simulation technicians are utilized in many nursing programs, Bailey et al. (2015) found that most lacked formal training or set background, although those with an education in engineering were the most prepared for the position. On-site training was the main component used to train simulation technicians. On site train-the-trainer models which are used at many institutions, continue to leave discrepancies in simulator programming knowledge (Nestel et al., 2016). Kelly et al. (2017) identified a need for increased technological support in a simulation program and successfully sought to employ an engineering internship within the simulation center which created a symbiotic relationship between the engineers and nursing faculty, and provided the technological support required by nursing faculty while advancing engineering knowledge of simulation technology and medical terminology.

Barriers to simulation integration continue to exist despite evidence that SBE is an essential pedagogy to be employed in nursing curriculum. A critical obstacle identified is the need for competent individuals who are capable of providing adequate technological support to nursing faculty. Currently there are few formal programs for individuals to become proficient as a simulation technician with on-the job training continuing to be the relied upon educational method (Nestel et al., 2016).

Engineering has been historically more engaged in technology improvement as opposed to the educational aspect of medical simulation as a training method for healthcare professionals (College of Engineering, U. o. S. F, 2017). Because of rapid improvements in the computer industry and in fabrication, ongoing research has set goals to integrate these systems into the world of medical simulation (Brailsford et al., 2010) A few examples include the creation of realistic soft tissue enhancements for manikins that render them more life-like (Delingette, 1998) the development of systems that simulate bile duct exploration (Basdogan et al., 2001) haptic palpation (Ullrich and Kuhlen, 2012) versatile ultrasound simulation that can be integrated with manikins (Farsoni et al., 2017) the development of a system for virtual surgery simulation and heart modeling (Bramlet et al., 2016) the implementation of a comprehensive environment that presents realistic surgical simulation (Mike Koon, 2017) and the development of advanced manikins that can simulate the human reaction in response to treatment (Gaumard, 2017; Laerdal, 2017; Simulaids, 2017).

One of these advanced robotic manikins used in this study is the SimMan 3G (Laerdal, 2016). This manikin has been designed to be programed to emulate a regular human patient with different health-related issues and healthcare scenarios. The hardware design of this robot is very advanced and consists of five controllable modules. Each module is a separate computer system mastered by a main computer where all use a server system to connect to the outer world. Thus, this manikin contains six computer modules and an internal router. This advanced design is similar to the electronic control units (ECUs) used in the automobile industry. Also, the manikin has multiple mechanical systems that are controlled by these ECUs such as the pupil dilation mechanism, fluids pumping system, breathing system, and vibrators that simulate heart-beat and seizure cases. Additionally, it has several sensors including RFID (Radio Frequency Identification) sensors for medication detection, fluid rate monitoring, and pupil dilation control. All of the state-of-the-art hardware work with advanced software systems that can also simulate the environment of an actual patient in a real hospital employing the patient monitor application, scenarios programming tools, and several other software for function control, multimedia capturing and recording.

While these advanced technological abilities provide vast opportunities for students to participate in life-like scenarios, they also contribute to hindrances. As most nursing faculty have little to no technological expertise, when IT problems arise, nursing faculty are incapable of utilizing the problem-solving processes necessary to correct and move beyond technological glitches. As a result, many of the vast simulation opportunities available to faculty and students go unused. In this study, a worthy solution is presented for lifting barriers to simulation based education.

3. Methods

High fidelity manikins were purchased for the baccalaureate nursing simulation laboratory at a university in the New England region of the USA. Based on the complex technology of the manikins, the university's School of Engineering was approached by the School of Nursing to support a Ph.D. engineering student to work in the simulation laboratory alongside of nursing to test the hypothesis that having on-site technological expertise will allow for the facile navigation of high-fidelity manikins and therefore, maximize the intended