Chapter 13
Medical Educational Simulations: Exploring Reciprocity Between Learners' Skills, Attitudes, and Career Intentions: A Case Study of Simulation Education Research

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13.1 Introduction: Experiential Learning in Healthcare Simulation

The concept of experiential learning embraces traditional fields of study, such as cognitive psychology and experience-oriented pedagogy, as well as emerging areas of digital technology including medical simulations (MedSims), which provide interactive engaging platform for professional training and education (Armstrong 1979; SiTEL 2010). The Council of Residency Directors (CORD) at the American Board of Emergency Medicine has established the following recommendations for simulation in their statement (Chakravarthy et al. 2011):

1. Simulation is a useful tool for training residents and in ascertaining competency. The core competencies most conducive to simulation-based training are patient care, interpersonal skills, and systems based practice.
2. It is appropriate for performance assessment, but there is a scarcity of evidence that supports the validity of simulation in the use for promotion or certification.
3. There is a need for standardization and definition in using simulation to evaluate performance.
4. Scenarios and tools should also be formatted and standardized such that EM educators can use the data and count on it for reproducibility, reliability, and validity.

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Increased awareness of student-centered approach is often limited by focusing on conceptualization of the approach with very little success in practical application development (Libin and Libin 2006a). As instructional designers strive to incorporate interactive methods to make professional education both meaningful and engaging by employing online courses, games, and medical simulations, the reciprocity, or co-influence, between learner's characteristics and new experiences during the training remains unexplored. It is not clear how cognitive prerequisites, such as attitudes and perception, impact the learning outcomes, in particular, professional intentions, and how they relate to learners' functional skills required by immersive educational technologies, such as MedSims.

The studies conducted at the MedStar Health address gaps in our understanding of the digital technology implications for both healthcare providers and healthcare takers focusing on developing role-playing video games (Libin et al. 2010), designing MedSims for professional skills training (SiTEL 2010), and utilizing online communication platforms to promote self-management of health conditions (Libin et al. 2011). The practical outcomes of the previous work included use of simulation to prepare for high-acuity, low-frequency clinical occurrences, use of simulation team training to improve the culture of safety in high-risk hospital environments, and development of haptic simulation devices.

The case study presented in this chapter explores the nature of experiential learning through express assessment focused on measuring learners' interaction with educational medical simulations in the context of functional skills, attitudes toward usefulness of MedSims in professional education, and career intentions.

13.2 Preparing the Healthcare Professional of Tomorrow

The use of advanced simulation and online technologies will increasingly play a role in preparing the healthcare professionals of tomorrow. Today, we have the ability to teach using authentic medical scenarios and authentic roles in "modeled" clinical settings. We can quickly organize and reorganize the learning space to accommodate team training, a diverse set of tasks, and real-world medical problems.

Although the job market continues to struggle, one industry is actually projecting growth: healthcare. The US Department of Labor expects a 22% increase in wage and salaried positions in the field by 2018, which is double the rate of growth for all industries combined (U.S. students… 2010). Despite the growing need for healthcare workers, the United States lags behind much of the world in its share of college graduates majoring in science and technology, ranking 29th of 109 countries in the percentage of 24-year-olds with a math or science degree. According to the Southwest Washington Workforce Development Council, there are many reasons for the healthcare shortage, but the most pressing issue appears to be recruitment (Addressing… 2003). This puts the United States in a compromising position. If unable to obtain people's interest in these fields, the impact be on economic

stability could be significant, especially considering the economy is becoming more science and technology driven. So, what is preventing students from pursuing healthcare degrees?

In the University of the Sciences in Philadelphia's 2010 Healthcare and Science Jobs Survey, approximately 45% of 600 American teens, 13–18 years of age, reported that they were not considering degrees in healthcare or the sciences. Of these teens, 21% expressed that they were not good enough at these subjects in school, 19% did not feel prepared to pursue this type of degree, and 12% said that it would just be "too difficult" to obtain this type of degree. In addition, of the 45% not interested in healthcare degrees, 22% reported that their lack of interest stemmed from a lack of knowledge about the various healthcare jobs (U.S. students… 2010). Southwest Washington's study mirrored these findings, stating that one of their challenges is that "There is a lack of awareness in K-12 about the broad array of health care careers especially in areas beyond physician and nursing, such as medical office, imaging and laboratory occupations" (Addressing… 2003). Their study showed that this lack of awareness directly caused two other problems: if students were unaware about the various healthcare jobs, they were also unaware of the class work necessary to prepare for such a career, and the healthcare curriculum is different in each high school and does not cross over to community college programs.

The National Student Leadership Conference (NSLC), a collaborator on the presented case study, seeks outstanding high school students from around the world who demonstrate academic excellence and leadership ability. NSLC strives to provide a safe and supportive environment which encourages students to explore their academic and career interests while developing leadership skills essential for their success. The NSLC's goal is to provide innovative and challenging learning opportunities through hands-on simulations and workshops in conjunction with some of the nation's premier colleges and universities. The NSLC on Medicine & Health Care, located at the American University in Washington, DC (USA), uses an interactive approach to learning that provides students with an opportunity to immerse oneself in the challenging complexities of the medical profession. The youth leadership program on medicine exposes students to the techniques of doctors and nurses during hands-on clinical rounds.

Clinical Simulation Training programs developed at SiTEL, a simulation and training center in Washington, DC, metropolitan region (USA) which was the study's main site, aim at creating new immersive learning environment for students at different levels of professional development. Learning experience includes what it is like to use the latest virtual reality simulators that assist surgeons to perform minimally invasive surgeries, or "delivery" of a newborn baby using a high-fidelity birthing simulator, or leading a resuscitation team while experiencing how to save a "patient" in cardiac arrest. Doctor for A Day Simulation Program (DOC) was developed for the purposes of vocational, medical training for students, thus providing them with experience of what it is like to be trained in a high-tech simulation training environment. This training course allows a learner to capture a brief glimpse into the current and future education programs for healthcare providers. Sisters

Kristen and Lauren Johnson, aged 15 and 18 respectively, were the first recipients to participate in the Doctor for A Day Simulation Program in June of 2010. Both girls expressed an interest in pursuing a healthcare career. The teenagers said their experience at SiTEL reinforced their interest in becoming healthcare professionals (Sanfuentes 2010).

The presented study was part of the Doctor for a Day Simulation Program (DOC) focusing on exploring reciprocity between learner's characteristics and new immersive experiences provided by MedSims developed at SiTEL.

13.3 Case Study: Research Design, Methods, and Procedures

The field study was based on cross-sectional design focusing on exploring the reciprocity between learners' functional skills, attitudes toward medical simulations, professional intentions, and learning experiences provided during learning-on-demand event. A homogeneous group of 510 students balanced by gender (55% female and 45% male) with the age range from 14 to 18 years, who were rising sophomores through seniors in high school and attended a summer school at the National Student Leadership Conference (NSLC) in Washington, DC, participated in A Doctor for A Day Simulation Program at SiTEL.

The study inclusion criteria were as follows: students must be attending 9th, 10th, 11th, or 12th grade and maintaining at least a "B" average at the time of enrollment as defined by the NSLC guidelines. SiTEL of MedStar Health, chosen as the study setting, has four simulation centers in the US District of Columbia metropolitan region, providing clinical simulation-based training courses for all the disciplines in healthcare. The centers had 14,467 participants in the year 2010. SYNERGY, a simulation education research program, developed both by SiTEL and MedStar Health Research Institute, focuses its efforts on four domains including psychomotor skills, clinical reasoning, communication, and team training.

13.3.1 Research Design, Methods, and Procedures

Five hundred and ten students spent 4 h total at the SiTEL centers. Each student enjoyed 45 min in each of four out of five offered skills stations (see below for more details), with 30 min used for registration and evaluation via express assessment, *Learning Experiences with Technology Scale (LETS)*. *DOC* event was led by simulation technologists and operation managers of SiTELs simulation centers. Each station was staffed with a proctor with a student to proctor ratio of approx. 12:1. The proctor provided the overall goal of the station, performed a demonstration, and mentored the students experience each.

Educational medical simulations employed by the skills stations included the following:

Basic surgical skills: Students learned basic knot tying and suturing techniques practicing their skills on a variety of task trainers.

Endoscopic surgery: Students used simulation equipment to gain exposure for laparoscopic surgical skills employing simulation equipment that is used to train healthcare professionals in laparoscopic surgery. MedSim application utilized the latest in virtual reality simulators and task trainers for this station.

XBOX for medicine: Students participated in SiTEL's first medical game using the XBOX platform to complete modules on anatomy and physiology and navigate through a simulated bronchoscopy procedure.

High-fidelity SimExperience: Using a high-fidelity patient simulator to recreate real medical scenarios, students assisted with delivering a baby during a normal vaginal delivery scenario and/or assisted in performing lifesaving maneuvers during a cardiac arrest scenario.

Introduction to basic life support: Students were provided with an overview of the essential skills and knowledge required to become certified in basic life support. They observed and practiced what it feels like to perform chest compressions, assess unresponsiveness, and perform artificial ventilation support on a simulated patient.

Learning Experiences with Technology Scale (LETS) was used for self-assessment by all students. *LETS* is a 13-item questionnaire with each item rated on a 5-point Likert scale from totally disagree (0) to totally agree (5). The *LETS* prototype was developed and tested during robotic psychology and robotherapy study focusing on quantifying person–robot interactions along with three main domains: technology skills, attitudes, and communication modality (Libin and Libin 2006b). For the *DOC* event, the scale items were adjusted by the educational instructor and study researchers to reflect medical focus of educational simulations. Three subscales were developed. Subscale LETS_skills utilized three items assessing the level of functional skills as they relate to video gaming and digital technology (sample item: *I play video games on a daily basis*). Subscale LETS_attitudes utilized three items measuring students' attitudes toward the usefulness of MedSims in professional healthcare education (sample item: *The use of simulation provided a greater understanding of medical procedures*). Subscale LETS_intentions employed three items to measure students' intention to pursue a healthcare career (sample item: *I am currently interested in pursuing a career as a healthcare professional*). Each subscale measured responses using summative scores ranging from 0 to 15.

A single 5-point item on the *LETS* was used to assess the participant's previous exposure to MedSims through the home school course work (item: *My school includes the use of medical simulation for my course work*). Two items related to specific experiences with XBOX simulation are not included in the presented paper and were collected for the purposes to inform the development team on the ongoing progress in utilizing XBOX application in training. One item was used to control for possible false responses and was also excluded from the presented analysis.

Each student performed self-assessment via *LETS* after program completion using electronic interface under proctor's supervision. The data were stored electronically via LMS online interface (in-house developed online Learning Management Software), and de-identified data matrix was extracted in MySQL format.

13.3.2 Analysis

MySQL data were converted to a data file readable by the IBM SPSS 18.0 (Statistical Package for Social Sciences) statistical software for further analysis. Phase I of analysis included descriptive univariate and bivariate statistics using frequency distributions, means, and standard deviations for the study variables based on the item-by-item analysis and LETS subscales summative scores, measuring students' intentions, attitudes, and level of skills. During phase II, a group analysis based on univariate model of analysis was conducted using main outcome variables and covariates to compare continuous data. In phase III, an exploratory principal component factor analysis of nine variables describing three studied domains (skills, attitudes, and intentions) was conducted employing a Varimax method of rotation with Kaiser normalization using IBM SPSS 18.0 and focusing on analyzing the relationships (codependent reciprocity) between three individual domains: skills, attitudes, and intentions. For all analysis, statistical significance was defined a priori to be at the 0.05 level.

13.4 Results and Discussion: The Anatomy of Simulation Experiences

In phase I analysis, the frequency algorithms allowed to describe the study participants as follows:

- Moderately experienced user of digital technology (45% of the sample evaluated themselves as being "poor" to "average good" experts in digital technology (Internet, cell phones, etc.) usage).
- Rather moderate video gamers with only 18% playing games on a daily basis and another 16% having advanced video-gaming skills.
- With positive attitudes toward usefulness of MedSims in medical professional education with 73% providing the highest score for the item "*The use of simulation provided an engaging learning experience*" and another 22% of the participants providing next to the highest score for the same item.
- Almost 92% of learners thought that the use of medical simulations provided them with a better understanding of medical procedures used in MedSims.
- Eighty-nine percent enjoyed their immersive interactive experiences, and 77% of the students wanted more similar participation in the future.
- With regard to their past experiences, 53% of learners indicated as unsatisfactory the use of MedSims by their home school to support relevant course work.
- When evaluating their career intentions, 80% of participants thought of a healthcare field as an attractive career path because of their immediate experiences with MedSims at SiTEL, and 87% were interested in exploring more possibilities with regard to healthcare professions.

Table 13.1 Characteristics of domains' summary scores

Individual domain	Mean	Standard deviation	Scores range
*LETS*_skills	8.09	3.29	3–15
*LETS*_attitudes	13.76	1.54	7–15
*LETS*_intentions	8.72	1.33	4–10

Table 13.1 presents summary scores resulting from phase II analysis for each *LETS* subscale that were calculated with the following means and SD:

A univariate analysis based on General Linear Model aimed at studying reciprocal relationships between study main outcome variables, the summative scores for each of the individual domains measured via LETS, and the covariate variable that assessed students' past experiences with MedSims at their home school. Results demonstrated that higher sum scores on *LETS*_attitude and *LETS*_intentions domains were not impacted by the high scores on *LETS*_skills domain, when adjusted for the level of past experiences with MedSims. This finding was also confirmed using a different analytic technique. A subgroup comparison based on the independent *t*-test, with the item evaluating learners' past experiences with MedSims used as a group criteria, revealed that the subgroups differ only on the level of functional skills ($F = 15.4$, $p = 0.001$), with the lower skills associated with minimal or no past experiences with MedSims.

An exploratory principal component factor analysis, employed for phase III analysis, using the Varimax method of rotation revealed that a clustering pattern based on a two-factor solution incorporating all three studied domains (skills, attitudes, and intentions) accounted for 68.5% of the observed variance. The resulting first factor included items from two domains, attitudes and intentions, with the second factor indicating a latent dimension of functional skills (see Table 13.2).

A variable indicating past experiences with MedSims at the home school, as well as age and gender, constituted a hypothetical secondary level in our factor model and was excluded for the purposes of the presented study, so that interrelations among the experiential learning domains could be further explored. We hypothesized that identified factors are oblique or non-orthogonal in order to achieve a more interpretable structure. The oblique method of computation rotates factors so as to best represent clusters of variables without the constraint of factors' orthogonality. A resulting two-factor model, similar in its structure to the model explored while using orthogonal algorithm, represented 68.5% of the variance. The content of the factors, as well as its order identified via the first factor analysis method, was confirmed by the oblique algorithm using Promax with Kaizer Normalization Rotation (see Table 13.2). The first factor accounted for 42.8% of the total variance, with the second factor accounting for 25.7% total variance, respectively. The oblique method allowed us to explore the reciprocal relationships between identified factors demonstrating very low correlation between factors, thus representing them as rather independent dimensions of learning experience.

Training in medical and healthcare procedures prepares students to enter a wide variety of occupations and specialty areas within the field. Multi-method analysis of

Table 13.2 A two-factor structure[a] of experiential learning domains

	Factors	
Individual domain	1	2
The use of stimulation provided an engaging learning experience	**0.733**	0.82
I am confident to choose a path toward healthcare education	**0.748**	0.128
The use of stimulation provided a greater understanding of medical procedures	**0.750**	0.024
I am an experienced user of technology	0.253	**0.646**
I play video games on a daily basis	−0.040	**0.894**
I am currently interested in pursuing a career as a healthcare professional	**0.593**	−0.062
I would like to participate in more simulation activities like this	**0.729**	0.109
I have advanced video game skills	−0.029	**0.905**

Items with highest load are in bold
[a]Rotation converged in 3 iterations

the reciprocity between three main elements of experiential learning, such as functional skills, attitudes toward MedSims usefulness in educational practice, and intentions to pursue healthcare career, revealed that despite widespread assumptions that the level of functional skills is reciprocal with cognitive domain (measured via attitudes and intentions), these factors are rather independent. At the same time, our findings demonstrate that in a large group of participating students ($N = 510$), the level of functional skills relevant to mastery of interactions with cutting-edge digital technology, such as MedSims, does depend on the frequency and intensity of students' exposure to medical simulations during their course work.

Results from this study have important implications for practitioners, researchers, and students alike. Vocational counselors working with students oriented toward healthcare career need to consider more than a level of testable functional skills. The focused courses that familiarize future medical professional with the nuts and bolts of their day-to-day work to be, combined with motivational profession-tailored training, could tremendously increase recruitment rates and address healthcare shortage.

13.5 Conclusion: Building Career Technology Education

Presented case study thought to provide a contribution to the area of experiential student-centered pedagogical practices by exploring reciprocal relationships between learners' characteristics (skills, attitudes, and intentions) and immersive experiences provided by highly engaging MedSims. Our findings demonstrate the following advantages of using simulation-based education for training of future healthcare professionals:

(a) An interdisciplinary approach emerging on the crossroad of exploratory educational technologies, experiential learning, and situated cognition has the potential to address vital needs in professional education through the comprehensive implementation of vocation-tailored realistic simulation.
(b) Understanding of how learner's individual characteristics impact educational outcomes allows design of student-centered approaches that take into account reciprocity between psychological domains, pedagogical designs, and students' experiences.

The study's main limitation is that it was based on convenience sample of high school students participating in a summer school, which limits the generalizability of findings. However, study findings might be also beneficial for career technology educators as they prepare curriculum for science and technology tracks. Developed conceptual and experimental framework based on experiential learning approach can serve as a basis for considerations for technology integration into the career technology educator tracks for high school students interested in pursuing medical professions.

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