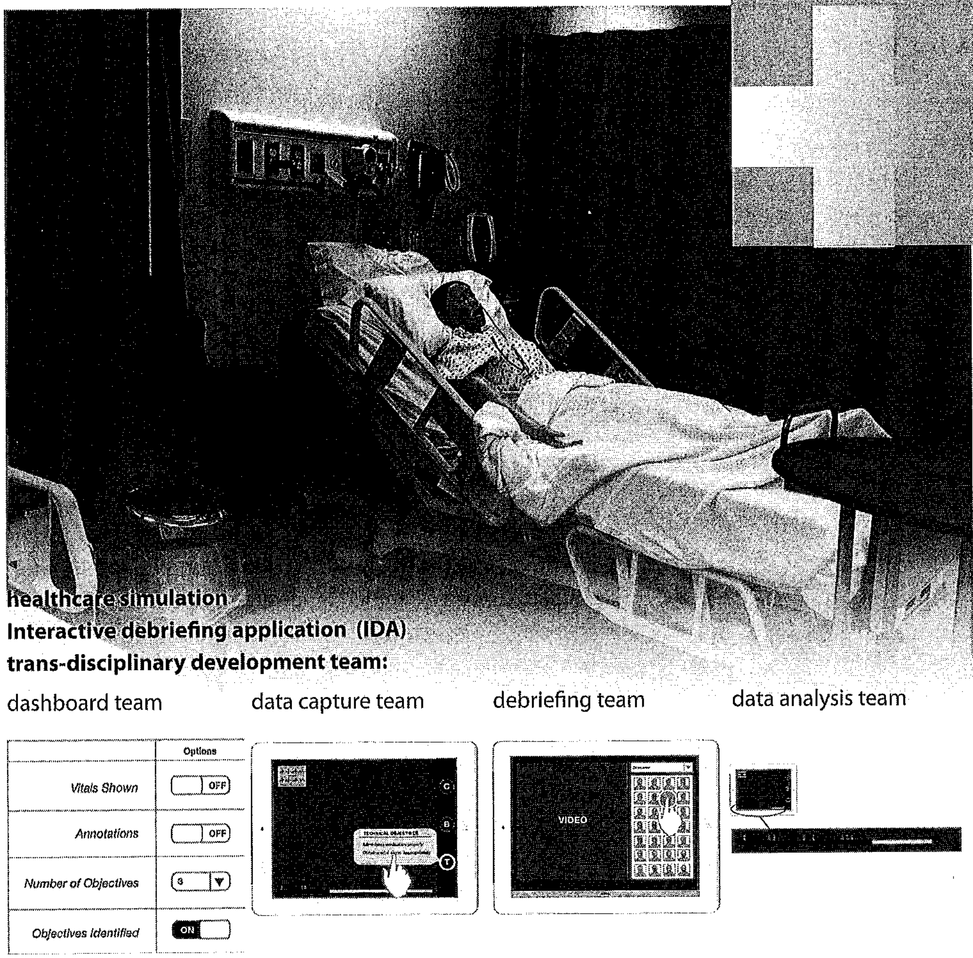


Trans-disciplinary Partnerships in IT Health Software Development: *the benefits to learning*

Sarah Lowe, Tami H. Wyatt, Xueping Li, Susan Fancher

ABSTRACT

Healthcare has followed the footsteps of the aviation industry with respect to teaching and learning. Pilots practice endless hours on simulators prior to flying solo. Likewise, healthcare workers increasingly use simulation to practice skills and clinical judgment prior to providing care to patients in a professional setting. With the growing interest in healthcare simulation, there are increasing needs to enhance the learning that occurs within a simulation to ensure the effectiveness of this practice in healthcare education. In an effort to meet this growing demand, the University of Tennessee, Knoxville builds technologies to enhance simulation learning. This paper presents the process and benefits of using trans-disciplinary teams to build healthcare products. Specifically, the paper discusses the experiences of a team of designers, engineers, and nurses in a university setting who work together with their students, to build and test healthcare products including educational tools to support simulation.

KEYWORDS:

simulation, trans-disciplinary partnership, educational software design, Health IT, graphic design classroom

. INTRODUCTION

Just as airline pilots use simulated flight experiences to gain understanding of the variability surrounding flight, so too does the field of healthcare use simulation scenarios to prepare for the clinical world beyond the classroom. Simulation activities provide opportunities to link theory and practice in an experiential learning environment (Cantrell, 2008) by placing learner(s) in settings that mimic medical facilities and asking them to perform an activity that will result in the learner's knowledge of identified skillsets. Simulation facilitators typically use one or more, or a combination of different types of simulation activities[1] to achieve the classroom objectives. In particular, high-fidelity digitally enabled manikins are manipulated remotely via observation booths where a learner's every move in relationship to the manikin is documented and video recorded for discussion post-simulation.

Due to the large learner to facilitator ratio in simulation classroom settings, it is necessary to have active participants, those performing patient care activities, and observers, those who are not participating, but watching. Typically observers watch on monitors outside the room or possibly inside the room, neither of which requires any type of interaction on behalf of the observers thereby resulting in a lack of engagement and subsequent missed opportunity for learning (Kolb, 1984).

Simulation software used in today's classroom setting has only just begun to consider a simulation scenario that includes the passive observer. The software detailed in this paper is unique in that it not only addresses the tacit needs to transform the passive observer into an active observer, but represents a trans-disciplinary partnership across the Colleges of Nursing, Engineering and Arts & Sciences in seeking a solution. This blending of the team disciplines, in conjunction with a graphic design class served as a catalyst for a simulation software concept based on intuitive input and meaningful output.

As a result of this collaboration and outcome, we argue the need for mobile health (mHealth) initiatives to seek solid partnerships between commercial development and higher education in responding to the increased demand of technology software in healthcare education. Aside from the clear benefit of beta-testing directly with the intended audience, the expertise that arises in trans-disciplinary partners working on-the-ground in educational institutions allows for outcomes focused on documented methods of learning within an experiential learning space.

. SIMULATION IN NURSING EDUCATION

Simulation based medical education is defined as any educational activity that utilizes simulation

There are five different simulation activities that are considered effective in nursing education executed through simulation enarios: Standardized patients, Task trainers, Software-based simulation, High-fidelity manikins and virtual reality (Rosen, 2008).

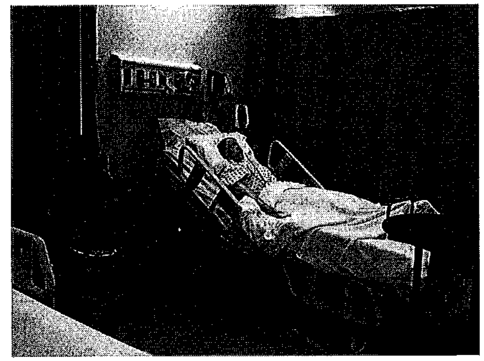


FIGURE 1

Simulation classroom

aides to replicate clinical scenarios (Al-Elg, 2010). In turn this furnishing of the conditions in which learning can occur is thought to improve clinical skills, clinical reasoning, patient safety and team building. A simulation can take place within either a modified space or a full-scale replica of a medical facility. (see *Figure 1*) Trained facilitators who execute the simulation activity range from instructional technologists to tenured professors. This variability in a facilitator's background places an increased reliance on the simulation software to assist in staging an effective learning experience.

Simulations are constructed within what is known as a scenario with a fictitious patient in the form of either a high fidelity manikin or an actor representing a standardized patient with a pre-determined sequence of events, both of whom respond to the actions of the learner. Scenarios can be as simple as taking vital signs to as complex as life or death situations. For this paper we will focus on simulation scenarios using a high-fidelity manikin. Running upwards of $100K, these human stand-ins have eclipsed the widely known Resusci-Annie to become complex technological devices that exhibit incredibly life-like functions such as breathing, palpable pulses, bleeding, pupil dilation and perspiration. Procedures such as catheterization, intubation and IV insertion can be completed and are accompanied by the display of real-time patient data such as blood pressure, heart rate and oxygen saturation on the bedside monitor. For a learner, this culminates in an experiential environment in which knowledge is built from observation through to reflection (Kolb, 1984) in a low-risk setting.

To stage a scenario, a facilitator working with a high-fidelity manikin in an equipped simulation setting, will interface with a piece of software to preset the outcome for the select number of learners actually participating with hands-on activity in the scenario (participants). The remaining learners are left to observe (observers). When the luxury of a small facilitator-to-learner ratio is present, the observers can be in the room within clear sight of the activities. However as classroom numbers increase, observers may be asked to monitor the activity on a screen from a remote location and make notes as needed, thereby exponentially decreasing the ability of the facilitator to maintain engagement of the observers. Therefore, the physical limitations of the venue can have a direct impact on learning outcomes.

2.2 KNOWLEDGE DOMAINS IN SIMULATION SCENARIOS

For an active simulation participant, the scope of understanding within a scenario grows in complexity to result in higher order learning via the pre-determined set of objectives identified by the facilitator. Objectives are events of cognitive, technical or behavioral skills that advance from novice to expert following the same order of Bloom's domains of learning, from cognition/knowledge to behavioral/clinical judgment (Bloom et al., 1956).

Cognitive skills: skills based on knowledge such as the ability to cite the signs and symptoms of influenza.

Technical skills: skills that require knowledge and the ability to perform those tasks such as the technical skill of an intramuscular injection for an influenza vaccine.

Psychomotor or Behavioral Judgment: decisions about clinical actions requiring critical thinking and communication based on one's cognitive, technical and/or behavior skills. For example, the ability to communicate with the patient effectively to recognize, assess, and relay the signs and symptoms of influenza in a clear and concise manner that lead to interventions for the patient.

2.3 DEBRIEFING

Similar to after-action review, a Socratic method using leading and open-ended questions to understand what happened in a military training scenario and why (Baker, Dickieson, Wulfeck & O'Neil, 2008), debriefing is a discussion-based process that is critical to the pedagogical value gained through conducting medical simulation scenarios (Cantrell, 2008; Fanning, 2008). Per the Gold Standards set forth by the International Nursing Association for Clinical Standards of Learning, (INACSL), effective debriefing includes a trained facilitator to lead the debriefing session who is skilled in both diagnosing learner needs and managing group processes (Decker, 2013 INACSL Standard VI). Upon conclusion, all learners should have a clear understanding of the scenario and the levels of learning (cognitive, technical, behavioral) that led to the outcomes. Effective debriefing will allow the learner to create new knowledge through examining the meaning and implications of actions during a simulation, while ineffective debriefing can lead to detrimental outcomes such as negatively transferring a mistake into practice without realizing it had been poor practice.

3. CURRENT SIMULATION TECHNOLOGIES

The use of software-based simulation began in the early 1980s in the form of computer-based training platforms accessed through a single computer (Rosen, 2008). Today there many different educational software packages on the market designed to assist in a simulation setting[2]. Many of these were developed to first and foremost help with scheduling, inventory, and managing multiple simulation scenarios at once. It was not until increased facilitator demand did the products expand to include more robust learning features.

Current software is highly effective in participant(s) learning by providing an ease-of-use interface for the facilitator who structures the hands-on manikin scenario and leads the face-to-face post-simulation debriefing session. It also allows for digital manipulation in the form of diagnostic machine output (blood pressure readings and the like) and the administering of the manikin activities via remote control. However, providing an effective digitally mediated tool for the observers who are observing the simulation remotely has been slow developing and shows the most promise through the use of mobile technologies. Aside from the obvious advantages of locational flexibility, mobile technology allows for learning to occur in a direct context of understanding; one which is both individual and collective, and holds greater opportunity for the transfer and retention of knowledge (Brown 1989; Lave & Wagner 1991) for the observer. In addition, the Interactive Debriefing Application (IDA) presented below further advances simulation software through its grounding in learning theory.

4. METHODOLOGY

Representing a collaborative partnership across the Colleges of Nursing, Engineering and Arts and Sciences at the University of Tennessee, Knoxville, the IDA is built upon today's simulation software with the goal of transforming the passive observer into an engaged learner through both real-time interaction and archived activities; each of which build the learner's competencies in cognitive, technical and behavior skills that improve clinical judgment and patient safety. This partnership included a Professor of Nursing with extensive background in Instructional Design and Technology, a Clinical Instructor who serves as the Simulation Coordinator for the College of Nursing, an Associate Professor of Industrial and Systems Engineering with expertise in complex systems and simulation modeling and an Associate Professor of Graphic Design with expertise in information, experience and interaction design.

The 16 Junior students working on the project were enrolled in an Intermediate Graphic Design course that explores research methodologies and practices as they pertain to the design process including in-depth investigations into audience and context in relationship to form and meaning. The very nature of the design process identifies the early iterative stages as critical to the final end result however in the development of software, the process is imperative in identifying the interactions before the time is put towards implementation (Buxton, 2007). Therefore the class was divided into 4 focused teams each tasked with strategizing for a specific user experience (UX) within the IDA. The first three teams represented the core functionalities:

2 Software which the authors include as current developments in the field include: SimView, CAE Replay, KBPort, B-Line SimCapture and EMS Simulation IQ.

DASHBOARD TEAM

Develop a dashboard that allows a learner and facilitator to access all of the data related to simulation scenarios in which they have both been active participants as well as active observers; as well as identify scenarios they still have left to cover.

DATA CAPTURING TEAM

Develop an interface that allows for real-time intuitive observer engagement with a simulation; engagement that can be captured, measured and assessed and re-presented via the dashboard.

DEBRIEFING TEAM

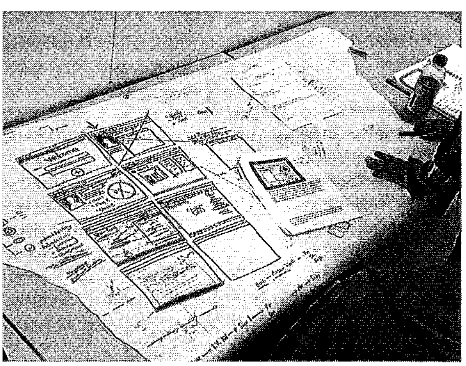
Develop a robust interface for retrieving annotations and selected snippets of video for review across a given timeframe and across 1-12 students to be expedited by the facilitator in a face-to-face debriefing session with all participants and observers.

The fourth team focused on the visualization of data generated by observer engagement with the IDA:

DATA ANALYSIS TEAM

Develop both a visual and textual manner in which the collected data can be quickly compared across multiple variables for display in the dashboard.

Parsing the students into discreet teams allowed for targeted research into UX precedents and patterns unique to each function, thereby diffusing the notion that the project would be 'designed' by any one person or any one team; presumptions that can often derail professional projects that are brought into a classroom setting. What was to be the primary challenge for the design students lay in the goal of imbuing known learning theory paradigms throughout the observer activities in an intuitive and meaningful manner. Identifying methods for translating this theoretical knowledge into practical application was guided by detailed and iterative mapping of mobile technology affordances, user workflow scenario building and wireframe prototyping (see *Figure 2*). This was coupled with tours of simulation settings on campus and in-depth lectures from, and team meetings with, the involved project faculty to best understand the



IGURE 2

ı-process development of
)A wireframes

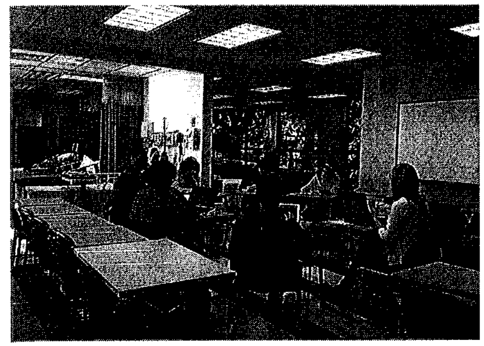


FIGURE 3

Graphic Design students working directly with team partners

definitions of both a nursing simulation scenario and the subsequent knowledge domains (figure 3). In order to allow the focus to remain on the UX the design faculty outlined the end goal as a strategic brief that would go as far as the development of low-fidelity wireframes.

5. RESULTS

The following chronicles the outcome of this interdisciplinary partnership designed to be deployed on a mobile device.

5.1 LEARNER DASHBOARD

The learner dashboard consists of the typical features associated with today's digital dashboard (profile, preferences, reminders, etc). Within the IDA it is also a personalized, secure interface allowing access to all of the content needed for participating in a simulation in addition to storing and retrieving critical reflection of learner performance when reviewing past simulations. Critical reflection as defined by Sociologist Jack Mezirow is a self reflective process that takes place after an experience when the learner evaluates their actions and attempts to view them from an objective viewpoint (Mezirow, 1990). The ability to review and reflect on their own simulation experiences across time will assist the learner in revealing patterns or concerns as they matriculate through future simulations

The dashboard is also the gateway to engaging with an upcoming simulation. All learners involved will receive critical information prior to the simulation that requires review such as objectives and patient profiles. Once a learner has reviewed this material, they are granted authorization to participate in the simulation via a notification from the facilitator. This step assures observers, who will be watching in real-time, are prepared for the upcoming simulation thereby increasing their accountability in the activity.

5.2 FACILITATOR DASHBOARD

The facilitator dashboard supports pre-simulation information in regards to patient data and objectives as well as a post-simulation review of each student's engagement activity. At any time the facilitator can provide needed feedback to a selected student. Most unique will be the ability for the instructor to scaffold the objectives of a simulation to the learning level of the observer. For example, if an observer is demonstrating that he/she is not properly identifying a set of technical skills critical to advancing higher levels of clinical judgment, the facilitator could limit the variables in that student's simulation objectives to ensure that those particular skills are brought to the

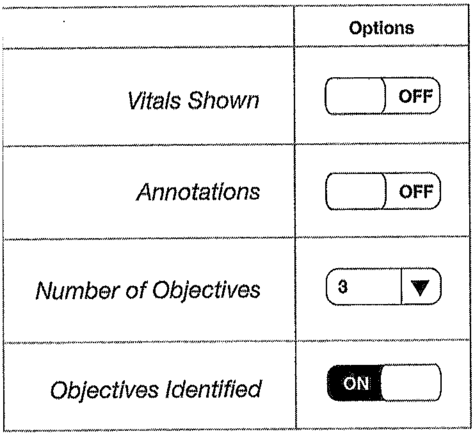


FIGURE 4

Facilitators have the capability of scaffolding the experience for the learner

foreground (see *Figure 4*). This type of customized educational scaffolding allows for the facilitator to constrain options with or without the learners knowledge to allow personalized focus on particular tasks (Pea, 2009).

5.3 DATA CAPTURING

Active learning, which is in direct opposition to passive learning, is a state in which the desire to learn is triggered through active participation (Bonwell and Eison, 1991). Therefore, the heart of the IDA is in the data capturing component, the active process of converting an observed experience into a form that can be analyzed. Real time video will be transmitted from the simulation scenario documentation cameras directly to the mobile device making it the premiere element in connecting the observer directly with the simulation. This interface provides for engagement through flagging capabilities, interactive checklists, specific profiles, and accessible vitals, granting the observer autonomy to contribute to the overall learning environment thus leading to greater accountability.

In order to effectively balance the potential to overwhelm the observer with the required tasks, the interface applies intuitive gestural affordances to minimize the "cognitive burden" that can arise when a user is forced to step outside of content engagement to address a confusion in using the interface (Turner, 2008). For example, dragging screens for repositioning (see *Figure 5*), pinching inward to minimize, or swiping are all gestures that are inherent affordances within the use of mobile devices.

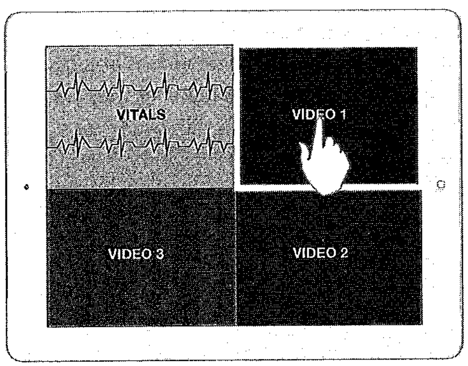


FIGURE 5

The observer can select which camera angle to enlarge.

Throughout a simulation, the observing student will be asked to acknowledge moments within the activity in which the participant met, or did not meet, a particular learning objective. When one of these conditions is observed, the student would select either 'C' for cognitive, 'B' for behavioral, or 'T' for technical event; modeled on the knowledge domains as identified in Bloom's Taxonomy learning theory (Bloom et al., 1956). If students observe a success they would select the corresponding letter and swipe their finger up to indicate success. Likewise a down swipe would indicate a mistake (see *Figure 6*). This gestural movement references known paradigms of thumbs up for success or thumbs down for a deficit. For the beginning observers, the facilitator can opt to show titles of specific events (see *Figure 7*) while more advanced observers may be asked to type in what event they are witnessing in accordance with the scaffolding needs of the observer. Students are granted a set amount of time post- simulation in order to review their annotations and flags and add any additional thoughts prior to debriefing.

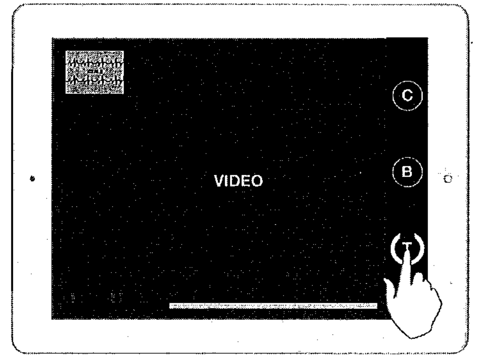


FIGURE 6

Swiping a Technical event upwards to flag a success in the simulation.

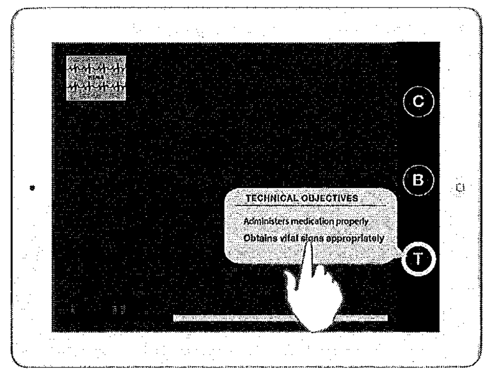


FIGURE 7

Selecting the exact type of Technical event being observed in the simulation.

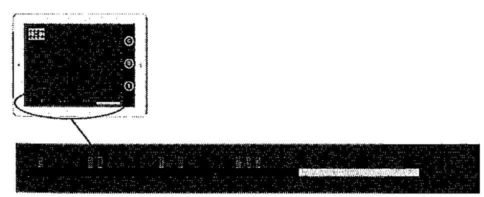


FIGURE 8

Flags above timeline are success while below indicate mistakes.

Upon selecting an event and indicating success or misstep, the timeline at the bottom of the interface will receive either a flag on top of the timeline for an accomplishment or a flag below the timeline indicating a mistake (see *Figure 8*). Each flag is synced directly with the point in the video where the observation was made.

5.4 DEBRIEFING

Interaction with the collected data during the debriefing will take place in three phases: initial reflection, discussion, and final reflection thereby widening the opportunities for student learning.

Initial reflection: Observers will begin with a quick reflection activity in which they submit a written summary of the observed simulation. This information will be available to both the instructor as well as in an anonymous form to the participant(s) who performed the simulation.

Video Discussion: All notated flags will be compiled into a single visual timeline indicating the category of the observation (cognitive, technical, behavioral) through color and the number of instances through size. It will take only a glance to determine exactly where in the simulation an error (or a greater number of errors) were noted by the observers (see *Figure 9*).

Final Reflection: The final stage of the debrief is similar to the first—observers are given a brief time to compose a reflection on the scenario and add in anything new that they learned in their debriefing discussion (Dreifuerst, 2009).

Instructors will have a visual student roster to the right of the main video allowing a one-click projec-

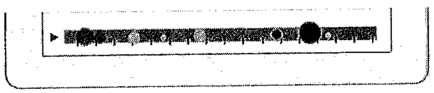


FIGURE 9

Aggregate of all flags across three events; the larger the circle, the more errors that were observed

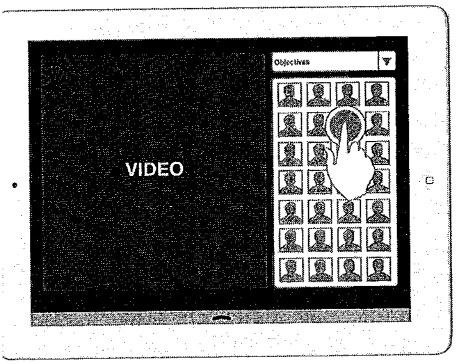


FIGURE 10

Student roster is projected on the right of facilitator's screen

tion of any student screen allowing student to go directly to the point of conversation to for the class to see (see *Figure 10*). All information displayed and submitted within the debriefing session will be archived and accessible via the observers' dashboard in the future.

5.5 DATA VISUALIZATION

The IDA will employ interactive visualizations of all collected data to be delivered to the student via their personal dashboard. The ability for a real-time data-driven assessment interface that can be customized and filtered provides both the learner and facilitator a means of understanding performance across time (Johnson et al., 2014). Students will be able to compare across multiple variables to reveal patterns, isolate concerns, assess outcomes and identify potential patterns and trends. In turn, pattern identification allows the brain to more easily absorb information and transfer knowledge accordingly (Mayer & Sims, 1994).

6. DISCUSSION

To date, simulation debriefing software has focused on the learners performing the simulation. The scenario is developed for *their* engagement with the manikin while subsequent debriefing activities focus on *their* specific actions. Due to high numbers of students enrolled in simulation classrooms and limited resources, students may serve more as observers than actual participants throughout the course of a semester; increasing the need to better develop an experience in which observers can be engaged and their engagement can be measured and assessed.

Digital technology provides the benefit of real-time feedback, a speed of delivery in-line with increased motivation and learning, and advances assessment beyond just post-simulation accountability (Stiggins & Chappuis, 2005). The design of the IDA to organize the learner's simulation history as a visually-driven interface provides better assessment of their learning needs over time. This is a valuable set of information as the perception of low performance from an individual event does not always take into consideration the understanding of knowledge to date, therefore the ability to see performance across time is a constructive comparison (Stiggins & Chappuis, 2005). This aligns with the needs of a learner to be scaffolded through their experiences and witness evidence of success or weakness.

When developing educational software for learning today it is no longer sufficient to simply follow an execution model that concentrates predominately on content access. Technology has developed to a degree in which it can, and should, provide an experience that is cognizant of the learning objectives inherent within the interaction. While there are many similarities between the IDA and known simulation software paradigms, this outcome is unique specifically because it was developed within the context of higher education. We contend that when the goal first and foremost is learning based on theory and practices and led by experts in the fields of educating practitioners, the end result is a product designed to meet the needs of the learner and the educator; including reporting mechanisms and analytics to identify more detailed student learning needs. In reorienting the process of simulation software development from one born from necessity to meet market demand to one that anticipates the needs of the learners, the outcomes of educational software products such as the IDA will fill current gaps in addressing all learners. Designing with this focus on learning will also aid trained facilitators who may be excellently versed in the use of the software but lack the pedagogical background to ensure the transfer of knowledge. A concern that increases as the growing market demand for nurses places more emphasis on the need for simulation education.

The involved design students were placed in their own simulation scenario wherein they were tasked with the practicable objective of applying their newfound research skills and design knowledge towards the development of a strategy for the IDA UX; one in which the interactions of the users were grounded in theoretical knowledge. This required an education on their part as to the relevant theories, which by the very nature of their being current students enrolled in higher education courses, felt familiar yet appeared foreign due to the theoretical terminology. The advantages of first-hand design classroom involvement with both design students and a design educator were many including: 1) ability to empathetically approach the design of a technology-driven tool for student peers who are also active consumers of today's digital culture; 2) rapid prototyping for project partners to quickly illustrate the affordances of the interface in relationship to the theoretical needs; 3) an overall advancement of the suite of tools and interactions to be developed for the IDA, including the addition of the dashboard to display learner analytics in a highly visual format. The next phase of the project will include the construction of the beta with a class of Industrial Engineers and its subsequent testing in a simulation classroom with nursing students continuing to advance the interdisciplinary emphasis of this project.

The inner-working of the interdisciplinary partners was benefited from a certain level of prior experience in past collaborations, however the manners in which these prior partnerships developed echoes the difficulty many design faculty have in identifying successful collaborative teams within the context of a large campus community (Spivey 2015).

And while the project partners were able to meet as needed, class scheduling proved an insurmountable obstacle in allowing the design class to interact directly with the potential IDA users. Rather user interviews were executed through informal gatherings driven by design students with peers enrolled in the nursing program. Software development does not often have to schedule around classes and critiques, however for inter-disciplinary partnerships to filter down into the classroom so that all stakeholders benefit from the interaction, this must be a consideration from the beginning planning stages as curriculum and course schedules are often set months, if not years, in advance.

7. CONCLUSION

Given how technology has affected healthcare simulation education in combination with how quickly digital advancements are eclipsing expectations, it is feasible to anticipate a future in which simulation scenarios are fully capable of allowing the live annotations of the faculty and observers to have an immediate effect on the unfolding scenarios and participant learners. It is also feasible to conceive of partnerships that include experts in the fields of educating practitioners in instructional technology, clinical instruction, complex systems and interaction design. Of course this is not without careful thought and strategic alliances to avoid impetuous partnerships. These are relationships that take time to cultivate, a critical factor for progress and development when working within the transitory nature of technology.

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