Next Time Won't You Play With Me:

Scalability of Simulation-Based Learning at Northwestern University

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Research Question

What variables of scale contribute to achieving stated outcomes of simulation-based medical education at the Feinberg School of Medicine and how do they compare to the variables of scale proposed for other types of game-based learning innovations?

Data Results Summary

Introduction

The purpose of this study is two-fold: (1) to examine the key variables of scale defined by Clarke and Dede (2009) for game-based learning innovations on the simulation-based learning at Northwestern's Feinberg School of Medicine; and (2) to provide an examination of how these variables might need to be accounted for in similar or different ways than other types of game-based learning when determining the depth, sustainability, spread, and shift in reform strategy required to scale the simulation-based learning at Feinberg to other settings (Clarke & Dede, 2009; Coburn, 2003). The data gathered, therefore, was based on the 39 variables of scale from Clark and Dede (2009) across five main categories as described in detail earlier. To triangulate this data, the researcher used three methods of data collection: artifact analysis, faculty interviews, and observations of simulation sessions.

The data results are summarized based on these same variables of scale. Beginning with the artifact analysis, each method of data collection is summarized in the following section based on the information gathered (see Table 1 in the Data Collection section) and reported based on the five main categories of variables: (1) student level variables, (2) teacher level variables, (3) technology infrastructure conditions, (4) school/class level variables, and (5) administrative/school level culture variables. The first category of student level variables describes the background and participation of students in the game-based learning environment. Teacher level variables describe the background, teaching style, and comfort of the teacher in the game-based learning environment. Technology infrastructure conditions describe the amount and type of technology used and the reliability and support provided for that technology in the game-based learning environment. The fourth category of school/class level variables describe the characteristics of the school environment such as class schedule, time for participation, and class setting for game-based learning environments. Finally, administrative/school level culture variables describe the supportiveness of the environment within which the game-based learning environment exists. The overall themes and specific ties to the literature are further expanded upon in the Data Interpretation section following this results summary.

Artifact Analysis

Artifact Analysis was used to gather data about the simulation-based learning at Feinberg across four of the main categories of variables: (1) student level variables, (2) technology infrastructure conditions, (3) school/class level variables, and (4) administrative/school level culture variables. As such, the researcher examined information available publically online on the Feinberg School of Medicine website, the Northwestern University website, and through blog posts and articles written about simulation-based learning at Feinberg. Information about the various forms of simulation-based learning at Feinberg, the stakeholders involved, and the school conditions for simulation learning were all readily available through the website, with varying levels of detail provided for different types of simulation. The artifact analysis was conducted with the goal of summarizing the data collected regarding the four variable categories.

Student level variables. As reported on the Feinberg School of Medicine simulation program (NUSIM) website, Northwestern runs simulations in four areas: (1) clinical simulations, (2) surgical simulations, (3) standardized patient interactions, and (4) virtual reality. Each of these four areas of simulations are set up and run differently with different learning objectives. As such, the types and level of learners who participate in simulations across all types is not the same in all cases as reported on the Feinberg website. Table 2 below is a breakdown of the different types of learners who participate in the different simulations at Feinberg.

Table 2

Types and Levels of Learners Participating in Northwestern Simulations

Type of Simulation	**Medical Students**	**Residents**	**Surgeons**	**Fellows & Attendings**	**Nurses/ Physician Assistants**	**Paramedics**	**Others**
Clinical simulations	X	X	-	X	X	X	-
Surgical simulations	X	X	X	X	X	-	Industry Partners
Standardized patient interactions	X	-	-	X	X	-	Physical Therapy; Genetic Counseling
Virtual reality	-	X	X	X	-	-	-

Table 2 represents a variety of different levels of general education for students (and professionals) who participate in simulations at the Feinberg School of Medicine. It also represents a variety of different types of education. For example, not just medical doctor students and residents participate in simulations; there are also Nurses, Paramedics, and others in related health care fields who might come to simulations with different levels of general education previously.

Technology infrastructure conditions. On the whole, the simulation facilities occupy multiple independent spaces within the medical school buildings and affiliated hospitals. Table 3 shows the space devoted to simulations at Northwestern.

Table 3

Location of Technology/Facilities Used in Northwestern Simulations

Type of Simulation	Square Footage	Simulation Spaces	Other Spaces
Clinical simulations	11,000 square feet (combined with Surgical)	5 Patient Rooms; Double trauma room	Outside the rooms is a hallway with the capability of capturing video of clinicians discussing patients.
Surgical simulations	11,000 square feet (combined with Clinical)	6 operating room stations; 1 telerobotic surgery operating room	Inanimate technical skills laboratory and virtual training room
Standardized patient interactions	12,000 square foot standardized patient Clinical Education Center	14 examination rooms	Three seminar rooms, computer lab, video viewing room for learners, faculty viewing stations, and a technical skills laboratory.

Table 3 shows space devoted to the technology and teaching of simulations. In addition to the spaces listed in Table 3, there are further simulation spaces mentioned but not reported in detail on the Feinberg website. These include spaces for pediatric care, women's health services, including childbirth, and training in emergency preparedness which all occupy separate spaces within the various hospitals and education buildings comprising the Feinberg School of Medicine and its affiliated hospitals.

The level and type of technology available within these simulation spaces varies depending on the type of simulation and learning objective. However, the simulation labs at Feinberg are equipped with a wide variety of state-of-the art simulation-based medical education technology. Table 4 below provides a breakdown of the types of technology available within each type of simulation—clinical, surgical, standardized patient interactions, and virtual reality.

Table 4

Types of Technology used in Northwestern Simulations

Type of Simulation	Audio/Video	Simulator Mannequin(s)	Other technology
Clinical simulations	Audio/video capture and playback available in every room, meeting space, skills lab, and hallway.	Each room has the capability of using a high fidelity simulator (electronic manikin)	Rooms are also equipped with suction, oxygen, ventilators, telemetry monitors, a code system, and x-rays viewers.
Surgical simulations	Audio/video capture and playback available in every room, skills lab, and debriefing space.	-	One operating room equipped for telerobotic surgery training.
Standardized patient interactions	The majority of the rooms have two video cameras and a microphone which connect to a monitoring/observation room.	"Harvey," a computer-based cardiac simulator.	Computer lab, video viewing room for learners, faculty viewing stations, and a technical skills laboratory
Virtual reality	-	-	Mimic Robotic simulator, Simbionix, LapMentor, Simbionix GI/Bronch Mentor, Simbionix Hyst/Turp Sim, VRMagic Eyesi Ophthalmologic simulator

As shown in Table 4, much of the technology used is in the clinical and surgical simulations, with standardized patient interactions using less technology. Several of the simulation spaces use simulator mannequins which are computerized model patients that can simulate many of the actions of patients. With the exception of these simulator mannequins and the equipment used for audio/video capture and monitoring, much of the technology used is the same as would be found in a similar hospital setting.

School/class level variables. As described by Clarke and Dede (2009), school/class level variables describe the setting within which game-based learning takes place. For Feinberg, Northwestern Simulation is housed within a top-tier, private medical research school whose mission is toward the advancement of learning and research in medical training and patient care delivery. The simulation facilities are located on the Chicago campus of Northwestern University's Feinberg School of Medicine.

There are over 1,200 learners who utilize the Clinical Education Center every year for simulation learning in standardized patient interactions. No data is available on the Feinberg website on the number of learners who annually participate in clinical, surgical, or virtual reality simulations, but these facilities are used year around to support learners across all types of training and education. The specific types of skills and educational learning objectives taught vary depending on the type of simulation. For example, clinical simulations include training with "crashing" patients, advanced cardiac life support, and anesthesia operating room performance. The center also trains clinicians using task trainers to perform realistic simulated procedures. Standardized Patient Simulations, on the other hand, train clinical skills on a wide array of competencies such as communication, history taking, physical examination, counseling, clinical reasoning, patient safety and advocacy, and some procedural skills.

Administrative/school level culture variables. Clarke and Dede's (2009) final variable category relates to the amount of support provided for game-based learning within the school including from administrators and fellow staff and teachers. At Feinberg, NU SIM is a fully staffed facility, with space provided and faculty and staff support for running the simulation programs. As described on the Feinberg website, new simulation sessions in general go through a central faculty and staff Simulation Curriculum Committee before they are approved and used to teach or assess learners. Faculty members are encouraged online to submit proposals to receive funding for simulation-based curriculums. The research of faculty is supported both administratively and financially for further investigations into high-quality educational simulation training. The Innovation Lab—offered through Feinberg—provides researchers with the infrastructure and expertise to build and evaluate anatomic models, modify simulators, and create novel learning tools. Virtual reality simulation is currently being investigated by a variety of department-led research efforts into its effectiveness in training residents. The specific conditions for simulations at Feinberg are reported in more below based on how faculty reported the variables of scale in in-depth interviews.

Faculty Interviews

Interviews with faculty involved with teaching and running the simulation-based learning at Feinberg were utilized to gather qualitative data related to all five categories of scale from this study. Three NU SIM educators agreed to participate in an interview regarding simulation-based education. These educators were each highly involved in running at least one aspect of simulation-based education at Feinberg and covered the following areas of simulation-based learning: clinical simulation (undergraduate medical school), clinical simulation (clerkship and residency), and standardized patient interaction simulation. All three interviews were transcribed and then coded for the variables of scale discussed throughout this study. The names of each interviewee were changed to protect participants.

Dan and Will were faculty members who teach numerous different clinical simulation sessions at Feinberg on a regular basis. Mary was involved in standardized patient interaction simulations and while she has taught simulations in the past, she no longer teaches in the NU SIM center. Table 5 below describes the background, academic specializations, professional development, and demographic characteristics of the faculty interviewed who teach simulation sessions. As she no longer teaches, Mary's teaching background was not gathered.

Table 5

Faculty Interviewee Backgrounds and Academic Specializations

Interview Participant	Years of Teaching Experience	Years of Simulation Teaching Experience	Academic Degrees	Self-reported Academic Specialization	Professional Development Related to the Innovation
Dan	10 years within medicine	5 ½ years	BA Chemistry Medical Doctorate Masters of Education	"It's probably split 50/50 between emergency medicine and medical education."	2 year fellowship in medical education and simulation focused on the curriculum development
Will	13 years	1 year after overall teaching. 12 years	Bachelor of Science Medical Doctorate Masters of Education Candidate for PhD	"I would say that health professions education is my specialty. More narrowly, sort of learning through experience."	5 ½ day simulation course at the center for medical simulation in Boston; 3 day USim simulation educator course in 2007; 3 day USim advanced simulation educator course in 2007;

As Table 5 displays, the Dan and Will had multiple degrees, varying levels of teaching experience, and had completed various faculty development opportunities. Mary has taught simulations in the past but was no longer teaching simulation education at the time of the interview. However, Mary worked with faculty and provided administrative support to faculty who do teach within the standardized patient interaction simulation sessions at Feinberg.

The following section presents the findings from the three interviews based on the five categories of scale related to (1) student level variables, (2) teacher level variables, (3) technology infrastructure conditions, (4) school/class level variables, and (5) administrative/school level culture variables.

Student level variables. The three interview respondents worked with different types of student populations in the simulations with which they were involved. Nevertheless, all three reported a similar breadth in the level of general education of students participating in simulations. All three mentioned simulations as a part of the regular curriculum for first and second year medical students and as part of the clinical rotations of students in their third and fourth years. Mary described simulations in standardized patient interactions as taking place almost exclusively in the first two years of medical school with some simulations going into the third year and beyond depending on the clerkship (third year). Mary also noted that fourth year medical students are required to teach simulation sessions as part of their fourth year medical school requirements. This is described in more detail in the teacher level variables below. Will also described using the simulation space for training fellows and professional doctors.

Emphasis on collaboration. All three interview participants described the importance of small group work and collaboration as part of simulation-based education. Dan described that "what I've found teaching these sessions as well as watching them is that especially for the first year students, a lot of them need multiple brains in order to pull it all together and to learn from each other and think about what to do." Will also describes how with simulation "Rather than assuming a role, it's assuming a role within a group and perspective taking from people who see things differently because they've been trained differently than you, because they're from a different group, professional group, or disciplinary group." Mary, for her part, described simulations as learning in a setting where "there's a lot of interaction and discussion and touching base." For this reason, all three interview participants described the importance of small groups and finding the right number of students to participate in simulation sessions as is discussed more below in relation to school/class level variables.

Students' technology familiarity and fluency. The extent to which faculty reported that students need to be familiar with technology used for simulations depended on the type of simulation. As such, characteristic quotes from Dan and Will are reported in Table 6 below based on the contrasting opinions of a need for students to have technology familiarity or not. Standardized patient simulations used little or not technology. Mary thus reported no need for students to have any familiarity or fluency with any technology to participate.

Table 6

Illustrative Comments about Student Technology Familiarity and Fluency

Interview Participant	**Technology Familiarity is Important**	**Technology Familiarity is *not* Important**
Dan	"…people who had not grown up their entire lives using tablets or touch screen devices or whatever else it was, who actually really struggled a lot when we put them in the 'rater' position and have them use the same technology the students are using."	"On the very simplistic level, the technology component of a simulation—it should be no different than taking care of a real patient in a hospital." "Our medical students, even our residents, have grown up their entire life with some sort of device in their hand. . . they are used to technology and they are used to faculty using and implementing technology in appropriate ways."
Will	"How do [students] get information from the simulated patient, i.e. the manikin that they normally would be able to examine or see?"	"I think the emphasis is always on the technology and with how do learners engage not with technology but how do they engage in an environment where the environment is limited and how do they still perceive it to be real?"

As Table 6 illustrates, both Dan and Will described varying levels of technology familiarity and fluency depending on the circumstances and the type of learner. In general, both emphasized more of a need for orientation to the simulation space than specifically to the technology. In some cases, this orientation involved explaining technology components used in simulations, but not always. For example, Will discussed how the ways in which students interact with the technology is important for orienting students to the environment. However, Will also emphasized that familiarity with the technology is the less important factor for this orientation. Instead, Will described the importance of orienting learners to the clinical problem and making students understand how to engage in a “realism-limited” environment.

Teacher level variables. One of the main purposes of the interviews was to assess the teacher level variables of scale, including the basic characteristics of the individual faculty members as well as the general level of support and comfort level faculty have teaching with simulation-based learning. All three interviewees discussed the difference between clinical and simulation-based teaching. Based on this, Dan and Will both discussed the background they believed necessary to be an effective teacher in a simulation session. Will discussed, for example:

> “I think that being a simulation educator requires very specific skills that can be acquired within a degree program, but more importantly learning from more experienced teachers. The notion that someone is a good clinical teacher in the clinical environment can automatically do simulation, I don't think that's possible.”

Dan also reported the need for faculty to be trained to work with simulations but did not think any particular degree was required. Dan explained, for example, how “I think that there needs to be some element of faculty development to do simulation well, but I don't think you need a specific degree or advanced training to do that.” Dan also described how there are varying levels of teaching and engagement with simulation-based learning. For those who are teaching simulations created by others, there is no particular degree required, but for those who are involved in developing and writing the curriculums, “for those higher order things, I think that having advanced training is really helpful.” Similarly, Mary discussed how faculty are involved as teachers and not specifically as simulation experts. As such, Mary did not report a need for faculty development in the area of simulation training/education because “their focus is not on simulation. Their focus is on curriculum that uses simulation.” Related to this, all three interview participants emphasized the support provided to faculty teaching simulation sessions as discussed below.

Support related to the innovation. Dan emphasized the layers of support built into simulation-based education in the clinical simulation lab at Feinberg by describing it as a pyramid:

> “The goal would be more of a pyramid such that there's a huge group of people at the bottom who are the educators and who can come into the simulation center and feel comfortable and have some level of expertise with debriefing and teaching using simulation as a methodology. And then there would be fewer and fewer people as the people go up in terms of who can teach the teachers—who can develop the content that the teachers are going to build—who can be all the way up at the top of the pyramid thinking about the 30,000 foot view and thinking about the curriculum and the implementation and how can we figure out ways to use technology more effectively, and then teach the other people how to use that technology, but not necessarily mandate that everybody can do it.”

This makes it so that, as Dan described, the faculty are supported on the technology so that they can focus on teaching. Dan describes the supportive structure as such:

> “We've created a world in which my role is the delivery of the simulation, so I oversee the technology component of it, making sure that the scenario unfolds the way that we want it to, and then I get one of my fellow faculty from one of the various departments to

> be the discussant and to talk about the medical management. What many of them have said to me is ‘this is great.’ They love the teaching. They love the immersive component of it. And they love the fact that I'm the stage manager and I'm coordinating all the different aspects of changing the lights and changing the screens and making sure the manikin is talking when it is. They get to do the teaching.”

Dan and Will both talked about the people involved in simulation sessions, including specifically simulation technicians, nurses, and faculty educators. Both stressed that faculty should be able to focus on teaching and not on running the technology or coordinating the activities of the day.

For standardized patient interaction simulations, the emphasis discussed in the interview was less on the technology support but still focused on the support for faculty within simulation sessions. Mary discussed the involvement of a curriculum coordinator who is there “to help make sure everybody knows where everybody is supposed to get to and everybody are [sic] in the right place at the right time.” Mary also discussed the involvement of trained actors as standardized patients and a standardized patient trainer who “takes care of the coordination of that and making sure that the standardized patients are prepared, oriented, and are in the right place at the right time.” A video technician is also present to support the video recording, streaming, and playback for feedback and self-assessment sessions. Finally, Mary described being involved herself in simulations as an overall coordinator for the standardized patient interaction sessions on a more general level, including working with faculty on a lot of the case writing.

Because of the level of support provided, all three interview participants mentioned that faculty do not have to have a high level of technology familiarity and fluency to teach simulation sessions. Instead, those who have that familiarity write and run the simulations while the faculty members focus on the learning of participants.

Teachers' beliefs about technology in the classroom. As some simulation sessions can involve a high level of technology, the beliefs of faculty on the use of technology in the classroom was an important characteristic described by interviewees. Both Dan and Will reported the value of technology on promoting education, but also discussed the importance of being careful in how technology is used. Table 7 gives a sampling of the things interview participants said about the positives and negatives of technology on education.

Table 7

Illustrative Comments about Teacher Technological Beliefs

Interview Participant	**Technology as a *Positive* Influence on Education**	**Technology as a *Negative* Influence on Education**
Dan	"Technology in the hands of someone who knows how to integrate it well can be very supportive of the overall mission." "I think that trying to figure out ways that technology can support their learning is beneficial…" "There are ways that I, using technology, through scaffolding… can then encourage their brains to make connections between new things and old things, then technology is helpful."	"I think technology in the wrong hands is a total disaster…" "…even the greatest ideas could fail if technology in and of itself was useless." "…but also identify ways in which technology interferes with learning and then trying to avoid that." "…as people in general try and push the boundary on what can be accomplished… there's greater and greater opportunities for failure of technology.
Will	"…there's lots of things you can do to enhance learning because of the technology…" "If the technology is added value to the learning activity it is great."	"…I think people often get caught up in the technology and forget that it's a technique that needs to be integrated within a larger philosophy of curriculum design and implementation." "…if it is not adding value… that's where I would draw the line."

Table 7 shows particularly illustrative examples of how the faculty interviewed viewed technology as a tool for learning.

Will also emphasized the disconnect between teaching and curriculum development within simulation session that require a lot of high technology. To illustrate the point, Will described the problem as such:

> "With increasing technology we are needing now technicians to run the technology which can also become onerous for simulation programs. . . because often people who run the equipment have technological expertise but don't have medical savvy and so with every technical expertise you run the risk of misrepresenting clinical conditions because that's not real. So it could be working technically but the representation for a practicing clinician is not on target."

Will was particularly cautious about a reliance on high technology solutions when low technology or no technology solutions could do the same thing as well or possibly better. This is particularly true as described by all three interviewees as it relates to how simulations are implemented as part of the curriculum and how the learning objectives of simulations relate to standards of medical education. How interview participants described how simulations relate to the curriculum of medical school and standards of medical education is described in more detail below.

Teacher's assessment of content as congruent with standards. All three interview participants noted the relationship between simulation learning and medical school education. Both Dan and Will stressed the relationship between simulations and the ability to practice skills which are used in clinical practice. For example, Will described the relationship between simulations and standards of care as follows:

> "The institution has patient safety goals for which we orient ourselves. So when you think about what are the problems we are addressing? Why are we designing these scenarios? We tend to align what we do with the problems the hospital is facing or areas of improvement the hospital sees."

Mary also stressed how standardized patient interaction simulations related to medical school examinations known as OSCE's. According to Mary, by the time students are entering their clinical rotations in their third year, they have been tested on the skills from their simulations six times. Mary also discussed how students participate in simulations followed by clinical practice where they use the skills practiced from simulations in real world scenarios.

Both Dan and Will stressed the additional factor of fidelity as it related to the objectives of a simulation session and what is being taught. For example, Will stated:

> "If we're doing a situation where a patient becomes very unwell and their heart stops, if they're on the chest and doing chest compressions, the chest should be flexible like a human's chest to some extent, it should compress, it should recoil. There should be some realism to that. I could pretend that this table is a chest but it doesn't move at all and that would be a very important aspect of reality that needs to be on target for that."

Dan also talked about how technology related to the objectives of the session and how that relates to how the simulation is effective in training students. To talk about this, Dan stressed how high tech is not always better:

> "If I am trying to teach a communication skill, a high tech manikin won't work, because I don't have that fidelity of that facial reaction. Manikins don't really cry and if they do it looks kind of funny. They can't grimace. They can't sit back in a chair and be like I don't really want to talk to you."

As such, all three interviewees discussed this idea of high versus low technology and fidelity related to the assessment of content against learning objectives and medical school standards. The technology used for simulations as described by the interview participants is discussed more in the next subsection.

Technology infrastructure conditions. All three interview participants, and particularly Dan and Will, stressed that technology is not required for a simulation. Dan, for example, discussed that “there's [sic] some simulations that require zero technology whatsoever.” Will echoed this idea, stressing in particular that technology is often not the most important part of a simulation, instead asking: “How much technology do I need to augment what I have in front of me? Whether that's a simple doll, so that people are engaged and feel something, that's what promotes learning: the emotional engagement—makes them feel like that's real.” Similarly, all three interviewees discussed how simulations involving human actors don’t require any technology. All three discussed how these simulations are often augmented by the use of video recording, but that this technology is not required, nor does it have to be expensive equipment. Mary, for example, discussed how video recording was used for standardized patient interaction simulations in order for students to watch and complete self assessments.

However, both Dan and Will discussed some of the possible technology that are used for simulations, classifying certain technology as necessary and other technology as nice to have or supplementary to simulations themselves. Dan explained how complicated the technology can get when adding additional layers:

> “Manikin based simulations can be super high-fidelity. . . where someone's sitting in a control room in an adjacent room behind a mirror and they’re running a computer which is running the manikin, which is responding based on however it's been programed by the

> faculty who are leading the session. And then you can add on layers from there. You can run additional computers of x-ray machines, and additional computers that are running vital signs monitors, and additional technology of having iPads to put in the learners hands so that they can see images and augment their learning."

Given these layers of possibilities, Dan and Will both emphasized that the technology used varies greatly depending on the type of simulation and the objectives of that session.

Location of Simulations. Dan reported that the simulation lab consists of five simulation rooms with control rooms and adjacent debriefing spaces. Dan also mentioned that sometimes simulator mannequins are taken to the classroom to be used for simulation-based sessions in front of a larger audience. Will reported that the pediatric hospital had a simulation lab with a control room for pediatric simulation sessions. Mary reported that the Clinical Education Center included six simulations spaces set up as outpatient care facilities, with adjacent video feedback spaces and a computer lab for self-assessments. Mary also reported using the technology from the clinical simulation lab when necessary to simulate an inpatient setting.

Reliability of Technology. Both Dan and Will reported challenges related to the reliability of the technology used for simulations, particularly as more technology is used. Dan stressed the issues with network problems which cause the mannequins to become disconnected from the control room or have caused feedback sessions to be interrupted. Will also discussed challenges related to technology in simulation sessions with technical glitches happening "almost always." However, both Dan and Will stressed that issues with technology are not necessarily a deal breaker. Will for example described how "It depends on what you want to do and how much you are relying on the equipment to create a sense of realism for the participants." As such, both Dan and Will emphasized a need to be responsible in the use of technology so as not to run into issues with it not working when they could do a similar simulation session using less or no technology. The conditions interview participants described for when and where simulations are used are reported in more detail below.

School/class level variables. Since each of the three interview respondents were from different areas of simulation education, each interviewee described different types of simulations and simulation environments. The three interviewees also reported a breadth of answers in the number of students participating, the schedule for participation, and the length of time for participation. A sampling of this variation in number of participants based on the population and type of simulation is shown in more detail in Table 8 below.

Table 8

Number of Participants Based on Type of Simulation and Population of Students

Type of Simulation	Population of Students	Number of Students Participating
Clinical Simulation	First and Second Year Medical Students	7, 8, or 9
Clinical Simulation	Fourth Year Medical Students	4 or 5 ideal; fewer struggle
Clinical Simulation	Residents	2
Trauma Simulation	Residents	15+
Classroom with clickers and ARS questions	First and Second Year Medical Students	150+
Standardized Patient Interaction	First and Second Year Medical Students	7-8 per faculty; 3-4 per simulation
Clerkship Orientation Simulation	Third Year Medical Students	30+

Table 8 shows a wide variety of different simulations occurring on a regular basis, including variations in the number of participants, their level of general education, and in the type of class. Similarly, all three interview participants described different schedules for participation. Dan described first and second year students as participating in clinical simulations a few times throughout the year, with certain clerkships (specializations) having additional simulations in the third and fourth year. Will described pediatric simulations as occurring on a weekly schedule for those in that specialization. Will also mentioned that pediatric fellows also run simulation sessions for more advanced residents, attendings (doctors), and practicing nurses and other care givers in pediatric medicine on a non-regular schedule. Mary described the most concrete schedule for participation for standardized patient interaction simulations. For these simulations, first and second year students participate every other week, four days a week for four hours during the regular school year. First and second year students switch off each week with their off weeks practicing their simulation skills in clinical settings.

Length of time to participate in simulations. As can be seen in part from the schedule for participation in Table 8, interview respondents reported variations in the length of time students participated in simulations. However, all three interviewees discussed how participation in simulations gets easier and more intuitive for students the more they participate in them. Dan described this by explaining as such:

> "The more and more that you do a certain type of activity, the more you can break down the barrier of realism and become immersed into what you are doing. . . . so, I think that part of it is for lack of a better term, learning how to play the game and understanding and immersing themselves in reality in much the same way that learning how to play the game in the hospital and take care of real people, you just become a little bit more comfortable after a while.

Mary made a similar point by discussing how students are always nervous when they first participate in simulations then get more comfortable after coming and participating for a while. The support for simulations described by interviewees from the school and administration is reported below.

Administrative/School Culture Level Variables. The final category of variables discussed within interviews were those related to administrative support and faculty mentorship. All three interview participants discussed a high level of administrative support for simulation learning at Feinberg. Dan, for example, stated that “There's a lot of other administrative people, so in the dean's office or even across this office that are hugely supportive of the use of simulation within the medical student curriculum and are trying to figure out ways to integrate that more so.” Will similarly stated that within pediatrics, simulation is highly supported:

> “There are [sic] administrator support here that support the simulation effort. There are simulation technicians downstairs. There's actually an incredibly well-supported program which makes it on the one hand a model, but on the other hand something that's difficult to emulate because there's significant resources for the program at the children's hospital. . . . The simulation program is a line item on the hospital budget so that's a key stakeholder.”

Will also emphasized that administrative support can take several forms, including financial resources and giving time to staff to devote to simulation teaching as well as “allotting time in the curriculum for their trainees to engage in simulation and seeking to integrate that in the process.” Mary, for her part, stated that administrators were generally supportive and that administrative support is incredibly important. However, Mary also noted that staffing was currently “lacking” because of changes in the curriculum which means “you need personnel to support all that. And I think it's probably a struggle in any institution, because it's expensive to run programs like this.”

Faculty mentoring. All three interview participants reported a supportive environment from faculty at Feinberg for the use of simulations for teaching. Dan, in particular, emphasized the importance of faculty mentorship as faculty learn to teach in the simulation lab by stating the following:

> "Much in the same way I was mentored once upon a time, [I] mentor them in the development and creation of what they want to do and then help them better understand how can we use technology perhaps? How can we make this session so that the educational outcome might be a little bit better?"

In a similar vein, Will also emphasized that teaching simulations required a specific skills set which should be acquired by "learning from more experienced teachers." In the final data collection method used to triangulate the data reported here, how all of these variables were observed in simulation sessions at Feinberg are reported in the next section.

Observations

The researcher observed two days of simulations in the clinical simulation lab. The two days of simulations involved different topics; different numbers of faculty, students, and support personnel; simulations of varying lengths; and different levels of student participants. These general characteristics of the observed simulations are reported in Table 9 below.

Table 9

Observation of Clinical Simulations Background Data

Simulation Session	**Level of Students Participating**	**Number of Students Participating**	**Number of Simulations**	**Avg. Length of Simulations**	**Number of Faculty Involved**	**Support Personnel involved**
Day 1	4th year medical students	10 students	4 sessions including debrief	11 minutes + 33 min. Debrief	1 faculty teacher	2 lab technicians; 1 nurse
Day 2	2nd year medical students	40 students	5 concurrent simulations; 2 sessions	78 minutes (debrief concurrent)	1 faculty coordinator; 5 residents in sim rooms)	5 lab technicians

As can be seen from the brief overview provided in Table 9, the observed sessions represented a wide variety of simulation sessions; however, they all took place in the clinical simulation lab space using high-technology simulation spaces, including the use of audio/video recording, simulator mannequins, and iPads for feedback.

While there was variation in the types of simulations, number of students, and length of time as shown in Table 9 above, observed simulation sessions had several common characteristics in their structure. Both days of simulations began with an introduction to simulations and the simulation space, including how to interact with the simulator mannequins and other technology in the room. The overview and introductions on Day 1 took approximately 45 minutes, including having students and the teacher introduce themselves, going over the rules of simulations, and explaining and practicing with the equipment used in the simulation room. Day 1 included an additional introduction for how to use iPads provided for live simulation session feedback. Ten students participated on Day 1, split into two groups. After a brief overview and introductions, the first group of five students went into the simulation room for their first session. The other group watched the live simulation audio/video feed from the debriefing room and provided feedback on performance live through the provided iPads. After the first simulation finished, the first group returned to the debriefing room and went over the simulation session, using a recording of the live classroom alongside the iPad feedback to discuss the case. The groups then rotated so that the group which had been observing was now in the simulation room, and the other group was providing feedback. They rotated like this four times so that each group participated twice in the simulation room and twice in the live observer role.

Day 2 was structured differently. Day 2 also began with a general overview of simulations and the rules of the simulation space. Less time was taken for the overview than Day 1, only about 10 minutes. Less time was taken on introductions and less equipment was used that required explanation and practice. After the overview, students broke into five pre-assigned groups, each with their own medical resident acting as simulation room facilitator. The groups each went to their own simulation room where simulations began and ran through their entirety simultaneously. The researcher rotated between the breakout groups to observe parts of every session group. The simulation covered a basic diagnostic case for a simulated emergency room patient. After the first simulation, there was a brief break followed by a second simulation conducted in the same fashion with the same groups as the first simulation. Two cases were covered on Day 2.

The following section presents the findings from these observations based on three of the five categories of scale related to (1) student level variables, (2) teacher level variables, and (3) technology infrastructure conditions.

Student level variables. One of the main characteristics under student level variables from Clarke and Dede (2009) observed and assessed by the researcher was related to the level of engagement and collaboration exhibited by students in the learning environment. Observed simulation sessions were interactive, involving a good amount of collaboration. On Day 1, students exhibited engaged behavior throughout the simulation session by actively participating. After the first simulation, students discussed team roles and strategies before beginning simulation sessions and acted on their roles within the session. Day 2 was facilitator lead. Students were observed less actively engaged in the simulation itself and more focused on answering questions as directed by the facilitator in the room. Students were largely clustered around the base of the bed throughout the first case. During the second case, students began to take on roles more and were more clustered around the bed during the session.

Student technology familiarity and fluency. The students on both days exhibited no difficulty interacting with any of the technology used in the rooms at any point during the simulations. On Day 1, for example, students were excited about using the iPads to give feedback. One student exclaimed: “It’s like a game!”

Teacher level variables. The two days of simulations were very different in terms of how they were taught and by whom. However, both Day 1 and Day 2 included a basic overview of the day by the faculty lead, in which he established the environment for the day. For example, on both days, the faculty lead discussed the confidentiality of the simulation session; nothing is reported back to other faculty for grading. Participation itself is the grade for simulations. On both days, the faculty lead also emphasized the importance of failure within the simulation sessions and stressed to students that they are not expected to be perfect within the simulations. Finally, the learning objectives of the session and the expectations of what students should get out of participating was clearly articulated at the beginning of both days of simulations.

Teacher comfort with the innovation. Day 1 was taught by a single faculty instructor. The faculty instructor took time at the beginning of the day to introduce himself and establish his rapport as an instructor within simulations and within emergency medicine. He also asked all of the students to introduce themselves and their area of specialization, which he incorporated throughout the rest of the day, asking different students to respond to questions or demonstrate tasks depending in their area of specialization. After the introductions, the faculty instructor on Day 1 walked students through the equipment in the simulation room and asked students to demonstrate how to use it. Once the simulation session started, the faculty instructor watched from the control room, speaking to a professional nurse within the room through a two-way radio. For feedback and debriefing, the faculty instructor returned to the debriefing room and asked students to discuss how they felt about the session before addressing specific skills using the recorded feed from the room.

Day 2 involved five medical residents acting as instructors with one faculty coordinator. There was a one hour orientation for the medical residents and other support staff before students arrived. The orientation covered the cases—which were given to each facilitator as a paper copy from start to finish. The faculty coordinator also went over best practices for engaging students in simulation sessions and how to encourage students to struggle and learn for themselves instead of giving them the answers. Finally, the faculty coordinator gave the facilitators an overview of the simulation rooms, including the equipment and technology that would be used for the simulations. The faculty coordinator stressed in conversations with the researcher later, the amount of work that goes into coordinating this type of simulation session. For example, he explained how the cases have to be written ahead of time with a script including timing in a way that doesn't feel contrived. He stressed that the "back side" of the production is more work than running the actual simulation.

Once students arrived and after the initial overview by the faculty coordinator, the residents did introductions with their specific groups within the simulation rooms. Less time was spent on introductions and getting to know each other on Day 2. The group facilitators remained in the rooms throughout the simulations and guided students through the process. While in the rooms, the faculty coordinator moved between the observation areas and control rooms for each simulation room to make sure each session continued moving at the same pace and any issues were resolved as they came up. The facilitators in each room were engaged in the session and were actively asking students questions to get them to move along in the case. The sessions had a brief debriefing in their small groups within the simulation rooms at the end of each case. The faculty coordinator also noted later that residents are highly rated as facilitators for simulation sessions because of their status as “near peers.” They are someone the students can relate to and look up to who is less intimidating than a faculty member.

Faculty support. For both days of simulations, there was support provided for the instruction by other personnel. Day 1 included a professional nurse who was in the room with the students and could help facilitate the use of any equipment in the room. Additionally, the faculty instructor was connected to the nurse through a two-way radio and would give instructions to the nurse during the session to keep things moving in the direction he wanted. There were also two lab technicians on Day 1 who were facilitating the technology. One technician acted in the role of the simulator mannequin while the other helped set up the room and the technology equipment for the cases.

Day 2 was a larger production with five medical resident facilitators and five lab technicians. The facilitators were supported in their use of the technology and the teaching by the faculty coordinator for the day. The lab technicians all acted in the role as a different simulator mannequin as well as controlling the mannequins and vital signs monitors using the technology. The faculty coordinator explained later to the researcher that the lab technicians play a critical role in keeping the script moving so that the teachers in the room can focus on the students and what’s happening in the room. The lab technicians controlled all of the technology in the room as well from control rooms. The in room facilitators were observed on more than one occasion asking the control room to change something on one of the monitors in the room during the middle of a simulation session. The technology used is discussed more below.

Technology infrastructure conditions. Both days of simulations took place in the clinical simulation lab at Northwestern. The simulations used one or more of the five available simulation spaces. On Day 1, a debriefing space was parceled off with removable wall panels to create a separate classroom. This classroom had two television monitors and audio/visual equipment. Students sat around a table with iPads to provide feedback while watching the simulation room on the TVs. On Day 2, the debriefing space was left open with row seating, and was used minimally for instruction. There are also three control rooms used to control the five simulation spaces. Each control room had a one-way mirror into at least one simulation room, several computers, servers, audio/visual equipment, monitors, and wireless headphones/microphones which lab technicians used to monitor the room and speak for the mannequins. There were also observation stations with one-way mirrors, computers, and audio headphone hookups in the hallway outside each simulation room.

The simulation rooms were equipped with standard hospital equipment plus the simulator mannequin. The faculty coordinator explained that the equipment was the same as the equipment used in the actual hospital. For example, on Day 1, the faculty instructor cautioned students that the defibrillator was real and could do harm if not handled properly. Each room was also equipped with telephones which were used in simulation sessions for students to call "specialists" for help—also played by the lab technicians based on their script on Day 2.

Reliability of technology. None of the equipment in the simulation rooms experienced any problems during either of the days of observations. On Day 1, the iPads did not connect correctly to the program used for giving feedback. However, this was resolved when the faculty instructor reset the iPads and reconnected them to the program used for giving feedback.

Conclusion

This study is looking into the conditions that affect the scalability of simulation based learning as exhibited at Northwestern's Feinberg School of Medicine. The data gathered and reported here is related to the variables described in the literature related to scaling technology-enhanced, game-based learning innovations. The artifact analysis, interviews, and observations illustrate the ways in which these variables affect the simulations at Northwestern. In particular, the data gathered shows how simulations are affected by the five categories of variables: (1) student level variables, (2) teacher level variables, (3) technology infrastructure conditions, (4) school/class level variables, and (5) administrative/school level culture variables. The artifact analysis showed a wide range of students participating in simulations across multiple types of simulations. It also showed support for faculty and devotion of space provided for simulations. The interviews described variations students level of engagement with simulations, level of familiarity with technology, and importance of orientation to simulation spaces. An emphasis was placed on how and when technology should or should not be used for simulations. Interviewees also described faculty development and training related to teaching within simulations. Finally interviewees emphasized administrative structures which support teachers in developing simulations and running sessions. Finally, observed simulations sessions showed engagement by students in simulation sessions. It also showed variations in the roles of teachers and level of support provided for simulation sessions depending on levels of learners and comfort of teachers. Through interpreting this data all together in the next section, it is possible to begin to see the ways in which simulation-based education might be scalable across other departments, schools, or disciplines.