BRINGING GOOD TEACHING CASES "TO LIFE":
A SIMULATOR-BASED MEDICAL EDUCATION SERVICE

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ABSTRACT

Realistic medical simulation has expanded worldwide over the last decade. Such technology is playing an increasing role in medical education not merely because simulator sessions are enjoyable, but because they can provide an enhanced environment for experiential learning and reflective thought. High-fidelity patient simulators allow students of all levels to "practice" medicine without risk, providing a natural framework for the integration of basic and clinical science in a safe environment. Often described as "flight simulation for doctors," the rationale, utility, and range of medical simulations have been described elsewhere, yet the challenges of integrating this technology into the medical school curriculum have received little attention.

The authors report how Harvard Medical School established an on-campus simulator program for students in 2001, building on the work of the Center for Medical Simulation in Boston. As an overarching structure for the process, faculty and residents developed a simulator-based "medical education service"—like any other medical teaching service, but designed exclusively to help students learn on the simulator alongside a clinician-mentor, on demand. Initial evaluations among both preclinical and clinical students suggest that simulation is highly accepted and increasingly demanded. For some learners, simulation may allow complex information to be understood and retained more efficiently than can occur with traditional methods. Moreover, the process outlined here suggests that simulation can be integrated into existing curricula of almost any medical school or teaching hospital in an efficient and cost-effective manner.

On the eve of the new millennium, an auditorium filled with teaching faculty from Harvard Medical School (HMS) convened at the American Academy of Arts and Sciences to consider the future of medical education. A large breakout group was asked to review the role of educational technology in curricular reform. Reflecting on years of local discussion and pilot work in medical simulation, the committee observed: "Simulators are important tools and their use should be funded. . . A principal urging of this committee [is] an increased incorporation of simulation into the students' education." Little more than a year later, an on-campus program in medical simulation at HMS was born.

High-fidelity patient simulators—full-body mannequin-robots that breathe, talk, blink, and respond "like a real person"—promise to play a revolutionary role in undergraduate medical education.2 Allowing students to “practice without risk” on the simulator creates a powerful new framework for the thoughtful integration of basic and clinical science, long a goal of medical educators worldwide. Often described as “flight simulation for doctors,” the rationale, utility, and range of medical simulation have been well-described elsewhere,3–5 yet the challenge of integrating this technology into medical school curricula as preparation for treating real patients has received relatively little attention.
Our goal in this article is neither to describe the range of applications of medical simulation nor to review the extant literature on use of medical simulators. Rather, we detail one example of the development of a simulator program in an undergraduate medical curriculum, hoping to share the lessons of our experience with the growing number of medical schools considering such an initiative.

REALISTIC PATIENT SIMULATION IN MEDICAL EDUCATION

The use of realistic simulation in medical education has expanded worldwide, with the number of simulation centers rising from under 20 to over 200 in less than a decade. Following on early work at Stanford, the anesthesia departments affiliated with HMS collaborated to create an off-campus Center for Medical Simulation (CMS) about ten years ago, “dedicated to improving the quality of health care through teaching teamwork and clinical decision making using simulation.” Simulation exercises at this center and others appear to be playing an increasing role in medical education not merely because the sessions are enjoyable, but because they provide an enhanced environment for experiential learning and reflective practice.

In particular, medical simulation promises to enhance learning by targeting commonly elusive pedagogic objectives: realistic training prior to the care of actual patients, uniform exposure to clinical case material, and flexible learning in a dynamic environment. Consider the issue of patient safety, and imagine a practitioner who makes a clinical mistake; immediately after realizing the error, he or she will experience an emotional reaction that is powerfully instructive—but only for the next patient. What if educators could replicate such cognitive dynamics in a simulated environment, allowing trainees to “live through” a compendium of important cases in a fraction of real-time? At least for some medical students under this paradigm, simulation may allow complex information to be understood and retained more efficiently than would be the case with traditional methods, favoring early development of expertise in the formative years.

THE PROGRAM

Objectives and Preparation

To explore these possibilities, a group of faculty and residents instituted a simulator-based “medical education service” at HMS. It was intended to function as any other medical teaching service, but designed exclusively to help students recreate integrated clinical experiences, on demand. Built on years of pilot work at CMS, the on-campus program at Harvard was formally established in 2001. With the announcement of start-up funding, several organizational steps were taken to formalize the initiative:

Step 1: Interdisciplinary oversight. The dean for medical education invited a select group of educators to join a new Medical Education Center (MEC) Simulation Executive Committee. An on-campus program director was appointed and supported by a faculty teaching fellowship award. The interdisciplinary composition of the committee was critical for establishing credibility and oversight; the group was co-chaired by the dean for medical education and the associate dean for student affairs, and comprised a range of faculty physicians, administrators, educators, and bioengineers as stakeholders.

Step 2: Capital equipment and training. Arrangements were made to bring a high-fidelity patient simulator to campus (Human Patient Simulator, on loan from Medical Education Technologies, Inc., Sarasota, Florida). It was important for the company to provide on-site installation and customer support in order to quickly and efficiently train an initial core of educators and staff. Although basic maintenance and programming are not difficult, institutions that fail to partner with manufacturers and technical-engineering staff during the installation phase may find the equipment “still in the box” long after delivery.

Step 3: Dedicated space allocation. School officials identified space for the simulator on the central medical school teaching campus as part of the existing clinical skills lab. To facilitate curricular integration, the space was available to all students and faculty, and located within close proximity of core teaching and work areas. Initial space was only large enough to house a patient stretcher with adequate room to move around the bedside and store basic equipment. Our initial 400-square-foot (20’ × 20’) space allocation was small but adequate; as activities expanded, we began planning renovations for a larger space.

Step 4: Administration and partnerships. The dean for medical education initially named the enterprise “The MEC Program in Medical Simulation at HMS” to distinguish the program as a dedicated on-campus resource for undergraduate medical students, designed to complement off-campus work at CMS. CMS was founded in 1993 as the Boston Anesthesia Simulation Center by a collaboration of the academic anesthesia departments affiliated with HMS (Beth Israel Deaconess Medical Center, Brigham and Women’s Hospital, Children’s Hospital and Massachusetts General Hospital); the name was changed in 1997 to reflect a broader educational base. CMS has become a world leader in expanding the use of simulation to improve the quality of health care. This center pioneered the use of realistic simulation at HMS and continues to offer unique programs for physicians (residents and faculty), nurses, technicians, and industry person-
nel. When the on-campus program was established, medical student programs were transferred to the school’s MEC, where a senior school official became the institutional steward and provided administrative oversight for a dedicated budget. HMS stationary reflecting the multidisciplinary, multi-institutional nature of the new collaborative enterprise was drafted and approved for use.

Curricular Development and Integration

By the late spring of 2001, these preparatory steps culminated in the first “official” class on campus. A group of second-year medical students learned about respiratory physiology and the care of an asthmatic using the simulator. The response was overwhelmingly enthusiastic, and the inaugural class session was featured in the on-campus newsletter and the annual dean’s report.18

The development of problem-based learning over the past two decades has provided a robust foundation for the introduction and integration of simulator-based teaching. Countless clinical cases have been created by peer review and consensus, along with tailored learning objectives and curricular material. Rather than “reinvent the wheel,” simulation can almost seamlessly be integrated into problem-based curricula by simply “brining to life” existing case material. Consider the following simulation scenario, drawn directly from an existing New Pathway tutorial case19:

A 75-year-old gentleman with diabetes and hypertension suffers a heart attack overnight and is admitted to the ICU with mild congestive heart failure; he is stabilized with reperfusion and diuretic therapy but becomes hypotensive the next morning. On rounds, the day team expresses concern over recurrent myocardial ischemia and cardiogenic shock; the overnight team questions dehydration from over-diuresis. Approaching the bedside, the residents and staff are called away; a group of five students remains behind. Together, they find a patient who is indeed hypotensive and tachycardic, complaining of nausea and lightheadedness. “Hello,” the patient calls out, “I don’t feel so well—can you help me?”

In the simulator lab, students at all levels are encouraged to interview and examine the patient, proceeding with diagnostic workup and treatment as a team. In this case, first-year physiology students are mentored through the clinical encounter and asked to reflect on determinants of cardiac output according to the Frank-Starling mechanism. Second-year students are prompted to consider basic interventions, and often concentrate on pharmacologic effects of sympathomimetic drugs. Third- and fourth-year students are asked to manage the case as if they were interns on the ward. They may be asked to perform and understand basic procedures (e.g., interpretation of chest x-ray or electrocardiogram; intubation or placement of a pulmonary artery catheter), or else deal with complex professional and ethical issues (e.g., “Doctor, I don’t want to be on a respirator”). All students are also debriefed either during or after the case as a critical component of the exercise; some watch a videotape of the exercise to critique their own performances.

Because simulator sessions often use existing curricular material, wholesale changes in course content or faculty-student time scheduling are not required—only a change in venue. For example, rather than spending the last half-hour of a preclinical tutorial session around a discussion table, students and their instructor can simply transfer the conversation to the simulation lab; faculty scheduled to give a clerkship lecture in the hospital can do the same. Although flexible scheduling is required for programs with a single simulator, institutions with multiple simulators might envision natural synergy with established course routines (both manufacturers of simulators, Laerdal and Medical Education Technologies, Inc., now produce basic units for under $50,000).

Preliminary Utilization and Plans

Our first year of operation expanded off-campus pilot work and saw hundreds more students use the simulator. Students throughout our curriculum frequently report that simulation should be a mandatory component of their medical education,12 and many request more exposure—a finding consistent with other reports.11 Both preclinical and clinical students routinely identify critical thinking through experiential learning as the primary advantage of simulation-based learning, rather than procedural practice.12 While the students enjoy hands-on practice, the procedural aspect of full-body simulation provides a cognitive framework for integration and recall, rather than a lesson in technical proficiency (e.g., tracheal intubation is a lesson in pharyngeal anatomy, airway physiology, and respiratory failure, rather than an exercise in dexterity). After introducing the new program through e-mails, lecture announcements, and course directors, simulators have been incorporated into the curriculum in the following ways:

Preclinical education. Each year the entire cohort of first- and second-year medical students (approximately 160 students per class) are given the opportunity to see specific curricular material “come to life.” In the traditional cardiac physiology block, students are scheduled for mandatory “clinical field exercises”; the simulator lab now directs this experience several hours a week for a month-long block, allowing groups of five to ten students per hour to actually “take care
of their own tutorial patient. Tutorial groups are further encouraged to explore class material on an elective basis, an opportunity afforded to about half of the first-year class during the year. To accommodate all students together in one room, the anesthesia department uses the simulator to conduct an interactive teleconference in the medical school auditorium, where second-year pharmacology students direct the care of a simulated anesthetic induction.20 Another course that traditionally used animals for teaching physiology has experimented with using a simulator to achieve similar course objectives.

**Transitional education.** Simulation exercises are also offered to facilitate ongoing preclinical practice sessions for interview and examination skills in both ambulatory and acute care settings. These sessions typically encompass three to five students caring for common case presentations such as chest pain or shortness of breath over two hours; approximately half of the second-year class participates each year. The simulator is also incorporated as an introduction to “codes” for all third-year students as they transition to the clinical year.

**Clinical education.** During the core surgery clerkship, the off-campus simulator had been used for several years to review the pathophysiology and management of the various forms of shock.17,21 This program has now expanded on campus and is integrated into several clinical rotations including medicine, critical-care anesthesia, and emergency medicine.22 Because the simulator has a radio-transmitted “voice” for patient–physician interaction, almost any specialty can be accommodated (pediatric and obstetrical modeling is also available). While the simulation experience is an expected component of some clerkships, it is completely elective in others. The structure of these sessions is left up to individual course directors, and usually encompasses three to five students managing a few clinical cases over one or two hours. Approximately 100 clinical clerks attended simulator sessions during the inaugural year of the program.

**The Promise of a Medical Education Service**

One of the main challenges of the on-campus program was to provide a feasible level of instructor staffing that would allow simple, affordable, and comprehensive access to the simulator. The executive committee wanted to provide a service that could be used by students or instructors at any time, and hoped to involve teachers and learners from across all disciplines and institutions. To accomplish these goals, the Medical Education–Patient Simulator Service was established, complete with a pager system and “on-call” physician–educator. “Education on demand”16 at HMS is now possible because “the good teaching” case can be reliably recreated on the simulator. The service comprises the following:

- **Faculty On-Service.** We identified a core of faculty educators who wanted to play a prominent role in simulator education. Several faculty across disciplines over the course of the year are “on-service,” and provide direct supervision of student exercises.
- **Residents On-Call: The Medical Education–Patient Simulator Service Elective.** Although residents provide much of student education in the clinical setting, they often have no formal practice or instruction as teachers. Moreover, some of the best training of residents occurs when they have an opportunity to teach inquisitive students in a rigorous fashion. We offered senior residents across specialties the opportunity to participate in a “medical education elective” at the simulator lab, hoping to complement existing departmental electives and resident-as-teacher23 initiatives. During the inaugural year of the program, we had several senior residents participate in the month-long elective, providing near full-time educator staffing for an on-demand service.
- **Education On Demand.** Students and faculty are informed of the program by e-mail, course materials, and lecture announcements. We even established a pager service via Massachusetts General Hospital, through which students can request the “physician on-call for the medical education service.” In general, however, students appear more comfortable using direct e-mail messaging or posted sign-up sheets to arrange an educational tutorial session of their choosing—sessions can usually be arranged within hours to days of their request.

Simulator sessions typically require at least a technician and clinical instructor. As local demand for the simulator continues to increase, we have hired a dedicated technician and clinical educator; we also just appointed our first “simulator fellow,” a postresidency teaching and research position that will augment the program’s teaching faculty and further enhance collaborative evaluation and research activity.11,12,14,15,17,20,24

**A Powerful Beginning**

The on-campus simulator program at HMS has developed into a cooperative endeavor that promises to unite varied disciplines, institutions, and individuals within the medical school community for the benefit of students, teachers, and patients alike. Although only directed research will reveal the true potential of this technology, the sheer power of the simulator experience remains undeniable; students them-
selves have played a major role in expanding its use. One group of 15 graduating students who attended the original off-campus program wrote to the dean\textsuperscript{17,25}:

The simulator stands out as our most important educational adventure at HMS. We feel empowered by the experience. We now have a framework for clinical event management that will benefit us, our colleagues, and most important, our patients. . . We cannot imagine entering the profession without this structure.

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**References**


