White Paper

Evolution of Simulation-Based Education at Michigan Medicine

From Simulation Center to Skills-Commons

James Cooke, M.D.
Executive Director, Clinical Simulation Center
Associate Professor of Learning Health Sciences
Associate Professor of Family Medicine

Deborah Rooney, Ph.D.
Director of Education and Research in Simulation
Associate Professor of Learning Health Sciences

Clinical Simulation Center
Department of Learning Health Sciences
MICHIGAN MEDICINE
UNIVERSITY OF MICHIGAN

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University of Michigan Medical School skills training circa 1892, 2018 and future

Executive summary

The introduction of simulation as a training modality and performance-improvement mechanism within healthcare has caused a remarkable paradigm shift over the last 15 years. Although lecture, apprenticeship and practice-based learning continue to provide the foundational knowledge required for health professionals, simulation-based training has revolutionized the training experience by providing early procedural experience, opportunities for deliberate practice, and standardized assessment. Gone are the days of "See one. Do one. Teach one." We are now in the era of safe and deliberate practice to competency *before* patient interaction.

Due to the relatively brief history of simulation in health professions' training, dramatic improvements in technology, and changing environments of care, learner needs and stakeholder expectations, predicting the future role and scope of simulation over the next 15 years presents an enormous challenge. Looking to other skills-intensive industries, such as aviation, energy, and the military, we may begin to visualize the future of skills training in health professions.

Simulation centers will likely evolve over the coming decades into **'skills commons'** where learners and full medical teams gather for initial training, repeated practice, and assessment. Simulated operating rooms will be replaced by immersive virtual reality spaces for high-risk or high intensity training, table top skills trainers replaced by a host of haptic workstations for task training, and standardized patients replaced by sophisticated simulators for exam skills training. All of these training resources could be available 24-7, offering learners the ability to practice until learning goals are mastered and assured via on-demand testing.

Beyond the increased availability, higher technology and broader scope of skills available, the commons will drive a fundamental change in the culture of healthcare to one of rehearsal prior to performance, regular individual practice, deliberate planning and preparation for potential adverse events, post event debriefing, and continuous team development. As is true in any sport, both individual and team practice are essential to improve performance. Much like a baseball player taking batting practice, healthcare providers must individually practice position- or specialty-specific skills to objective targets. Just like a baseball player taking practice swings immediately before entering the batter's box, healthcare professionals must visualize and practice the critical steps just prior to performing a procedure. Finally,

and most importantly, as in any team sport, healthcare teams must repeatedly manage simulated critical events in preparation for the unexpected, especially when outcomes are dependent on team performance.

Best team performance depends on individuals and teams seeking to continually improve their performance through accessing performance data (going to the film room), testing 'new formations and plays,' incorporating advice from coaches, and regularly utilizing safe and relevant spaces for both individual and team practice. The *skills commons would act as the healthcare practice field* for rapid assessment, adaptation and improvement. With effective team training, teammates change perspectives, are encouraged to adapt, and engage in team feedback, resulting in a pervasive culture of continuous improvement.

The commons will also be the ideal place to leverage the broad strengths of the University to address the significant challenges within healthcare and health professions training, and to utilize simulation as a critical component of the learning health system. The 'skills commons' concept can guide health professions educators and system leaders to visualize a future state of simulation, not only as a modality for individual and team skills training, but as a mechanism for health system evaluation and improvement and an interprofessional hub for problem solving.

Looking Back to Move Forward: Background and history of simulation at Michigan Medicine

The University of Michigan was one of the first academic health centers to launch an interdepartmental simulation center, and its rapid growth and evolution has been both disruptive and transformative for educational programs and the health system. Launched in 2004, the Clinical Simulation Center (CSC) was established by the dean and department chairs to provide simulation-based education to graduate medical education (GME) learners across the institution. Unlike centers at most other institutions, the CSC was developed as a collaborative organization to distribute the cost of center operations and maximize the investment in technologies, including high-fidelity procedural and patient simulators. This structure provided the added benefits of access to educational and technical expertise on developing simulation-based education (SBE) programs, infrastructure for evaluating, purchasing, maintaining and upgrading simulation technologies and an academic home for faculty committed to cultivating educational programs and improving efficacy of training. The financial structure and stakeholder-based governance provided opportunities to break down silos, sharing expertise and resources to benefit all programs and the larger health system through efficiencies and improvements in patient care.

These benefits could not have been anticipated when the center was launched, and similarly, we cannot accurately predict the events that will follow, but the availability of this powerful tool in the hands of dedicated healthcare educators and investigators will continue to transform the delivery of education, assessment of learners, evaluation of healthcare systems and culture of healthcare to one of continuous evaluation and improvement.

Early years and facility expansion

The CSC began as a 1,500 square foot renovated classroom in the centrally-located Towsley Continuing Education Building with two team-training bays and a smattering of surgical and procedural simulators including laparoscopy and endoscopy for a few hundred learners per year. Task-training for bedside and surgical procedures and team simulation for cardiac, respiratory and anesthetic-related emergencies were rapidly adopted by GME programs from 11 clinical departments, including Anesthesiology, Emergency Medicine, Family Medicine, Internal Medicine, Neurosurgery, Obstetrics & Gynecology, Orthopedic Surgery, Otolaryngology, Pediatrics, Surgery and Urology, and was administered through the Department of Medical Education (later changed to Department of Learning Health Sciences or DLHS). The rapid improvement in observed performance on critical skills, positive feedback from engaged learners, and measurable improvements in patient outcomes seen in hospital-wide simulation intervention studies along with ACGME and ABMS mandates for simulation based education and assessment fueled a rapid increase in demand over the following 15 years. At several points, demand also far outpaced capacity prompting an expansion to 5000 sf in Towsley in 2008 followed by an additional 800sf 24-7 independent training space in 2016 and the addition of an entirely new purpose-built facility in Med Sci 2 in 2018. Simulation has also garnered a committed group of faculty instructors who understood the value of simulation in other industries, such as the military, aviation and

energy sectors for initial exposure, deliberate practice, and training prior to performance. As experience grew, more mature and more robust programs developed including standardized surgical training, video recorded team training scenarios with debriefing and robust assessments to improve the efficiency, quality, and retention of clinical education.

Over the last 15 years, the CSC has grown dramatically, now providing training for over 12,000 learners per year utilizing a wide range of procedural simulators and over 13,500 square feet of dedicated simulated learning spaces across two locations with nine simulated clinical rooms and bays closely matching those across Michigan Medicine. Learners have access to high-fidelity simulators covering a wide range of procedural skills, including laparoscopy, endoscopy, bronchoscopy, robotic surgery, intravascular procedures (endovascular aortic repair, transcatheter aortic valve replacement, cardiac catheterization, cerebral angiogram, and others), intraoperative perfusion/ECMO, mechanical ventilation management, microscopic surgery, and simulated tissue-based pediatric and adult surgical trainers- all accessible 24 hours a day, seven days a week to provide maximum value to our learners.

Team training and skills training for airway emergencies in CSC-Towsley for M4 students during Residency Preparation Course for Emergency Medicine

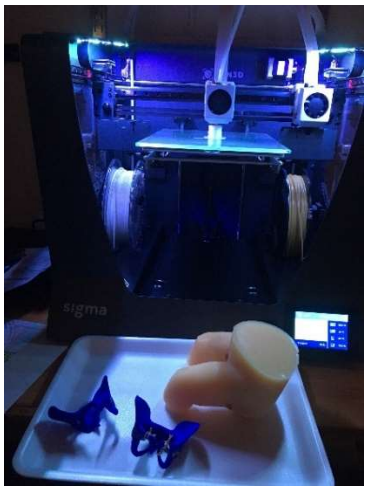
The new CSC-Med Sci II, which opened in February of 2018, includes five purpose-built inpatient rooms closely matching clinical spaces within the health system (EC3, Mott ICU, Von Voightlander delivery room, and two UH inpatient rooms), with control rooms, AV recording for review and debriefing, medical gasses, equipment, lighting and electronic medical record access to provide fully immersive EMR-enabled team training. The simulation rooms also have the infrastructure to readily convert to operating rooms, ECMO-capable intensive care rooms, NICU rooms and a host of other high-acuity treatment environments in use at Michigan Medicine.

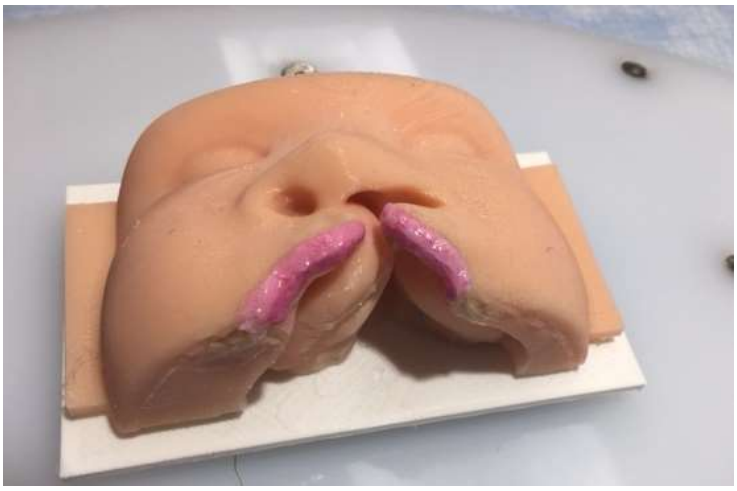
Schematic floor plan of new CSC-Med Sci II with 5 inpatient rooms, skills labs and independent simulation lab. Obstetric simulation for systems training for Interpreter Services

Academic inquiry and discovery

UM researchers continue to study the impact of simulation on undergraduate, graduate and continuing education programs. Simulation has become accepted as superior to other forms of education for both applied knowledge, complex task and procedural skill training, while providing significant safety benefits for learners. Beyond educational outcomes UM researchers have also evaluated the direct benefits of simulated team training for Michigan Medicine patients. One specific example includes the significant and sustained improvement in the pediatric cardiac arrest survival rate across Mott Hospital when simulated mock arrests were conducted at the beginning of each month over the course of three years with an overall 50% survival rate, far exceeding the national survival rate for in-hospital pediatric cardiac arrest.[1] In addition, researchers across the globe have examined and identified best training modalities for our learners and patients, while others have demonstrated the value of system improvements grounded in simulation-based training programs.[2,3] At the CSC, we have performed numerous studies to evaluate the fidelity and value of new simulators, evaluate the validity of simulation-based assessments, and demonstrate improved learner and patient outcomes across the full range of clinical specialties. We have developed novel simulators to support training and assessment of difficult, low volume, and high risk procedures, such as epistaxis management, neonatal hip dysplasia exam, cosmetic skin procedures and complex surgical reconstruction.

1. Andreatta P et al. Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates. Pediatr Crit Care Med. 2011 Jan;12(1):33-8
2. Brydges R et al. Linking simulation-based educational assessments and patient-related outcomes: a systematic review and meta-analysis. Acad Med. 2015 Feb;90(2):246-56
3. Gardner AK. et al. Using Simulation to Improve Systems-Based Practices. Joint Comm J Qual Patient Safety, 43(9):484 - 491





3D printed and molded congenital hip dysplasia model developed by Drs. Deborah Rooney of the CSC Innovations Lab, and Dr. Clifford Craig of Pediatric Orthopedics and cleft lip repair model developed by Dr. David Zopf and Dr. Chelsea Reighard in Pediatric Otolaryngology, Kevin Green in Biomedical Engineering as well as Dr. Rooney.

Most recently, we have begun to provide device testing services for medical and surgical devices being developed throughout the Michigan Medicine community, including new surgical instruments, patient monitoring devices, respiratory assist devices, antibacterial surface coatings and a host of devices developed by Biomedical Engineering colleagues. We continue to explore novel education delivery modalities, such as immersive virtual reality fire-in-the-OR training, in an effort to improve system-wide safety.


Demonstration of immersive virtual reality experience for fire in the operating room (beta test version imaged courtesy of Health Scholars, Westminster, CO) during CSC faculty instructor course and tracheoesophageal fistula repair training using 3D printed rib cage and tissue insert for pediatric surgery (developed by team at Northwestern including Dr. Deb Rooney)

These advances would have been impossible to predict back in 2004, but simulation has now been embraced by medical educators at all levels and has become the gold-standard for teaching and assessing competence of a full range of skills. On the national level, several specialty boards now require simulation-based training and validated assessment as part of certification (surgery, anesthesiology and obstetrics and gynecology). Further, several health systems and medical liability insurers, including Controlled Risk Insurance Company of Harvard's Risk Management Foundation (CRICO/RMF), have recognized the value of simulation-based training programs and are promoting their use by discounting malpractice premiums for clinicians who complete these programs. Faculty training and certification testing will likely be a significant growth area in the coming years due to the mounting evidence of benefit and adoption by procedure-intensive specialty boards.



Neonatal resuscitation bay in CSC-Med Sci II, residents practicing full-term and preterm resuscitation skills, and faculty and fellow training on Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) technique for trauma hemostasis

Similarly, the healthcare simulation industry has undergone exponential growth due to the rapid adoption of simulation into medical schools and teaching hospitals for skills and team-training. Recent global market research predicted an annual industry-wide overall growth rate of over 15% with overall market value estimated at $986 million in 2016 and projected market value of $2.5 billion in 2023. Few could have predicted this scale of growth for an industry that barely existed 20 years ago.

Beyond skills training and team training, assessment practices have continued to mature, and, similar to standardized tests, will increasingly be embraced by procedural specialties. As simulation-based procedural training decreases in cost and increases in availability, the demand for individual, standardized skills assessments, such as Fundamentals of Laparoscopic Surgery (FLS) will grow. The FLS program, which utilizes a set of specific manual dexterity skills, has now been mandated for initial board certification by two ABMS boards. Others, such as Fundamentals of Endoscopic Surgery (FES), Fundamentals of Robotic Surgery (FRS) and Fundamental Use of Surgical Energy (FUSE), all from

Society of American Gastrointestinal and Endoscopic Surgery (SAGES), are soon to follow. These programs require the review of specific on-line content, practice of standardized exercises to specific skills criteria, followed by a rigorous assessment. Several of these (FES and FRS) require the use of very expensive virtual reality trainers and a combination of simulator- and proctor-measured assessments, lending to a central education equipment core, while others utilize low-cost trainers, but still require proctor-administered assessments.

M4s practice Fundamentals of Laparoscopic Surgery on trainer boxes and VR laparoscopic surgery simulator in the CSC

Looking ahead: Future vision for simulation

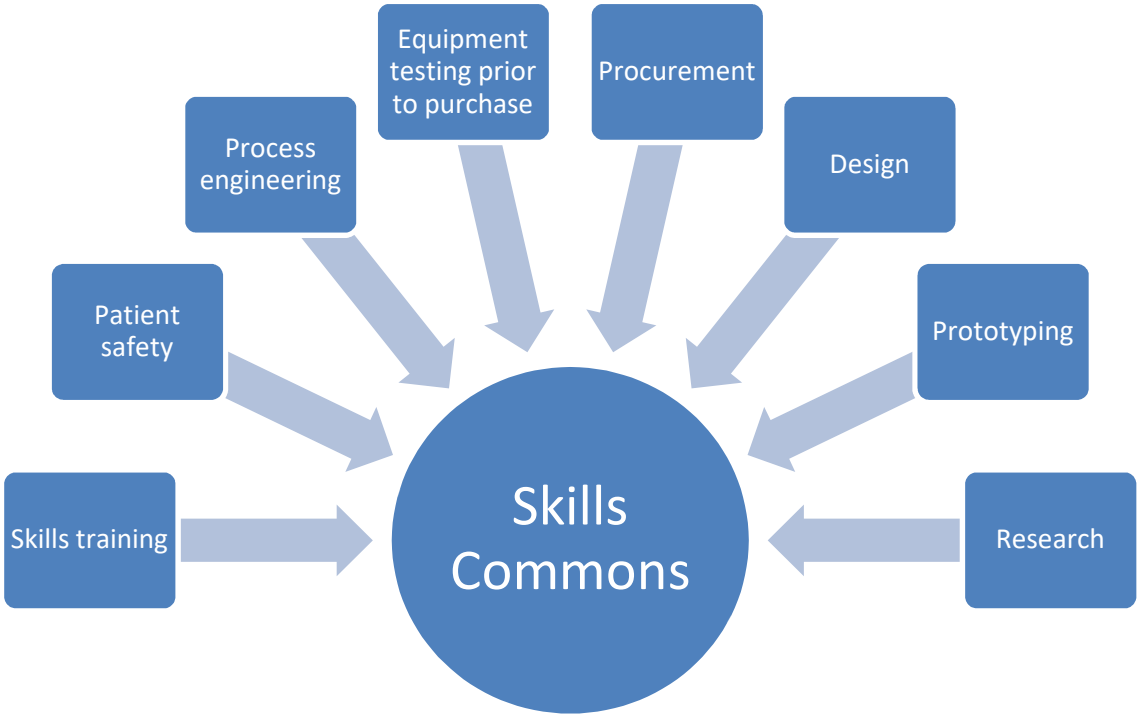
Predicting the future role and scope of simulation over the next 15 years presents an enormous challenge given the relatively brief history of simulation in health professions' training, dramatic improvements in technology, changing environments of care and learner needs, and evolving stakeholder expectations. Despite all of these challenges, trends in healthcare education will likely reflect those in other skills-intensive industries with a decreased emphasis on providing access to a limited number of high-cost simulators and increased emphasis on providing realistic environments for team training (regardless of simulators or scenarios utilized) and standardized testing for procedural skills.

Simulators will continue to become smaller, faster and more widely available while providing higher fidelity, but the need for healthcare teams to train together, practice new techniques and improve performance will remain. The footprint dedicated to procedural skills may migrate to smaller spaces, but will provide a wider array of training modalities (multiple surgical task trainers using a small number of interfaces to increase training access). We envision spaces dedicated to team learning, interprofessional training and problem solving will expand into more central and public spaces that allow for access and connections between multiple disciplines. The commons will become home to 'skills librarians' with expertise in evidence-based curriculum development, rigorous assessment

processes, educational research and new tool development (educators' R&D lab) to serve as resources for learners, instructors, researchers and health system administrators.

Simulation based research will also mature from current focus on understanding educational and assessment best practices to a collaborative practice utilizing simulation as a modality for testing health system protocols, devices, techniques and will be a hub for interprofessional problem solving. Much like collaboration spaces in the tech sector, problem solving teams will migrate from labs and back hallways to the lobby of the skills commons where clinicians, educators, learners and engineers meet and generate new ideas. Centrally located rapid prototyping labs are already being utilized at many institutions, including our own, to develop new tools for immediate and large volume testing in the simulated healthcare spaces allowing an innovation engine to emerge. As one of the only places in the school or health system where learners, faculty, staff and colleagues from the simulation center and other schools, such as engineering, information, business, art & design, the skills commons will be the ideal place to leverage the broad strengths of the University.

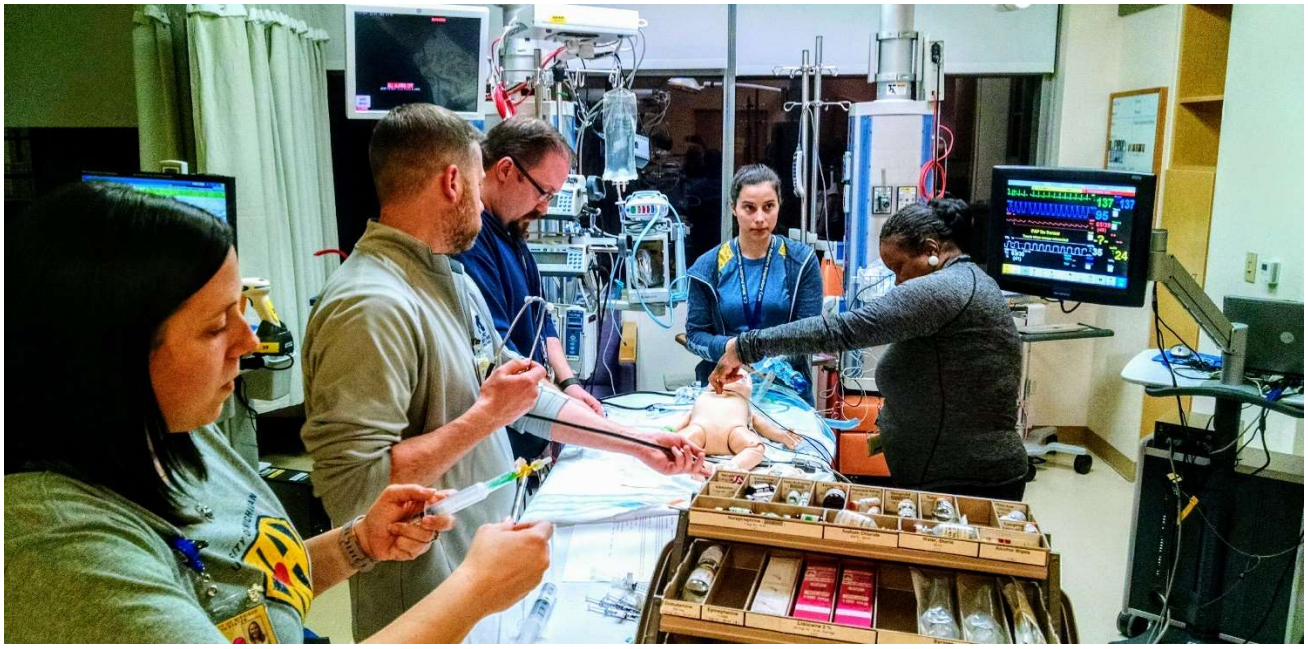
Benefits of simulation beyond individual or team training



Moving Forward

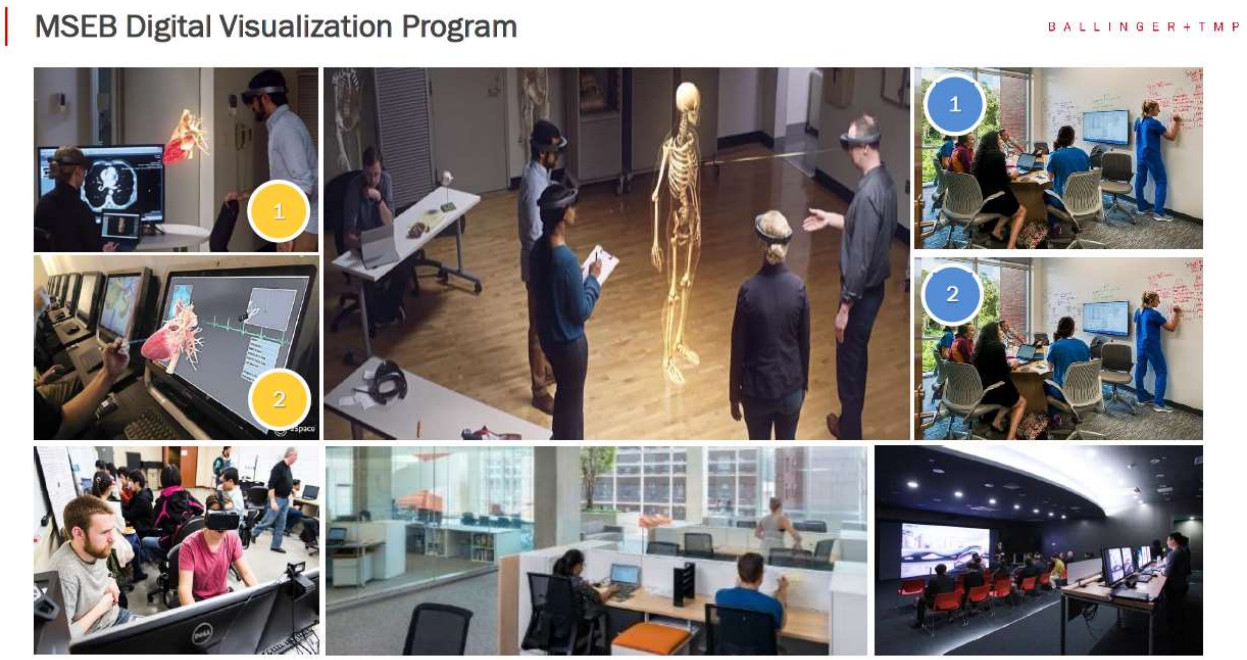
The commitment to simulation across Michigan Medicine has yielded incalculable benefits for our trainees, programs, institution, and patients, resulting in a very well equipped, accessible, high-fidelity, and efficient center with an experienced staff, dedicated core faculty and committed instructor base across 13 departments, the medical school and health system. Due to the stakeholder-based inclusive governance, utilization-based funding structure, distributed locations, resources and faculty and staff commitment, we are uniquely positioned to utilize our center as an epicenter for faculty, students and researchers from across health professions and other university colleges, such as architecture, art and design, business and engineering for the development of solutions to educational and clinical challenges.

Much like healthcare over the last decade and a half, health professions skill training will continue to rapidly evolve. For all of the reasons outlined above and the ones we have not yet anticipated, the value of the simulation center will continue to grow. The 'skills commons' will play a critical role in all health professions training programs to effectively evaluate and readily adapt to the changing needs of healthcare trainees, providers and teams while improving care. The foundational philosophy of the "practice" of medicine, traditionally interpreted as the art of healing, may now be able to be reinterpreted as the continuous cycle of improvement.



In-situ pediatric intensive care team training in C.S. Mott Children's Hospital

Future – “Skills Commons” concept (courtesy of Ballinger)



Future - Innovations Lab or “Educators R&D lab”