Comprehensive Healthcare Simulation
Series Editors: Adam I. Levine · Samuel DeMaria Jr.

Scott B. Crawford
Lance W. Baily
Stormy M. Monks *Editors*

Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice

Springer

Comprehensive Healthcare Simulation

Series Editors

Adam I. Levine
Department of Anesthesiology
Mount Sinai Medical Center
New York, NY
USA

Samuel DeMaria Jr.
Department of Anesthesiology
Mount Sinai Medical Center
New York, NY
USA

More information about this series at http://www.springer.com/series/13029

Scott B. Crawford • Lance W. Baily
Stormy M. Monks
Editors

Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice

Springer

Editors
Scott B. Crawford
Department of Emergency Medicine
Texas Tech University Health Sciences
Center El Paso
El Paso , TX
USA

Lance W. Baily
SimGHOSTS
Las Vegas, NV
USA

Stormy M. Monks
Department of Emergency Medicine
Texas Tech University Health Sciences
Center El Paso
El Paso, TX
USA

ISSN 2366-4479 ISSN 2366-4487 (electronic)
Comprehensive Healthcare Simulation
ISBN 978-3-030-15377-9 ISBN 978-3-030-15378-6 (eBook)
https://doi.org/10.1007/978-3-030-15378-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

We would like to dedicate this book to our spouses and children for supporting us through this project. We would also like to offer a special thank you to Dr. Veronica Greer; her guidance and support directly impacted all of us in our careers with healthcare simulation, and she continues to dedicate her practice to providing education and improving patient safety.

Foreword

As we move into the third decade of the modern advent of healthcare simulation, there are many variable configurations of program delivery, infrastructure, and human resources allocated to achieve intended goals. These goals vary from program to program, ranging from schools of health sciences to hospitals and healthcare systems. One constant in all of this is the healthcare simulation technology specialist (HSTS) who plays a pivotal role in the high-quality outcomes associated with efforts at hand.

In larger programs, the HSTS may have a role that is focused on the technology associated with simulation, along with innovation, and enhancement of existing theater and equipment that allows the achievement of intended goals. In smaller centers, the function of educators, administrators, and the technical community may overlap. These roles may be performed by one or only a few people. Nonetheless, the skill set required is constant across the spectrum of simulation programs worldwide.

The Sim Tech's career pathway has dramatically evolved over the last decade with the realization that the role encompasses a broader scope of skills than simply having knowledge of specific technology. HSTS are often involved in and integral to many aspects of the entire clinical skills program. Some examples include assisting in device recommendations and procurement, curricular design, and orientation and environmental training for faculty and learner participants. Additionally, programming and upkeep of high-technology simulators, task trainers and everything in between, as well as maintaining expertise in the complex audiovisual electronics, IT networks, and ancillary medical equipment are still essential.

With such a diversity of roles and assignments, persons serving in an HSTS position could benefit from a resource that covers the spectrum of possibilities associated with the expectations of the job. Further, such a resource could provide those who need to manage and integrate technical support staff into their program with a deeper understanding of the potentials of the role. This will allow for a win-win in terms of the simulation program optimizing its workforce for efficiency and effectiveness along with the development of a rich, professional career path for HSTSs.

After having the opportunity to review this textbook focusing on operations, technology, and innovative practice associated with the Springer series "Comprehensive Healthcare Simulation," I am convinced that it serves as a much-needed, all-encompassing resource for the global simulation community.

The book has been edited and authored by those who are pioneers and experts in understanding, defining, and developing the role of the healthcare simulation technology specialist, many of whom have been involved with various simulation organizations around the globe. Mr. Baily and Dr. Crawford were instrumental in the founding and proliferation of The Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS), which is the largest global nonprofit organization solely dedicated to the training and advancement of the HSTS profession. They, as well as many of the contributors to this text, have been closely involved with the Society for Simulation in Healthcare, the first organization to launch a wide-scale certification program for Sim Techs.

A number of the contributors to the text have been involved in a detailed cataloging of the skills and aptitudes associated with the ideal person to serve as an HSTS. Further, they assist in framing the activities in a way that has proven useful for creating career paths as well as job descriptions and a broader communal understanding of the actual breadth and depth required for one to be successful in this emerging professional role.

This text recognizes the continuing diversity of the role of the HSTS that may vary from program to program. It is well-suited for those who are planning or enjoying careers in healthcare simulation technology as well as a study guide for those pursuing certifications in the field and others in management and leadership roles.

You will find a masterful blend of high-level, conceptual overviews of the defining roles for the technology specialist in healthcare simulation as well as drilling down into hands-on tips, tricks, and how-tos. The text fulfills a need of the healthcare simulation community, which is to provide a comprehensive resource for the modern healthcare simulation technology specialist.

I invite you to read on and continue your journey in healthcare simulation while continuing to envision the increasingly important functions, capabilities, and versatility of highly trained simulation specialists.

Paul E. Phrampus, MD FSSH
Director, Winter Institute of Simulation
Education and Research (WISER)
Professor of Emergency Medicine and Anesthesiology
University of Pittsburgh
2013 Past President, Society for Simulation in Healthcare

Preface

Healthcare simulation has become the de facto standard for meeting the needs of medical skills training and healthcare team training over the past decade. Nearly every healthcare education and medical training program – from emergency medicine technicians to surgeons – uses simulation. Simulation training is a unique and practical way to train medical knowledge, skills, communication, teamwork, and professional behaviors. While several professional societies exist to advance the delivery of healthcare simulation related to research and all branches of healthcare education, the emerging profession that sets up, maintains, operates, and enables healthcare simulation to function is not as clearly defined. Healthcare simulation technology specialists (HSTSs) are an enigmatic group of individuals who have come from many diverse backgrounds to fulfill this need. Although there is no formal professional or educational pathway for this new career, it nevertheless has formed the backbone to successful implementation of simulation training technologies and practices. The development of impactful simulation experiences requires an operational team with extensive knowledge in simulation hardware, audiovisual systems, information technology integration, moulage, theatrics, adult learning theories, management, and more. Clearly, this role requires a unique and very broad skill set that can find some basis in almost any prior experience.

This textbook will serve as a comprehensive guide to the role requirements and skill set of the healthcare simulation operations and technology specialist, as well as provide recommendations for the training, recruitment, and support of the staff in this role. While this is not the first work to address this aspect of healthcare simulation, we hope it is the most focused on the successful development of the individuals who support and operate healthcare simulation technologies. Healthcare simulation technology specialists are responsible for anything, from how to adjust the computer's internet protocol (IP) address and port access to controlling exactly when to drop the blood pressure on a simulated geriatric patient given morphine, or attenuating the low-frequency input on the audio mixer, all while effectively communicating with healthcare professionals across disciplines. Additionally, they are often involved in selecting the appropriate technologies for desired learning outcomes, coordinating department leadership for the support of simulation-based activities, and promoting the simulation program to internal and external stakeholders.

For years, discussions have focused on the ideal background of individuals capable of performing the tasks required to support and operate simulation-based

education programs. Many centers have recruited from the information technology field, while others have sought medical educators and those with healthcare training. Both strategies have been effective to a degree; however, several gaps have been noted between abilities and expectations. This forced those in the field to improve by learning on the job. In 2011, Lance W. Baily founded The Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS) out of the Nevada System of Higher Education's Clinical Simulation Center of Las Vegas in an effort to start a specific and focused conversation to reduce those gaps.

Since then, over a dozen international meetings with thousands of participants have taken place, bringing together leading industry vendors, professional societies, and experts to improve the adoption and utilization of simulation technologies and develop the profession. While there are few professional or educational pathways for this type of training, the simulation community has come together to empower leaders in this field to overcome many of the hurdles HSTSs face, both individually and collectively. This book is a continuation of that spirit from SimGHOSTS and its passionate volunteer community to help one another learn and grow in the field of healthcare simulation.

The editors hope this text will serve as a guidebook for a new healthcare simulation technology specialist to gain a strong foundation for the work before them and allow educators to improve their knowledge of the technology and operations side of simulation.

The first portion of this book reviews the origins, settings, roles, and physical infrastructure common to many healthcare simulation programs. Additionally, it will describe different simulation modalities and personnel that function within simulation programs and how they relate to a program's mission and educational goals. Since many individuals entering into this field do not have a background in education, an overview of licensure, degrees, and the current state of training can be found in this section. Educational concepts related to research, institutional review boards, educational conferences, and preparing and drafting presentations and other publications are also addressed. Section 1 acts as a primer to those new to working in healthcare simulation operations.

The second section is specific to the knowledge and skills that many healthcare simulation technology specialists will be expected to master as they spend time in the field of healthcare simulation. Several simulation groups have looked at the disparate roles and expansive skills that are expected of these technology specialists. This book has broken the roles and skills apart into eight distinct categories, called domains, which will be addressed as individual chapters. An overview of these domains will describe how they were created and how they overlap between organizations.

A detailed description of each domain will provide new and existing HSTSs with an overview of skills required to be effective in the realm of simulation operations. The ideal HSTS candidate can be difficult to find, given that the potential needs are so diverse. Hence, by providing the description of these domains, the editors hope to highlight opportunities for development. Readers can identify areas where additional training could improve their abilities or identify specific needs for their simulation-based training program.

The book will conclude with practical tips, hacks, and innovative educational tools currently being used by many programs, including ideas on how to enhance the functionality of current training tools. By working closely with industry to better understand their technologies, we can best understand how to use, maintain, and repair their products. This will promote the most cost-effective and efficient use of technology for training and education. The book will also discuss healthy vendor relationships that are necessary and beneficial to meet the educational needs of the simulation-based programs served.

The editors of this book are passionate about the advancement of the field of simulation technology, operations, and those working within it as a means to improve the quality and effectiveness of healthcare education, training, and patient safety.

El Paso, TX, USA — Scott B. Crawford
Las Vegas, NV, USA — Lance W. Baily
El Paso, TX, USA — Stormy M. Monks

Acknowledgments

We would like to thank the hardworking and dedicated team of volunteers from the SimGHOSTS organization who have provided the knowledge, passion, and energy to support the individuals and institutions operating medical simulation technology and spaces. They are the inspiration for the information within this text. We would like to thank the staff at the TTUHSC El Paso Training and Educational Center for Healthcare Simulation (TECHS) for their support of this text and tireless efforts to improve the quality of healthcare education and inspire innovation. Additionally, we would like to thank Len Monks, Brian Wilson, Ruben Paredes, and Jennifer Crawford for their continuous support and review of the material.

Contents

Editors and Contributors

About the Editors

Scott B. Crawford, MD, FACEP, CHSOS is board-certified in emergency medicine and is an Assistant Professor in the Department of Emergency Medicine at Texas Tech University Health Sciences Center (TTUHSC) El Paso. He is also the Director for Simulation at TTUHSC El Paso. He served as President of SimGHOSTS from 2015 to 2017 and has presented both in the USA and internationally on topics related to audio/video design, information technology, and simulation innovation. He has served as a reviewer and author for standards of best practice for healthcare simulation and topics related to simulation and technology education.

Lance W. Baily, BA, EMT-B is the Founder and current Chairman of the Board of the international SimGHOSTS organization, as well as Founder and Managing Director of HealthySimulation.com and CareersinHealthcare.com. His background includes serving as Director of the Nevada System of Higher Education's Clinical Simulation Center of Las Vegas, operating simulation technology for the Los Angeles Community College District, training as a Fire Fighter and Rescue Diver, and helping to create thousands of Hollywood digital media productions. He is passionate to empower healthcare educators and simulation technology specialists to learn, network, and engage with their peers from around the world.

Stormy M. Monks, PhD, MPH is an Assistant Professor with Texas Tech University Health Sciences Center (TTUHSC) El Paso. She currently serves as a Research Scientist for the Department of Emergency Medicine, Division of Simulation Education. In addition, she has served as the Research Director for SimGHOSTS, an international nonprofit group dedicated to providing technology education and innovation to simulation centers worldwide. She sits on the TTUHSC El Paso Institutional Review Board.

Contributors

Michelle Aebersold, PhD, RN, CHSE, FAAN School of Nursing, University of Michigan, Ann Arbor, MI, USA

Elena An, BS, MS HCA VirtuOHSU Surgical Simulation Center, Oregon Health & Science University (OHSU) Simulation, Portland, OR, USA

Pamela Andreatta, EdD, PhD, MFA, MA, CHSE Institute for Simulation and Training, University of Central Florida College of Medicine, Orlando, FL, USA

Rachel Bailey, BA Engineering and Computer Simulations, Orlando, FL, USA

Lance W. Baily, BA SimGHOSTS, Las Vegas, NV, USA

Matthew David Charnetski, MSMS, NREMT-P Institute for Clinical Competence, New York Institute of Technology at Arkansas State University-Jonesboro, Jonesboro, AR, USA

Scott B. Crawford, MD, FACEP, CHSOS Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA

Todd S. Dadaleares Department of Medical Education, Maine Medical Center, Portland, ME, USA

Jesika S. Gavilanes, Master's Degree Mark Richardson Interprofessional Simulation Center (MRISC), Oregon Health & Science University (OHSU) Simulation, Portland, OR, USA

Nikita Joshi, MD Department of Emergency Medicine, Alameda Health System, Oakland, CA, USA

Suzan Kardong-Edgren, PhD, CHSE, ANEF, FSSH, FAAN Regional Research in Simulation Innovation and Education (RISE) Center, Moon Township, PA, USA

Amelia S. Lanz, EdD College of Nursing, The University of Alabama in Huntsville, Huntsville, AL, USA

Karen L. Lewis, PhD, CHSE The George Washington University School of Medicine and Health Sciences, Clinical Learning and Simulation Skills (CLASS) Center, Washington, DC, USA

Lori Lioce, DNP, FNP-BC, CHSE, FAANP College of Nursing, The University of Alabama in Huntsville, Huntsville, AL, USA

Eduardo R. Luevano, BA, CHSOS Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA

Jennifer McCarthy, MAS, NRP, CHSE School of Health and Medical Sciences, Seton Hall University, Nutley, NJ, USA

Crystal Miles-Threatt, BS, BSN, MA Emergency Department, Stanford Healthcare, Stanford, CA, USA

Stormy M. Monks, PhD, MPH Department of Emergency Medicine, Texas Tech University Health Sciences Center El Paso, El Paso, TX, USA

William Morton, BA Department of Information Technology Services, Des Moines University, Des Moines, IA, USA

Amar Pravin Patel, DHSc, MS, NRP, CHSE, FSSH CAE Healthcare, CAE, Sarasota, FL, USA

Lawrence M. Rascon Jr, EMT-P, CHSOS Division of Simulation Education, Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA

Teresa Roman-Micek, BS, CHSOS Center for Immersive and Simulation-Based Learning, Stanford University School of Medicine, Stanford, CA, USA

Ferooz Sekandarpoor Faculty of Medicine, University of British Columbia, Vancouver, BC, Canada

Kirrian Steer, BClinSc BOstSc MPrevMed Department of Rural Health, University of Melbourne, Wangaratta, VIC, Australia

Robert F. Stump, MD, PhD Department of Emergency Medicine, Texas Tech University Health Sciences Center, El Paso, TX, USA

Wendy Z. Thomson, EdD, MSN, BSBA, RN, CHE, CHSE VA Rocky Mountain Regional Medical Center, Aurora, CO, USA

Graham A. Whiteside, BSc(Hons), DipHE MHN, RMN, RGN Anatomic Excellence, LLC, Savannah, GA, USA

Part I

Introduction to Healthcare Simulation

History of Simulation

1

Lance W. Baily

Introduction

Healthcare simulation is an exciting field which combines advancing technologies, contemporary adult learning, and clinical healthcare practices. Simulation training in healthcare has been shown to reduce costs, improve performance, and reduce the risk of medical errors [1].

Medical simulation is the mimicry of patients, processes, and environments to reproducibly and realistically train healthcare professionals. The methodology and technology of healthcare simulation can be utilized to educate new learners, train current professionals, assess competence mastery, and research system level modifications to improve outcomes. Facilitators create realistic healthcare experiences and allow learners to review their performance with peers through reflective learning called debriefing. These facilitators can also provide directed feedback and instruction when needed. The practice of simulation moves far beyond the passive lecture and changes the old medical adage of "see one, do one, teach one" to "see one, simulate one, achieve mastery, do one, teach one."

The educational methodology of simulation has evolved following a millennium of technological advances necessary to better represent reality in a clinical setting. Technology necessary to teach simulation in healthcare was as basic as stone carvings, pulleys, glue, bronze molding – which eventually evolved into plastics, digital CPUs, and video recording systems. Without such technologies, advances in the methodology of healthcare simulation would not have been possible to explore and develop.

The first written history of healthcare simulators dates to circa 500 BC in the *Sushruta Samhita*, a collection of medical texts, discovered in Kucha which included

L. W. Baily (✉)
SimGHOSTS, Las Vegas, NV, USA
e-mail: lance@simghosts.org; https://www.healthysimulation.com

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_1

descriptions of natural materials that could be shaped into surgical trainers [2]. Since that time, simulationists from around the world have created thousands of tools to educate healthcare professionals including such devices as Weiye's life-sized bronze castings of acupuncture points in 1026, Angélique Marguerite Le Boursier du Coudray's hand-stitched birthing "machine" in 1751, and Collongue's first ever auscultation simulator dubbed the pneumoscope in 1864 [3–7]. Simulation, however, is not unique to healthcare.

Who Invented Simulation?

Defined as an imitation of a process or an action of pretending, one must assume that our earliest ancestors simulated spear throwing at defenseless immobile trees before hunting wild and dangerous animals. In that sense, almost all training involves some level of simulated experience, as even the basic educational metaphor requires cognitive imagination to provide relationships through imitation.

The success of training for the hunt through simulation naturally transferred into combat training for battles and warmongering. Eventually hunter/gatherer tribes evolved into cities and nation-states which increased the size and chaos of battle. The Romans were the first to notably train individual soldiers in sword fighting with the *palus*, a six-foot wooden post planted in the ground against which the recruit would strike their sword [8]. The individual soldier would then simulate specialized formations with his unit and their section, to train against potential enemy tactics well before a battle ever took place. Such simulated training resulted in a steadfast discipline for individual Roman soldiers and their legions, creating a massive empire and forever changing the face of war [3].

Learning to Fly, Safely

New, era-defining technologies like the airplane also brought decisive military victories. While the use of aircraft for military purposes began in World War I, it was not until 1934 that a simulated aircraft was used for aviation training. After multiple bad-weather crashes during domestic mail deliveries, the US Army Air Corps slowly began to adopt the "Link Trainer." The single-seat closed cockpit provided instrument flight training with pumps to mimic motion [9]. World War II saw a massive increase in the use of Link Trainers with more than 10,000 ordered by Allied Forces [10, 11].

The advancement of aviation simulators continued when the jet age brought a huge boom in commercial flights after World War II. However, the integration of simulation technologies and methodologies as regulated training standards took decades. Airbus Senior Training Advisor Captain Jacques Drappier explained that when he started flying in the 1960s that flight "simulation was very basic," and at the time many older pilots "resisted it" as it "wasn't very realistic" [12].

However, Captain Drappier later explained that a new generation of pilots in the 1970s saw the benefits of simulation, and embraced its use to train for situations too

risky or costly to learn or try during real flight. Advances in aviation simulation technologies like hyper-realistic carbon copy cockpits, hydraulic motion platforms, and three-dimensional computer-generated animations furthered the potential of simulated learning [12]. While these technological advances helped demonstrate the power of simulation to aviation educators, it was another invention that solidified simulation as a requirement for all pilots around the world.

Although the black box flight recorder was increasingly installed on commercial flights from the 1960s, its usefulness was questioned as a potential invasion of privacy – with some even suggesting the technology would "reveal more expletives than explanations" [13]. Sadly on March 27, 1977, two 747s collided on the Tenerife runway killing 583 people making it the deadliest accident in aviation history. The effectiveness of the black box was proven after both cockpit recorders demonstrated poor communication practices, and highlighted this as the cause of the accident. The aviation industry came together with the support of the National Aeronautics and Space Administration (NASA) to develop the Crew Resource Management (CRM) communication system, which would primarily be learned and practiced by cockpit and cabin crews through simulation.

The airline industry has since become one of the safest in the world, with the Aviation Safety Network reporting that 2017 was the safest year in history for flying [14]. In that year, 44 people died in commercial airline accidents around the world [15]. Contrast that exact number with the unknown but estimated 250,000 patient deaths attributed to medical error – in the United States alone [16]. Clearly, there is an opportunity for healthcare to continue learning from contemporary aviation, guiding us to more regularly assess healthcare systems and improve outcomes through simulation.

Modern Technologies

The Information Age brought electronic engineering and advanced computer technology to every aspect of life, and formed the basis for the healthcare simulation industry as we know it today. In the past century, several Information Age "Pioneers of Simulation" created game-changing electronic "high-fidelity" (high-realism) patient simulators – some of which were acquired to become flagship products of global corporations.

Dr. Stephen Abrahamson's "Sim One" was unveiled in 1967 after being awarded a grant from the National Institutes for Health (NIH) [17]. It had palpable pulses, computerized drug recognition, blood pressure indicators, eye movement, and breathing lungs. While the system was ahead of its time and the project made national headlines, the manikin was ignored by the slow-moving medical community and eventually the system was broken apart and lost [18, 19].

In 1960, the Norwegian-based Laerdal Company launched the world's most famous CPR trainer: the Resusci®-Anne. Its gentle face was taken from the death mask of a young girl who drowned in the river Seine in the 1890s (Fig. 1.1). The limbless upper torso has helped innumerable professionals and laypersons to

Fig. 1.1 Reproduction of the death mask of the "Girl from the Seine." On display at the Laerdal Headquarters in Stavanger, Norway

practice airway and resuscitation skills. Since then, the Laerdal Company has seen massive international growth by continuing to release innovative simulators such as the full-body high-fidelity SimMan in 2001, after acquiring Medical Plastics Laboratory [19].

In 1986, the "Godfather of Simulation" Dr. David Gaba utilized his electronic engineering background to build Stanford's Comprehensive Anesthesia Simulation Environment (CASE). Working with Canadian Aviation Electronics (CAE)-Link corporation, the group built a prototype manikin with breathing, pulses, and cardio-respiratory responses. Eventually, the device lost out to the Human Patient Simulator (HPS) created by Medical Education Technologies Incorporated (METI). The HPS manikin used technology out of the University of Florida in Gainesville. METI was later acquired by CAE Healthcare in 2012. Gaba went on to help lead the Society for Simulation in Healthcare and champion the research necessary to grow the new field by becoming the Editor-In-Chief of the prominent journal *Simulation in Healthcare*.

Another Florida-based simulation company, Gaumard, started creating simulation and education training supplies following World War II when its founder adapted knowledge of battlefield medicine to create simulators and training products for healthcare education. Gaumard now produces high-fidelity manikins for all stages of life with an emphasis on "tetherless" functionality and obstetric simulators [20].

Additionally, a number of companies around the world such as Simulab, Limbs & Things, Cardionics, TellYes, Kyoto Kagaku, and Pocket Nurse have advanced the technologies of mid-range and lower-fidelity task trainers, enabling learners to focus on specific clinical skills required for both general and specialty care. These include everything from arms for practicing IV starts to torso models for auscultation, and from simulated thermometers to fully digital eye examination simulators. Surgery-specific simulators like those from 3D Systems, Mentice, VirtaMed, Surgical Science, and Medical-X have also heavily influenced the field.

Another key technology crucial for the success of healthcare simulation activities are the audio-visual recording and debriefing systems like the ones from EMS SimulationIQ, B-Line Medical, KBPort, Studiocode, Level 3 Healthcare, SIMStation,

SMOTS, and others from specific manikin producers. Like a post-game review for professional sports teams, these video analysis systems allow facilitators to review learner actions at any moment, providing learners with the opportunity to directly re-experience their performance from a third-person perspective. Today's new healthcare learners can witness their own actions with the facilitation of a debriefer – creating a powerful learning environment unlike ever before. Today, these systems allow for full high-definition recording and live annotation to emphasize good and bad areas of performance.

Slowly Turning the Ship of Healthcare

Simulation has been present in healthcare training, in some form or another, for hundreds of years. Despite this and despite even newer advances in technology, simulation has only recently started taking root in the culture of training and safety. Today, simulation still remains mostly underutilized with few training programs existing for practicing clinicians. Continuing certification and training programs are not established for most specialties [21]. Simulation as a method of training and evaluation will likely play a pivotal role in addressing the issues of patient safety, mastery learning, and medical errors as adoption and appropriate utilization increase.

Although often, but incorrectly, attributed to Hippocrates or Galen, the Latin phrase *primum non nocere,* translated as "first do no harm," likely originated from the English physician Thomas Sydenham in 1860 [22]. Regardless of its origin, the statement serves as an important reminder to those in the medical profession that all efforts to render aid should be considered for potential adverse reactions, and all treatments are not without risk. This is highlighted by the 1999 report by the Institute of Medicine – Committee on the Quality of Health Care in America, titled "To Err Is Human: Building a Safer Health System." This was one of the first evaluations of the sources for errors in healthcare and called for systematic changes in the culture of healthcare delivery. In many ways, this article sparked the patient safety movement that has allowed simulation to come forward as a way to correct many of these concerns.

"The Checklist Manifesto: How to Get Things Right" written by Dr. Atul Gawande, attracted great media and public attention when it was released in 2009 as a non-fiction exposé of the problems with modern medical care. He also described the corollary with crew resource management thinking from the airline industry and applied this principle to the operating room. This was revered as a simple solution to a complex system that improved safety when implemented across multiple hospital systems. This is the same type of training advocated within healthcare simulation.

One should not assume that simulation faces unique scrutiny by the healthcare community, as the field has been notoriously slow to adopt change [23–25]. Take for example the story of nineteenth-century Hungarian physician Ignaz Semmelweis, who correctly published that the simple act of handwashing would drastically

reduce the mortality rate of women dying after childbirth. Unfortunately, Semmelweis's findings went against the established opinions of the medical community at the time, with some doctors offended by the idea that they be required to wash their gifted hands. After massive rejection and ridicule by his professional peers, Semmelweis died in an insane asylum after being beaten by the guards in 1865 [26]. Handwashing did not become accepted or supported by the medical community until two decades later when Pasteur, Koch, and Lister published evidence on germ theory and antiseptic technique [27]. While this an extreme example of laggard thinking, the trend to oppose innovation is still an obstacle today with studies continuing to be published on how to teach and enforce handwashing among healthcare providers [28].

So, while the use of healthcare simulation continues to expand globally, many industry experts believe the technology currently remains in the "early adopter" phase of Rogers' diffusion of innovations curve (Fig. 1.2) [29]. Those entering the field should consider that healthcare simulation has not fully matured, but is still on the uphill portion of adoption and integration.

Some champions of the healthcare simulation community have taken cues from the global aviation industry which has universally adopted, integrated, and regulated the required use of simulation at all levels of the profession.

The oldest international organization is the Society in Europe for Simulation Applied to Medicine (SESAM) which formed in 1994. Other notable international organizations include the Society for Simulation in Healthcare (SSH), International Nursing Association for Clinical Simulation and Learning (INACSL), the Association for Simulated Practice in Healthcare (ASPiH), the International Pediatric Society for Simulation (IPSS), Simulation Australasia, and the Association for Standardized Patient Educators (ASPE).

All of these leading organizations and international corporations come together annually through their membership to the Global Network for Simulation in Healthcare (GNSH) to drive industry growth and advocate for appropriate use of simulation-based education and training in healthcare.

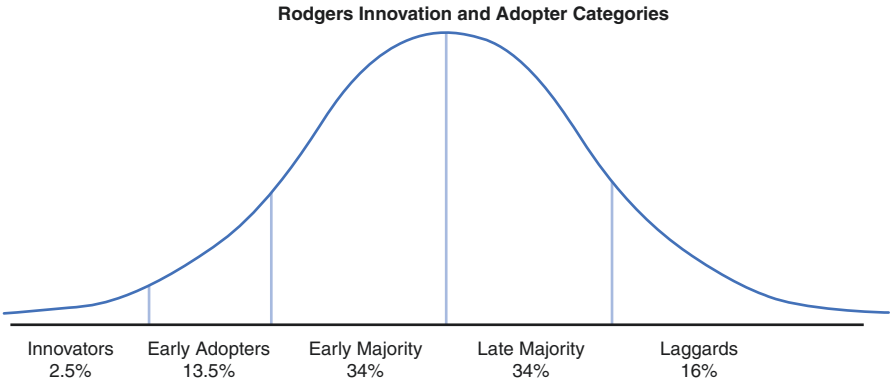


Fig. 1.2 Depiction of the Rodgers innovation and adopter categories represented by a bell curve. Estimates suggest that simulation is still in the "early adopters" portion of this curve

A New Career Emerges

Such new and advanced technologies and educational practices require simulation specialists to ensure proper selection, installation, operation, maintenance, and replacement of this unique equipment. While many simulation programs start with a single clinical educator to provide instruction, facilitation, schedule management, and technological operation, most have realized effective utilization requires multiple staff members, each who specialize in their own unique domain.

Even though the advance of technology has driven the expanded use of simulation as a learning tool, many healthcare administrators new to the practice still assume they can do without healthcare simulation technology specialists (HSTS). Clinical educators specialized in simulation debriefing practices are not commonly trained to efficiently troubleshoot many of the complex computer and A/V systems involved, nor have time to devote to developing this skill. This need was part of the rationale for the development of the Certified Healthcare Simulation Operations Specialists (CHSOS) certification, now offered by the Society for Simulation in Healthcare (SSH) [30].

Until recently, the global academic community had created numerous organizations, journals, and conferences to support the research, education, and advancement of simulation methodologies in healthcare, without supporting focused conversations about operating the technology.

More recently, these organizations have expanded their discussions of technology utilization with affiliations and partnerships with the newest international organization: The Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS), which started in 2011 out of the Nevada System of Higher Education at the Clinical Simulation Center of Las Vegas. SimGHOSTS focuses on hands-on training and online resources for those operating healthcare simulation technologies.

And Now, the Second Act

Healthcare simulation is on the cusp of transition from “early adopter” to “early majority” in most developed countries [31, 32]. While digital technology has rapidly expanded the utilization of simulation tools in the past half-century, the global healthcare industry has a long way to go for full adoption. The issue is multifactorial; engrained hierarchy, isolated training environments, and the overall complexity of the healthcare system make it difficult for clinicians and administrators to feel comfortable with new ideas, technology, or training. A change in system dynamics along with appropriate pressure applied from government and system regulations must be aligned to move forward. While likely beneficial, all these forces are viewed as a threat to the status quo, and final adoption will require acceptance of the benefit to the systems of healthcare training and delivery. As the population continues to grow rapidly, the need to modernize healthcare training practices through simulation should be clear. Even though the profession is aware of the serious issues

associated with medical errors, the general public may not know that there is a risk to receiving medical care, or what is being done behind the scenes to improve the quality and safety of the care they receive.

Captain Drappier reminds us again that "it took a generation of new pilots to understand the benefits of simulated training," and so perhaps healthcare too must wait for those currently learning clinical practices in simulation to become the clinical educators [12].

Technology, however, waits for no one. Vehicle dash cams, police body cameras, and citywide CCTV systems did not exist 20 years ago, but have since changed the nature of video surveillance for insurance and legal claims in those spaces. In a world where ride-share apps can overtake the centrury-old taxi industry in under a decade, simulation champions should also be ready for distruptive ideas and technologies to catalyze change in healthcare.

Whether a slow generational change or a fast technological disruption forces simulation into "laggard adoption," those in healthcare should acknowledge that innovation has and will continue to drive the educational methodology first and foremost. Healthcare administrators will find maintaining their competitive edge through modern technologies impossible without the permanent investment and support of those who operate such specialized simulation systems.

References

1. Cohen ER, Feinglass J, Barsuk JH, Barnard C, O'donnell A, McGaghie WC, et al. Cost savings from reduced catheter-related bloodstream infection after simulation-based education for residents in a medical intensive care unit. Simul Healthc. 2010;5(2):98–102.
2. Champaneria MC, Workman AD, Gupta SC. Sushruta: father of plastic surgery. Ann Plast Surg. 2014;73(1):2–7.
3. Owen H. Early examples of simulation in training and healthcare. In: Simulation in healthcare education. Cham: Springer; 2016. p. 9–19.
4. Gelbart NR. The king's midwife: a history and mystery of Madame du Coudray. Berkeley: University of California Press; 1998.
5. Acton RD. The evolving role of simulation in teaching surgery in undergraduate medical education. Surg Clin. 2015;95(4):739–50.
6. Owen H. Simulation in healthcare education: an extensive history. Cham: Springer; 2016.
7. Hureaux J, Urban T. La simulation en pneumologie: rationnel, données de la littérature et perspectives. Rev Mal Respir. 2015;32(10):969–84.
8. Davies RW. Fronto, Hadrian and the Roman army. Latomus. 1968;27(Fasc. 1):75–95.
9. Page RL. Brief history of flight simulation. SimTecT 2000 Proceedings; 2000. p. 11–7.
10. Van Hoek S, Link MC. From sky to sea: a story of Edwin A. Link. Flagstaff: Best Publishing Company; 1993.
11. Council Jr K. Should air force reserve command continue pursuing CAF DMO for its F-16 fleet. Air War College Air University Maxwell AFB United States; 2011.
12. Drappier J. WATS 2013 Pilot interview. In: Baily L, editor. Healthy simulation. [YouTube] https://www.healthysimulation.com/3854/wats-aviation-simulation-conference-demonstrates-the-potential-to-healthcare/2013
13. Uris D. Big brother and a little black box: the effect of scientific evidence on privacy rights. Santa Clara L Rev. 2001;42:995.
14. IATA. IATA Safety Report 2017; 2018. Available from: https://cdn.aviation-safety.net/airline-safety/industry/reports/IATA-safety-report-2017.pdf

15. Ranter H. ASN data show 2017 was safest year in aviation history; 2017. Available from: https://news.aviation-safety.net/2017/12/30/preliminary-asn-data-show-2017-safest-year-aviation-history/
16. Makary MA, Daniel M. Medical error-the third leading cause of death in the US. BMJ. 2016;353:i2139.
17. Denson JS, Abrahamson S. A computer-controlled patient simulator. JAMA. 1969;208(3):504–8.
18. Levine AI, DeMaria S Jr, Schwartz AD, Sim AJ. The comprehensive textbook of healthcare simulation. New York: Springer; 2013.
19. Cooper J, Taqueti V. A brief history of the development of mannequin simulators for clinical education and training. BMJ Qual Saf Health Care. 2004;13(suppl 1):i11–i8.
20. Dahlberg N. Miami-based Gaumard's medical simulators provide human (like) touch. Miami Herlad. Bus Mon. 14 Sept 2014.
21. Levine AI, Schwartz AD, Bryson EO, DeMaria S Jr. Role of simulation in US physician licensure and certification. Mt Sinai J Med J Translat Pers Med. 2012;79(1):140–53.
22. Smith CM. Origin and uses of primum non nocere—above all, do no harm! J Clin Pharmacol. 2005;45(4):371–7.
23. Plsek P. Complexity and the adoption of innovation in health care. Accelerating quality improvement in health care: strategies to accelerate the diffusion of evidence-based innovations. Washington, DC: National Institute for Healthcare Management Foundation and National Committee for Quality in Health Care; 2003.
24. Thakur R, Hsu SH, Fontenot G. Innovation in healthcare: issues and future trends. J Bus Res. 2012;65(4):562–9.
25. Prada G. Exploring technological innovation in health systems: is Canada measuring up? J Manag Mark Healthcare. 2008;1(4):362–74.
26. Davis R. The doctor who championed hand-washing and briefly saved lives. Morning Edition [Internet]; 2015. Available from: https://www.npr.org/sections/health-shots/2015/01/12/375663920/the-doctor-who-championed-hand-washing-and-saved-women-s-lives
27. Best M, Neuhauser D. Ignaz Semmelweis and the birth of infection control. BMJ Qual Saf. 2004;13(3):233–4.
28. Pittet D, Boyce JM. Hand hygiene and patient care: pursuing the Semmelweis legacy. Lancet Infect Dis. 2001;1:9–20.
29. Rogers EM. Diffusion of innovations. New York: Simon and Schuster; 2010.
30. SSH. CHSOS [online]. http://www.ssih.org/Certification/CHSOS: Society for Simulation in Healthcare; (cited 2018 May 3). Available from: http://www.ssih.org/Certification/CHSOS
31. Gaba DM. The future vision of simulation in healthcare. Simul Healthc. 2007;2(2):126–35.
32. Issenberg SB. The scope of simulation-based healthcare education. Sim healthcare. 2006;1:203–8.

Types of Healthcare Simulation: Locations and Training – Who, What, and Where?

2

Jesika S. Gavilanes and Elena An

Academic Groups: Who Is Being Trained?

Simulation is being integrated into the curriculum for both academic and nonacademic healthcare learners. This type of training is of importance across disciplines and between disciplines, as errors in communication and shared understanding are some of the most difficult areas to train and yet may be the most important to improve healthcare delivery [1]. While all individuals who work with patients can impact safety and patient care, the diversity of specific roles and training backgrounds is difficult to understand even for those in the healthcare field. It is with this rationale in mind that interprofessional education in simulation is being encouraged to improve communication and understand between care providers, and allow those involved with training and support across disciplines to understand the background and expectations for each type of learner [2]. Understanding who is being taught and their role in the larger healthcare system will help to match the learning objectives with the tools and appropriate space to ensure the most appropriate functional space is available to conduct training [3].

The following sections will describe the general background and role that each group has in the delivery of healthcare and how simulation has been integrated into their training experiences.

J. S. Gavilanes (✉)
Mark Richardson Interprofessional Simulation Center (MRISC), Oregon Health & Science University (OHSU) Simulation, Portland, OR, USA
e-mail: gavilane@ohsu.edu

E. An
VirtuOHSU Surgical Simulation Center, Oregon Health & Science University (OHSU) Simulation, Portland, OR, USA
e-mail: bradleye@ohsu.ed

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_2

Prehospital: Emergency Medical Services (EMS) and Other First Responders

Prehospital care providers can include any bystander or first responder, but generally this term focuses on ambulance crews and paramedics. Systems around the world vary in the training and possible scope of care provided. In the United States, emergency medical technicians (EMTs) are part of a national registry and certification with levels of EMT, advanced EMT (AEMT), and paramedic [4]. An entry-level EMT can administer a small number of medications and provide oxygen and CPR, while a paramedic can give opiate pain medications, cardiac active medications, and perform intubations. A physician is usually available to provide online knowledge and care assistance via a radio or telephone in addition to EMTs following established or written protocols. Countries outside of the United States have systems that vary significantly. France, for instance, may have an anesthesiologist physician on the ambulance that arrives at the scene.

Prehospital learners commonly practice skills training focusing on emergency stabilization of airway, breathing, and circulation. Simulation training may be conducted in a classroom, a simulation room, or in the field. EMT, paramedic, police, and fire and rescue personnel work individually as well as in groups for specific simulation trainings. Paramedic courses may include anatomy lab training that is directly applicable to their procedure training. There have been partnerships with police, fire, and rescue training programs working with academic-based standardized patient programs to be able to deploy hybrid training with manikins and actors. Often, these trainings will be done in situ which includes training on the side of the road and integrating moulage to create a more immersive experience [5]. Mobile simulation lab spaces have been added inside of functional ambulances with specialty cameras and recording devices to allow review and evaluation of learners as well as systems to control manikins on board (Fig. 2.1).

While the implementation of healthcare simulation-based training uses multiple modalities, in situ training using field exercises is the most applicable to this group. This can be everything from practicing lifts and carries for firefighters performing a

Fig. 2.1 Example of an ambulance that has been modified to allow simulation activities to be run and controlled within the existing and realistic space. This also allows simulation to travel to sites or areas without requiring learners to travel to a physical simulation center

rescue, to police drills with active shooter scenarios and incorporation of curricula for tourniquet training and campaigns like "Stop the Bleed," or working in lowlight conditions to evaluate a patient to provide stabilization and evaluation of a victim on the side of the road [6, 7].

Nursing School

Nursing training focuses on management and coordination of care through patient assessment and procedural skills and patient care interventions [8]. One of the most critical aspects of this role includes medication administration and monitoring. While their scope of practice limits autonomy to provide care or treatment only as directed by protocols or physician orders, they serve as the eyes and ears for changes in patient condition. Nurses are more likely to catch an error when in a supportive healthcare system such as that promoted in simulation training [9]. Nursing education for clinical practice can be an associate's, bachelors, or master's degree with training duration ranging from 12 to 48 months depending on the type of degree program and background of the student.

Nursing school at the undergraduate level has integrated skills training, high-fidelity manikin training, and often hybrid training with both standardized patients and manikins. There is strong literature that has come from nursing describing the debriefing components of simulation training and best practices for integration into curricula [10–12].

Skills training using task trainers is a common method to provide hands-on training to students prior to entering the clinical environment. This allows learners to demonstrate and educators to assess the evaluation and care for lines, tubes, IVs, surgical wounds, and examination skills. In addition to focused skills training, simulation centers have reproduced the look and feel of hospital wards, clinics, and intensive care units (ICUs) to allow familiarization with workflow, system processes, and equipment such as headwall systems, patient call requests, "code blue" activations, and medication dispensing units such as Pyxis and Omnicell that are ubiquitous in clinical practice.

Advanced practice nurses (APNs) progress beyond an initial nursing degree to become nurse practitioners (NPs), clinical nurse specialists (CNSs), certified nurse-midwives (CNMs), and certified registered nurse anesthetists (CRNAs) [13]. APN students integrate skills throughout their curriculum and have integrated Objective Structured Clinical Examinations (OSCEs) as well as the previously mentioned training for their initial nursing degrees. These OSCE scenarios can be high-stakes exams and can partner standardized patients (SPs) along with procedural skills training [14]. The APN curriculum may include gross anatomy, directly associated with clinical procedures, using an anatomy lab.

The hybrid model of training (mixing SPs and task trainers) is being used more and more to simulate the complexities of the healthcare environment across training disciplines. For example, nurse midwifery programs often incorporate hybrid solutions such as standardized patients with a birthing task trainer such as the Laerdal MamaNatalie® birthing simulation unit to create added realism from the human

face-to-face interaction with a mom during delivery. Not only are these procedural and skills training opportunities being assessed for grading and instruction, but there are also team training and communication components to improve the "soft skills" of communication with patient and coworker interactions.

Medical School

Doctors begin training with potentially limited or no prior specific health background. While any undergraduate training background is possible, many premedical students will major in biology or chemistry. Most medical school curriculums focus on providing an overview of basic sciences in the first 2 years of medical school, covering topics like gross anatomy, physiology, pharmacology, physical examination skills, biochemistry, and pathology. These involve simulation modalities that may access 3D-imaged human tissue, plastinated human tissue, or preserved donor tissue for dissections. Standard cadaveric dissection is still preferred at most programs but is frequently being enhanced with newer technologies such as augmented and virtual reality [15, 16]. As the learners move toward preclinical experiences in their first and second years, there is an increase in use of simulation to build on fundamental medical education. These simulations include high-fidelity manikin scenarios and hybrid training opportunities. Some of these simulation experiences are of even greater need during the first 2 years of training as other clinical exposure is often limited. The carefully constructed ability to apply book knowledge to clinical cases is invaluable as a training and educational tool.

During the third and fourth years of medical school, exposure to patients truly begins and rotations through the primary specialties of medicine round out the educational experience. These core specialties include Pediatrics, Internal Medicine, Surgery, Family Medicine, Neurology, Obstetrics and Gynecology, and Psychiatry. Medical schools utilize integrated skills training and use simulation training with the OSCE and Clinical Performance Examination (CPX) with standardized patients. In order to complete medical school, three separate licensing examinations must be completed and passed. One of these is a high-stakes OSCE-based clinical skills test.

Programs may create educational content to support textbook knowledge for body systems using different simulation modalities based on the subject matter being taught. In addition to working with standardized patients, learning procedures on task trainers is commonly incorporated into rotations for some specialties. This type of task training exposure may be a student's only exposure to a procedure before performing that skill on a real patient.

Physician Assistant (PA) School

Physician assistants are clinical care providers with significant autonomy, depending on the setting, to evaluate and direct patient care in much the same manner as a physician [17]. Although closely monitored and supervised by a physician, PAs are allowed

prescriptive authority (the ability to write for prescription medications) as allowed by state and national regulations. Most PA programs provide a master's degree as part of the training. PAs can work in a variety of settings including surgical and medical inpatient hospital settings, outpatient clinics, and across most specialties [18].

Physician assistant programs average 27 months in length and have integrated advanced science courses and skills training in addition to clinical experience. Training programs may also conduct simulation training utilizing OSCE and Clinical Performance Examination (CPX) formats using standardized patients in their training activities similar to physician and nurse practitioner programs. As would be expected from the potentially broad scope for practice, physician assistant programs use the anatomy lab environment as well as different modalities of simulation to train applied clinical skills. This is done with task trainers, manikin-based and hybrid simulations using standardized patients with the same knowledge and care expectations as most physicians [19].

Pharmacy School

As one of the public's most accessible healthcare professionals, pharmacists provide medication information and services. Community pharmacists require skills and training in over-the-counter medications, homeopathic remedies, and counseling that delve beyond the required compounding, packaging, labeling, and distribution tasks. Many pharmacists receive additional training in medical services like vaccination administration, anticoagulation management, pain management, and in some settings, prescriptive authority under protocol [20, 21].

Doctoral pharmacy programs have integrated skills training and many conduct simulation training [22]. With the integration of standardized patient encounters into training activities, learners are able to prepare with varying degrees of fidelity. Pharmacy students focus most training on clinical skills necessary for pharmacotherapy [23]. The Accreditation Council for Pharmacy Education has approved the use of simulation to count toward up to 60 hours of the clinical hour requirements for training and education and specifically encourages the development of interprofessional education activities [24]. Practice settings in community, acute care, and long-term care, among others, may require tailored experiential learning beyond the textbook. Many inpatient pharmacists are part of the hospital code response team, for example, and participate in monthly mock code training programs. By using high-fidelity manikins, learners are able to see and interact with the physiological response to medication administration, adverse effects, and complications using ACLS guidelines and CRM principles during a code.

Graduate Medical Education (GME)

After completing medical school, a medical student is awarded the initials MD (doctor of medicine) or DO (doctor of osteopathic medicine). Both degrees reflect

extensive and similar training on physical diagnosis and treatment as well as compliance with at least one of two national certification standards: United States Medical Licensing Examination (USMLE) for MDs or Comprehensive Osteopathic Medical Licensing Examination (COMLEX) for DOs. Most patients will not notice a difference in care provided by either type of physician. Either training type will then usually continue on to receive an additional 3–7 years of training in a medical specialty. Some physicians may then pursue an additional 1–3 years of subspecialty training called a fellowship. These training programs and expectations in the United States are governed by the American College of Graduate Medical Education (ACGME) with specific guidelines of training experiences and skills development. The American Osteopathic Association (AOA) and ACGME are transitioning to a single accreditation system for GME in the United States. It is to be fully implemented by July 2020.

Accredited GME programs have resident/fellow education guidelines and requirements facilitated through the American College of Graduate Medical Education (ACGME) and the associations that work with each specialty. Surgical skills competency is now being reviewed and guided by recommendations from a six-specialty group known as the Surgical Council on Residency Education (SCORE). SCORE has the goal to develop a comprehensive technical skills curriculum for surgeons and ensure competency [25]. GME learners often need off-hours access to labs to have opportunities for deliberate practice to achieve these expectations [26, 27]. Currently, each medical specialty has milestones that are outlined in the ACGME Milestones Guidebook. Individual specialty groups have developed outcome-based milestones to assess resident/fellow performance in the six core competency areas (Fig. 2.2) [28]. Surgical and nonsurgical GME programs use a variety of simulation modalities to assess these competency areas. Task trainers,

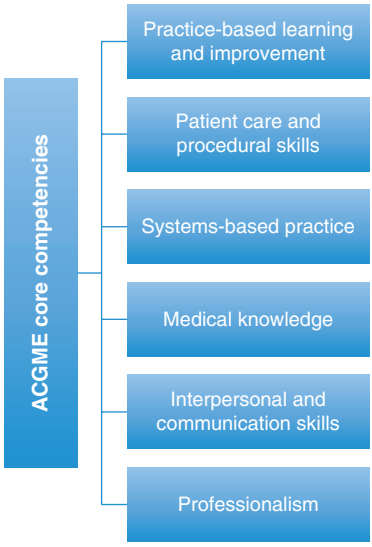


Fig. 2.2 The six ACGME core competencies

Fig. 2.3 Example of hybrid simulation using a live actor as a standardized patient wearing a surgical cut suit task trainer

virtual reality (VR) simulation, hybrid manikin cut suits (Fig. 2.3), high-fidelity manikins, standardized patients, human donor tissue, and live animal subjects may all be utilized during this time in training [29].

Residents and fellows are scheduled for training using various surgical and nonsurgical VR trainers based on their specialty [30]. Traditionally, this training has taken place in cadaver labs and throughout simulation centers across the globe. Laparoscopic surgical simulators and box trainers have been mandated by the American College of Surgeons as a minimum standard in graduate training [31]. Some of the groups that utilize this type of training include general surgery residents, thoracic surgery residents, and gynecological surgical residents. For the non-laparoscopic surgical simulators, there are VR trainers that have been designed specifically for otolaryngology, orthopedics, and neurological surgery [32]. Other forms of skills training use VR simulators or VR goggles. VR is used in procedural training and provides opportunities for learners to practice surgical, bronchoscopy, and endoscopy procedures with the use of virtual reality units (Fig. 2.4). There is also simulator training and residents will log in and have their hours and experiences documented and recorded into a personalized portfolio for faculty review. Centers are using VR for operating room safety training as well as basic employee or student safety modules. This type of orientation training may

Fig. 2.4 Examples of realistic computer-based virtual reality task trainers to allow clinicians to develop technical skills such as ultrasound (US), endoscopy, and laparoscopic surgery

be required and utilized for onboarding and new employee education. General surgery and obstetrics and gynecology residents are required to gain minimally invasive surgical skills, called laparoscopic surgical skills. Prior to their respective surgical board applications, they must successfully complete the high-stakes exam, Fundamental of Laparoscopic Surgery. General surgery residents are also required to complete the Fundamental of Endoscopic Surgery exam. These exams have a didactic and hands-on skills assessment and are completed at SAGES (Society of American Gastrointestinal and Endoscopic Surgeons)-certified testing centers [33, 34].

Professional and Healthcare Teams

Once the initial training and degree has been awarded, it is no longer acceptable for healthcare professionals to continue without some form of continuous medical teamwork and skills training. Professional and healthcare teams may have annual competencies where skills are reviewed and communication activities are implemented. There are also specialty certification programs such as the Maintenance of Certification for Anesthesiologists (MOCA) 2.0 that provides an intensive

longitudinal assessment model to foster lifelong learning and assessment [35]. This is in contrast to the previous design of MOCA as high-stakes recertification process initially pioneered by the American Board of Anesthesiologists.

For trauma surgeons, there are the Advanced Surgical Skills for Exposure in Trauma (ASSET) or Advanced Trauma Operative Management (ATOM) courses that instruct operative management of traumatic injury [36, 37]. These also review team-based skills development and communication in high-stakes situations. Hospitals and clinics participate in simulation to achieve better outcomes with patient interactions as well as with complex but rare event situations. These can range from employees doing annual harassment simulations with standardized participants to de-escalation of a mental health patient in the emergency department. Hospitals use simulation to evaluate patient transport flow due to construction, or for critical infectious situations, such as Ebola training. There are also many examples of hospital-based code team training such as the Simulated Code Interdisciplinary Team Training (SCITT) program that was created collaboratively by an RN manager and an MD at Oregon Health & Science University. There are others across the country and the world as well that are looking at team training opportunities to improve patient outcomes. One example of such a program is the healthcare solutions company MEDNAX®. This company has a network of over 3700 physicians across the country and supports them with a mobile simulation training program to provide on-demand, in situ, clinic- or hospital-based review and training for its providers [38].

Many hospitals have onboarding training that is done in collaboration with simulation centers and also in situ within units and departments. Some of the more intensive internship programs include specialized simulation trainings that include a variety of tools including: VR units or VR goggles, task trainers, high-fidelity manikins, standardized patients, and combinations of these. Healthcare teams often incorporate methods of Crisis Resource Management (CRM) into their training with the goals of improvement of quality and safety outcomes [39].

The World Health Organization (WHO) has advocated for inter-professional education (IPE) and team training to improve communication and collaboration. IPE requires two or more groups from different specialties to learn about, with, and from one another with the goal to improve communication and understanding about one another [40]. This is becoming a focus of current simulation training programs. With the number of specialties and types of training described in this section, it is no wonder that communication problems and discrepancies about the knowledge and skills between members of the healthcare team can occur. Many healthcare providers may not even fully understand the role, training, and expertise of other members of the healthcare team and it is the goal that IPE can improve this.

Military Simulations

The military has one of the most robust, evolving, and comprehensive systems for simulation training. Each branch of the military focuses on specific support trainings that are applicable to their division, but each shares in a growing

standardization on what is required prior to deployment as well as maintenance of skills post deployment. The Navy's Healthcare Simulation and Bioskills Training Center (HSBTC) does this through three main lines of operation: Graduate Medical Education Support, Patient Safety/Skills Sustainment Initiatives, and Combat Casualty Care training [41]. Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS) is a training program initially created jointly by the Agency for Healthcare Research and Quality (AHRQ) and the Department of Defense (DoD) in 2004. Since that time, it has been adopted by healthcare organizations globally due to its utility in training team communication and patient safety practices. Its use is supported by the Joint Commission, the Institute for Healthcare Improvement and the Surgeon General. The US Army now requires this training at all healthcare facilities [42, 43]. Medical Unit Simulation Team Training (MUSTT) is a derivative of TeamSTEPPS that utilizes a simulation-based course to allow for sustainment of TeamSTEPPS principles; it has been encouraged for use by all branches of the military [44]. TeamSTEPPS training examples that are important for review by surgical healthcare teams include the preoperative surgical team "huddle," making enough time in the operating room (OR) for the OR checklist, and preparing for rare but catastrophic events like hemorrhage, fire, massive transfusion protocols, and bad behavior in the OR.

Many of the following courses may be required prior to deployment depending on the location or background of the individual: Advanced Trauma Life Support (ATLS), Advanced Cardiac Life Support (ACLS), Tactical Combat Casualty Care (TCCC), the American College of Surgeons ATOM or ASSET courses, Emergency War Surgery Course (EWSC), and Combat Extremity Course [45–49]. Standardized patients, as well as high-fidelity manikins or hybrid manikin cut suits are used for these simulations. The military has training centers of varying sizes throughout the United States that recreate spaces such as rural villages, urban cities, foreign hospitals, low-light facilities, and various styles of aircraft or other vehicles. It is important to have different environments to execute these education events due to the varied and unpredictable situations in which military providers must be able to work successfully. One newer method for training these activities can utilize simulation centers with immersive training environments like the Wide Area Virtual Environment (WAVE) to simulate the complex environment of rendering care in a battle field situation [50].

There is currently legislation under review that would mandate military medical training to use only human-based training methods for the treatment of combat trauma injuries; this bill would likely continue to push simulation innovation to the forefront of military healthcare training [51]. This is on top of existing policies already calling for restricted use of animal tissue training activities except when alternatives do not exist [52].

Allied Health and Other Groups

Simulations are used increasingly in allied health programs including but not limited to physical therapy, occupational therapy, speech therapy, and hospital ancillary

staff, among others. Some simulation centers have built apartments or living spaces to allow therapists a deeper understanding of how patients interact with objects such as sinks, handles, doors, and appliances. These apartment-style living spaces may even have functioning showers and a variety of door handles and cabinet hardware to allow evaluation of how to interact with each. Additionally, some therapists work with patients in the hospital and intensive care units. Being exposed to the sights, sounds, tubes, lines, and equipment of these spaces will allow these individuals to interact more effectively and safely in this environment after gaining experience through simulation.

While simulation is used in multiple settings, this chapter is by no means all inclusive. The benefits of simulation are being seen now beyond the walls of the hospital and are even incorporated into programs in public health, dentistry, and veterinary medicine.

Lay Public/Good Samaritan

Healthcare training is offered to the lay public and increasingly enhanced using simulation training aids. These skills trainings range from allergic reaction epinephrine training, babysitting certifications, newborn preparation, basic first aid, Stop the Bleed, and Basic Life Support (BLS) training. These courses can be taken through the American Heart Association and the Red Cross and many community colleges, hospitals, and community outreach public health programs [53]. Training for these events may be at community centers, libraries, or even brief trainings like hands-only CPR that have been offered at supermarkets and shopping centers [54].

References

1. Stelfox HT, Palmisani S, Scurlock C, Orav EJ, Bates DW. The "To Err is Human" report and the patient safety literature. BMJ Qual Saf. 2006;15(3):174–8.
2. Buring SM, Bhushan A, Broeseker A, Conway S, Duncan-Hewitt W, Hansen L, et al. Interprofessional education: definitions, student competencies, and guidelines for implementation. Am J Pharm Educ. 2009;73(4):59.
3. Thomas PA, Kern DE, Hughes MT, Chen BY. Curriculum development for medical education: a six-step approach. 3rd ed. Baltimore: The Johns Hopkins Univ. Press. 2016.
4. Mistovich J, Karren K, Hafen B, editors. Prehospital emergency care. 10th ed. Boston: Pearson; 2014.
5. Mills BW, Miles AK, Phan T, Dykstra PM, Hansen SS, Walsh AS, Reid DN, Langdon C. Investigating the extent realistic moulage impacts on immersion and performance among undergraduate paramedicine students in a simulation-based trauma scenario: a pilot study. Simul Healthc. 2018;13(5):331–40.
6. Kragh JF, Littrel ML, Jones JA, Walters TJ, Baer DG, Wade CE, et al. Battle casualty survival with emergency tourniquet use to stop limb bleeding. J Emerg Med. 2011;41(6):590–7.
7. Journal of Emergency Medical Services Staff. What the White House's Stop the Bleed campaign means for EMS. Journal of Emergency Medical Staff Services [online]. 2016. [cited 2019 April 17]; Available from: https://www.jems.com/articles/print/volume-41/issue-40/

special-focus-gearing-up-for-active-shooter-tactical-high-threat-incidents/what-the-white-house-s-stop-the-bleedcampaign-means-for-ems.html
8. American Association of Colleges of Nursing. The essentials of baccalaureate education for professional nursing practice [Online]. 2008 [cited 2019 April 17]. Available from: http://www.aacnnursing.org/portals/42/publications/baccessentials08.pdf.
9. Flynn L, Liang Y, Dickson GL, Xie M, Suh DC. Nurses' practice environments, error interception practices, and inpatient medication errors. J Nurs Scholarsh. 2012;44(2):180–6.
10. Jeffries P. Evaluation. In: Nehring W, Lashley F, editors. High-fidelity patient simulation in nursing education. Sudbury: Jones and Bartlett; 2010. p. 405–24.
11. Jeffries PR. Simulation in nursing education: from conceptualization to evaluation. New York: National League for Nursing; 2012.
12. Harden RM. What is a spiral curriculum? Med Teach. 1999;21(2):141–3.
13. Newhouse RP, Stanik-Hutt J, White KM, Johantgen M, Bass EB, Zangaro G, et al. Advanced practice nurse outcomes 1990–2008: a systematic review. Nurs Econ. 2011;29(5):230.
14. Schram AP, Mudd S. Implementing standardized patients within simulation in a nurse practitioner program. Clin Simul Nurs. 2015;11(4):208–13.
15. Klaus RM, Royer DF, Stabio ME. Use and perceptions of plastination among medical anatomy educators in the United States. Clin Anat. 2018;31(2):282–92.
16. Losco CD, Grant WD, Armson A, Meyer AJ, Walker BF. Effective methods of teaching and learning in anatomy as a basic science: a BEME systematic review: BEME guide no. 44. Med Teach. 2017;39(3):234–43.
17. Jones PE. Physician assistant education in the United States. Acad Med. 2007;82(9):882–7.
18. AAPA. PA Prescribing. 2017.
19. Multak N, Euliano T, Gabrielli A, Layon AJ. Human patient simulation: a preliminary report of an innovative training tool for physician assistant education. J Physician Assist Educ. 2002;13(2):103–5.
20. Keely JL. Pharmacist scope of practice. Ann Intern Med. 2002;136(1):79–85.
21. Albanese NP, Rouse MJ, Schlaifer M. Scope of contemporary pharmacy practice: roles, responsibilities, and functions of pharmacists and pharmacy technicians. J Am Pharm Assoc. 2010;50(2):e35–69.
22. Seybert AL. Patient simulation in pharmacy education. Am J Pharm Educ. 2011;75(9):187.
23. Vyas D, Bray BS, Wilson MN. Use of simulation-based teaching methodologies in US colleges and schools of pharmacy. Am J Pharm Educ. 2013;77(3):53.
24. ACPE. Accreditation standards and guidelines for the professional program in pharmacy leading to the doctor of pharmacy degree. Chicago: Accreditation Council for Pharmacy Education; 2011.
25. Bell RH. Surgical council on resident education: a new organization devoted to graduate surgical education. J Am Coll Surg. 2007;204(3):341–6.
26. Ericsson KA. Deliberate practice and acquisition of expert performance: a general overview. Acad Emerg Med. 2008;15(11):988–94.
27. Agha RA, Fowler AJ. The role and validity of surgical simulation. Int Surg. 2015;100(2):350–7.
28. Holmboe ES, Edgar L, Hamstra S. The milestones guidebook [online]. American Council of Graduate Medical Education. 2016 [cited 2019 April 15]. Available from: https://www.acgme.org/Portals/0/MilestonesGuidebook.pdf
29. Crochet P, Aggarwal R, Dubb SS, Ziprin P, Rajaretnam N, Grantcharov T, et al. Deliberate practice on a virtual reality laparoscopic simulator enhances the quality of surgical technical skills. Ann Surg. 2011;253(6):1216–22.
30. Owens R, Taekman JM. Virtual reality, haptic simulators, and virtual environments. In: The comprehensive textbook of healthcare simulation. New York: Springer; 2013. p. 233–53.
31. Panait L, Akkary E, Bell RL, Roberts KE, Dudrick SJ, Duffy AJ. The role of haptic feedback in laparoscopic simulation training. J Surg Res. 2009;156(2):312–6.
32. Badash I, Burtt K, Solorzano CA, Carey JN. Innovations in surgery simulation: a review of past, current and future techniques. Ann Transl Med. 2016;4(23):453.

33. Gardner AK, Ujiki MB, Dunkin BJ. Passing the fundamentals of endoscopic surgery (FES) exam: linking specialty choice and attitudes about endoscopic surgery to success. Surg Endosc. 2018;32(1):225–8.
34. FES/SAGES. SAGES – fundamentals of endoscopic surgery [online] http://www.fesprogram.org/2018 [cited 2018 May 3]. Available from: http://www.fesprogram.org/
35. The American Board of Anesthesiology. Changing the paradigm - a new approach to assessment in maintenance of certification. [Online]. 2015 [Cited 2019 April 17]. Available from: http://www.theaba.org/PDFs/MOCA/MOCA-Summit-White-Paper
36. Bowyer MW, Kuhls DA, Haskin D, Sallee RA, Henry SM, Garcia GD, et al. Advanced surgical skills for exposure in trauma (ASSET): the first 25 courses. J Surg Res. 2013;183(2):553–8.
37. Jacobs LM. Advanced trauma operative management. Woodbury: Cine-Med; 2004.
38. Maurtua K. MEDNAX's innovative mobile simulation program is expanding nationwide. Medical Training Magazine [Internet]; 2017 [cited 2108 May 3, 2018]. Available from: https://medicalsimulation.training/hospital/mednaxs-innovative-mobile-simulation-program-expanding-nationwide/
39. Fanning RM, Goldhaber-Fiebert SN, Udani AD, Gaba DM. Crisis resource management. In: The comprehensive textbook of healthcare simulation. New York: Springer; 2013. p. 95–109.
40. Organization WH. Framework for action on interprofessional education and collaborative practice. Geneva: World Health Organization; 2010.
41. Perron RA. NMCP's simulation center opens doors during healthcare simulation week. Navy [Internet]; 2017 [cited 2018 May 7]. Available from: http://www.navy.mil/submit/display.asp?story_id=102516
42. Command UAM. Operation order 11–38 (AMEDD-wide implementation of TeamSTEPPS). In: Command UAM, editor. Fort Sam Houston, San Antonio; 2011.
43. Chiri AW. TeamSTEPPS enhances teamwork and empowers staff in Army medical homes. Army.mil [Internet]; 2016 [cited 2018 May 7]. Available from: https://www.army.mil/article/169592/teamstepps_enhances_teamwork_and_empowers_staff_in_army_medical_homes
44. Haque M, Napolitano P, editors. MUSSTT (Medical Unit Simulation & Safety Team Training): a TeamSTEPPS sustainment model. TeamSTEPPS national conference; 2016 May 3. Denver; 2018.
45. Kim K. NMCP's combat extremity surgery course prepares medical personnel for combat 2015 May 3, 2018 [cited 2018 May 3]. Available from: http://www.navy.mil/submit/display.asp?story_id=92185
46. Eastridge BJ, Mabry RL, Seguin P, Cantrell J, Tops T, Uribe P, et al. Death on the battlefield (2001–2011): implications for the future of combat casualty care. J Trauma Acute Care Surg. 2012;73(6):S431–S7.
47. Health.mil. Emergency war surgery course [cited 2018 May 3]. Available from: https://health.mil/Training-Center/Defense-Medical-Readiness-Training-Institute/Emergency-War-Surgery-Course
48. Department of Defense. Medical readiness training (MRT). In: Defense Do, editor. [online] http://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132224p.pdf?ver=2018-03-16-140510-410: Department of Defense; 2018.
49. Rush CRM. Simulation in military and battlefield medicine. In: Levine AI, DeMaria S, Schwartz AD, Sim A, editors. The comprehensive textbook of healthcare simulation. New York: Springer; 2013. p. 401–13.
50. Fitzhugh DC. Technology solutions for combat casualty care training. Human performance, training, and biosystems directorate newsletter [Internet]; 2015 [cited 2018 May 7]; (3). Available from: https://www.acq.osd.mil/rd/hptb/docs/newsletters/2015/HPTB_Newsletter_January_2015.pdf
51. BEST Practices Act, S. 498. 115 Cong. (2017).
52. Department of Defense. Use of animals in DOD conducted and supported research and training [Online]. 2019 [Cited on 2019 April 17]. Available from: https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/321601p.pdf.
53. Brennan RT, Braslow A. Skill mastery in public CPR classes. Am J Emerg Med. 1998;16(7):653–7.
54. Texas Two Step CPR. National Texas Two Step CPR [online]; 2018 [cited 2018 May 3]. Available from: https://www.tx2stepcpr.com/

Simulation Methodologies

3

Matthew David Charnetski

Medical and Healthcare Simulation Methodologies

People forget what they are taught. However, for almost as long as people have been learning, educators have known that relearning through deliberate practice improves long-term recall. Or, as Durant best summarized for Aristotle, "We are what we repeatedly do" [1]. While the specific discipline of medical education has gone through many variations of prevailing thought over its history, the field has held fast to this central theme of learning through repetition. Simulation thrives on the concept of repetitive reproducible scenarios to allow consistent prompts, practice, and performance to demonstrate competence. Simulation as an educational tool allows for an effective, consistent process of repetition and iterative learning practiced on an efficient scale while remaining safe for patients and learners at increasing levels of difficulty [2, 3]. However, as a modern healthcare simulation learning spaces can require a considerable amount of technologically advanced equipment and integration, those unfamiliar with the fundamental methodologies and learning practices may misuse the tools as simple knowledge tests.

Such an imprudent assumption leads to large-scale facility and human capital expenditures with diminished educational returns. Therefore, it is necessary to start with the most important healthcare simulation definitions. From there, one can apply them to a greater discussion of simulation methodologies in order to better design focused learning objectives. This leads to improved scenario design providing better patient and training outcomes with the opportunity for deliberate, iterative practice in contextually relevant surroundings.

M. D. Charnetski (✉)
Institute for Clinical Competence, New York Institute of Technology at Arkansas State University-Jonesboro, Jonesboro, AR, USA

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_3

Choosing an Appropriate Simulation Methodology

With all of the following tools and methods available, how does a program decide what best fits the needs of its learners?

By looking at the objectives for the scenario, considering the level of the learner and the anticipated complexity desired, each program can mix and match the following tools to create a learning environment that is best suited to fit the planned educational needs. Equipment possibilities are nearly endless, so one must consider the level of fidelity desired, expected skill or knowledge to be trained, required staff, necessary consumables, budget allotment, and access to functioning equipment [4]. All of these elements together will allow a determination of what methodologies can be recommended in order to design and execute an appropriate simulation event.

High-Fidelity Versus Low-Fidelity

Fidelity refers to the level of realism that may exist within a simulation scenario [5]. Adjusting the level of fidelity in a simulation can be as simple as adding additional sensory cues to augment the patient presentation, such as moulage, prostheses, or props. Sounds, and even smells, can be used to contribute to a scenario's perceived realism. Realism has been suggested to be more than just sight, touch, sound, and smell. There are three classifications for fidelity proposed to encompass a learners' sensory and psychological experience. Psychological fidelity, equipment fidelity, and environmental fidelity are components of the scenario as a whole (Fig. 3.1) [6, 7]. While there is no single distinction between devices that are high- and low-fidelity, these terms suggest a concept of realism where high-fidelity is often associated with greater complexity, cost, and physiologic representation. Along with these additional features, the chance for failure or error if not carefully set up and maintained may increase. The educational utility of the tool is the actual goal, not simply the "fidelity." This has been described more recently as the "affordance" each educational tool offers as to what it trains well [8].

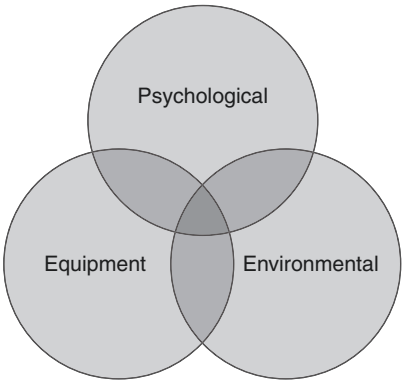


Fig. 3.1 Venn diagram describing the relationship of various components of a simulation experience that can be described by the term "fidelity" [6]

Low-fidelity simulations often have a lower cost of entry and reduced maintenance costs than high-fidelity experiences. Lower-fidelity simulations may also have shorter setup or turnover times. This allows for a greater number of learners or iterations to pass through a simulation in a shorter amount of time. The manikin torsos used for basic life support (BLS) training, which require no additional setup, are a common example of a low-fidelity method of simulation.

As fidelity increases, the practice environment more closely matches the real-world provider environment. Therefore, high-fidelity simulation has a lower threshold for the learner to overcome when suspending their disbelief to engage with the simulated scenario [9]. Higher-fidelity equipment and environment setup may also create an easier translation of skills from training to clinical practice. In a simulation learning experience with high environmental fidelity, one may find a manikin with a simulated family member present and moulage to provide physical exam findings consistent with the underlying conditions of the patient. In this same simulation, there may be a task trainer incorporated that allows the student to perform a skill and allow high-equipment fidelity Additionally, there may be extraneous medical equipment in the simulation room to provide a space similar to the practice area and sounds or smells to make the environment similar to the busy ER where the patient is being seen. The overall concept of training benefit and knowledge or skill transference has been called "high-feedback" simulation regardless of the technological or physiologic realism presented [6].

High-Technology Versus Low-Technology

A high-technology simulation involves technologically enhanced methods for addressing the training needs of the simulation. A low-technology simulation might use a simple analog to allow the performance of a task. The level of technology deployed in a simulation refers to the equipment that may be used within a scenario. However, more equipment and technology does not always mean the simulation is more realistic. Therefore, high- versus low-technology is an important distinction that may have little or no bearing on the fidelity of the simulation [10]. For example, when simulating childbirth for an otherwise normal birth, both high- and low-technology solutions could be used in either a high- or low-fidelity scenario depending on the other methodologies employed in the creation of the training environment. A high-tech solution would be a manikin that is capable of automatically giving birth to a manikin baby. A lower-tech solution to the same basic training need would be a false belly that can be attached to a standardized patient (SP) where the SP manually pushes the manikin baby through the birth canal [11].

Low-technology equipment often has the advantage of being less expensive and with its simplicity often has a lower risk for equipment failure during use. High-technology equipment has the advantage of being more versatile and/or automated than low-technology equipment. Higher-technology equipment often involves less direct human action which can result in a greater potential for consistency in delivery of content when set up correctly.

Manikin-Based Simulation

Manikin-based simulation involves a scenario where a central element of the scenario, often the patient, is a full-body manikin. Depending on its cost, capabilities, and desired function, the manikin may be high- or low-technology. In addition, manikins can be incorporated into both high- and low-fidelity simulations. Manikins are primarily used in scenarios where high-fidelity is a goal or when a collection of skills needs to be incorporated and performed in a realistic environment, because they allow for interventions, skills, and medications to be applied ethically and directly to the patient in a manner that would be impossible or unlikely with other methodologies (for example, delivering electrical and chemical interventions to a manikin patient during a code scenario such as cardiac arrest). Finally, a great advantage of manikins is the ability to create scenarios with critically ill patients where the patient's condition can be changed rapidly and realistically to match the interventions provided by the learners.

Ultimately, however, high-technology manikins paired with well-designed manikin-based simulation scenarios are considered to offer a higher-fidelity experience for the learner. A simulated full-body manikin patient can mimic a real patient encounter because the device can provide speech, display physical exam findings, and produce modifiable physiologic parameters in the form of vital signs. Further, such physiologically accurate full-body patient simulators can incorporate features and interactive components that might also be found in a human patient but could not be well simulated by a person playing the role of a patient. For example, when deploying manikins on the high-technology spectrum, one may find manikins that have abnormal breath sounds, irregular heart rhythms, or eyes that have variable pupil sizes or blinking. These highly customizable manikins also communicate with vital signs monitors and connect to a computer network in the same manner as a personal computer. Often, manikins on this spectrum can be pre-programmed with vocal sounds, or a human operator may speak through the manikin using a microphone to respond to learner queries.

Full-body manikins have variability in the amount of technology and capabilities, and some may not have any additional technology in the form of wires or additional peripheral device connections. The ability to program or remotely manipulate such manikins depends on the level of technology integrated into the resource. Some are set up using a laptop or tablet and can be adjusted to mirror the ongoing scenario from a remote location. Other manikins may only have a rubber bulb attached to the end of a tube that can be manually pumped to imitate a pulse or inflate a tongue that would challenge the learner to intubate.

A distinct disadvantage of manikins and manikin-based simulation is the up-front equipment purchasing expense and physical storage space requirement. While the price can vary significantly, the cost of a manikin will often be a function of its fidelity, technology, and overall capabilities. The cost-effectiveness of a manikin purchase can be measured by how often it is used and what functions are utilized to achieve a program's ongoing educational objectives. Typically, manikins require less scheduling and personnel management than other human-based methods that

will be discussed later. However, on average, manikins are more expensive than many other types of simulation methodologies. In addition, manikin-based simulation requires routine software and firmware updates with ongoing expenses for regular physical maintenance and manufacturer support. Personnel with specialized training are also required to set up and operate these tools to ensure effective and efficient use and troubleshooting of features during a simulation scenario. Manikins are generally purchased with an anticipated 6- to 8-year life cycle, and some manufactures have an end-of-life support after only 5 years [12].

Task Trainers

Task trainers are devices that are often shaped to mimic a single portion of a simulated patient for the performance of a task. For instance, a task trainer could be just an arm designed to teach intravenous therapy initiation, or a task trainer torso and head might allow for nasogastric tube insertion [5]. Both of these examples have no need for a full human patient simulator body, and so for cost and space considerations, these extraneous portions are absent in these procedurally oriented models. A task trainer is designed to meet the need for practicing one particular skill. Task trainers exist for almost any skill a healthcare provider needs to perform. Occasionally, a task trainer is designed to train several skills that might be performed in the same region of the body.

Often, these trainers are low-technology but can vary in their fidelity. Some can be bulky, making them difficult to move or integrate into a simulation with other equipment such as a full-body manikin. However, when compared to full-body manikins, most provide more nuance for simulating the skill provided and can be used in nearly any facet of a simulation program. For example, in a manikin, there may be only one place to start an IV. In a task trainer, the stand-alone arm may have multiple sites to initiate an IV, and it could also allow for the administration of fluid. Because they serve a less global use than other simulation methodologies, task trainers can have more specific details related to the task performed than a manikin or standardized patient. For instance, a task trainer and full-body patient simulator may both allow for a digital rectal exam. The task trainer, however, is designed to offer multiple different prostates or other attachments allowing for the simulation of different conditions, while the full-body patient simulator is designed to have only normal anatomy and physiology for this area at baseline.

Having smaller specialized training tools allows for lower repair and replacement costs as a smaller device can be replaced and shipped more easily. Having a series of task trainers in a room with a manikin may also add to the number of skills that can be performed in a scenario. Mixing two simulation modalities like this is termed “hybrid simulation” and is discussed in more detail later in this chapter [13]. While task trainers usually take much less time to set up, they can still have large time commitments for cleaning and maintenance. Some may also require regular restocking of consumable parts such as skins or tubes that get cut or punctured during procedures (see Fig. 3.2).

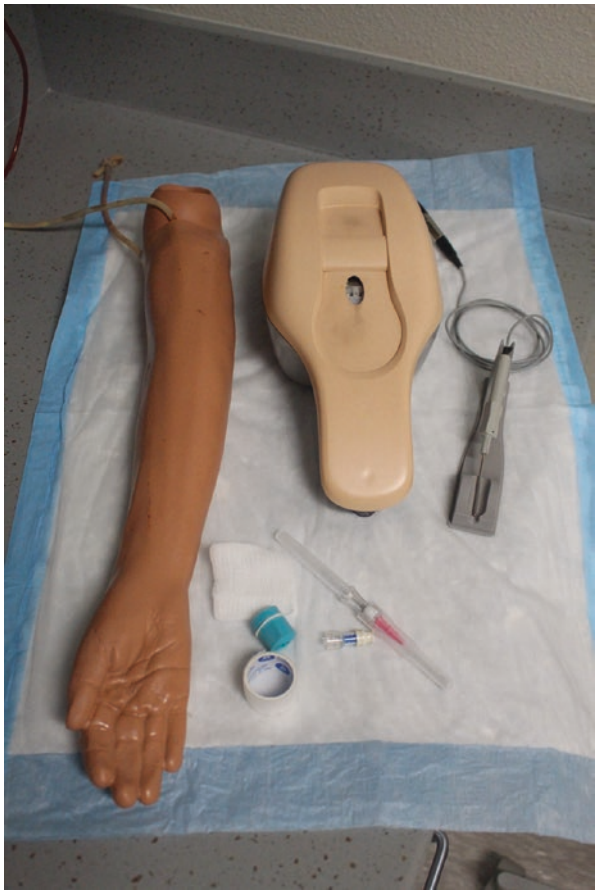


Fig. 3.2 Example of low-technology task training arm (left) and high-technology task trainer (right) with computer feedback. Both tools are designed to train the same skill of intravenous line insertion

Standardized Patients/Simulated Participants

Standardized patients, simulated participants, and simulated patients are often interchangeably referred to as "SPs." However, aside from some minor distinctions, these terms refer to people who have been trained to accurately and consistently reproduce the presentation of a patient or scenario participant with a certain condition with the aid of a script to follow based on that presentation. The standardization referenced in their titles refers to a group of people being able to reliably produce the same experience for a learner with every iteration being consistent throughout each portrayal. This makes them particularly useful for any summative or "high-stakes" testing because the test being administered to each student is the same. To achieve this result, standardized patients are trained to portray a specific, scripted patient condition and must be motivated not by their performance as an actor but by being a consistent and effective component in an educational experience. Because they have the advantage of being able to steer the learners and the scenario in a

particular direction, simulated patients have the ability to act and react naturally while being able to intervene to keep students on track or serve as a distractor in particularly complex scenarios [14]. A standardized patient is distinct from an actor who serves a support or ancillary role in the simulation scenario. While these individuals should still behave in a standardized and consistent manner between training sessions, they are not usually the focus of the learner encounter. These individuals may portray roles such as family members, bystanders, friends, or other healthcare providers. Some centers or educators may refer to this role as a confederate or embedded participant [5].

SPs are used in all different types of simulation. Standardized patients are often deployed for high-stakes evaluation. Further, they are currently utilized by almost every healthcare profession's final assessments of their learners. They are also found in many programs to give learners more opportunities to practice communication and patient relationship skills. In addition, SPs just like embedded participants can be used to help drive the participants toward a specific objective because they allow for a dynamic communication environment that can respond directly to student behavior and communication. An advantage of any SP form is the allowance for a truly human interaction with perspective given from those individuals in the SP role on how they felt throughout the care rendered [15].

Having a pool of available SPs is valuable to any simulation program, but it requires regular contact, training, and events to keep the SPs involved and properly prepared. In particular, standardized patients require substantial training as well as quality assurance measures to ensure that they are behaving consistently in their testing scenarios. The upfront cost of any individual SP may be somewhat low, but ongoing wage and training expenditures can quickly grow to be substantial. Therefore, smart, realistic budgeting is essential for a sustainable SP program. Standardized patients are covered in greater detail in Chap. 18.

Roleplaying

Roleplaying is when students or faculty play the role of the patient and/or another care provider; this allows the use of critical thinking and active involvement in the educational experience [16]. This may be for full patient encounters or specific pieces of any given simulation interaction. Roleplaying differs from SP scenarios because they are less structured with more latitude than any of the scripted methods [17, 18]. It is often used with early- and entry-level healthcare education programs to provide learners with hands-on experiences without requiring additional resources for other types of simulation. For example, wilderness medicine often pairs learners into groups during patient care simulation scenarios. One half of the learners act as providers with certain basic equipment for assessment and treatment, while the other half are given a short scenario storyline, central complaints, and, possibly, moulage meant to guide learners through patient assessment simulations. Little resources are required to successfully utilize roleplay in simulation. However, it can be difficult to

objectively assess learners during roleplay scenarios, and the experience is limited by participant's ability and willingness to treat the situation realistically.

Storytelling

Storytelling as a simulation methodology is a powerful resource for bringing the reality of patient care and decision-making nuance to learners while allowing the learner to think about how they might act in a similar situation. Whether the story is from the perspective of a healthcare professional or a patient, storytelling allows the learner to become involved and immersed in a situation they may not have been exposed to through more obvious methodologies [19].

Storytelling is inexpensive, and, because the storyteller is usually sharing a personal experience, there is a substantial opportunity for learners to ask questions and fully understand the mindset and perspective of the storyteller. For example, hearing a patient describe their journey through metastatic cancer or a healthcare provider speak about their experience during the commission of a medical error can provide impactful clinical and nonclinical scenario-based insight for leaners. Unfortunately, storytelling is only as good as the storyteller and may lose efficacy if the story is related poorly. Additionally, storytelling can sometimes require substantial effort on the part of the storyteller and learner to maintain engagement with the intended message and objectives.

Case-Based Learning

Case-based learning is not traditionally seen as a form of simulation. However, it is included here to demonstrate the true breadth of simulation methodologies and how it can be leveraged to work with many different types of assessment. Case-based learning is a tabletop exercise where learners work together to assess, examine, and treat an imaginary patient [5, 20]. These cases are standardized, and the learners are encouraged to come prepared for the type of patient they may see without being given too much specific information. The learners will then work in small groups or individually to determine what information they wish to gather, how they might treat this patient, and an ongoing treatment plan. They may also be asked to connect concepts from other areas of their training (like basic sciences) to better understand how important the rest of the curriculum may be to understanding and treating a patient. These scenarios usually include some form of patient presentation with the ultimate goal of preparing learners for clinical rounds [21].

Using case-based learning provides a great environment for observing and assessing underlying decision-making processes and for observing teamwork and communication in a "low-stakes" situation. It is inexpensive to implement and can be done in a standardized way. This type of simulation activity is also used by some medical specialties as part of their high-stakes credentialing and certification process. The American Board of Emergency Medicine uses this type of scenario design

in a one-on-one interaction enhanced with media and clinical information as the final step to become board certified [22].

Case-based learning is primarily useful for knowledge assessments and can occasionally be used to ensure that learners "know how" they might perform or prepare a procedure or examination. Case-based learning also requires significant preparation on the part of the faculty or facilitator in order to have the appropriate information prepared for the learners prior to the event.

Case-based learning is often used to present a case related to ongoing educational efforts in which learners are participating concurrently. This allows for a clinical context to attach any other information they are working through. For instance, learners may go through a cardiac lecture and receive several papers related to ACLS performance or guidelines and then have a case-based learning involving a patient with acute coronary syndrome. This provides the learners the opportunity to integrate different elements of knowledge into a cohesive decision-making and thought process before they are faced with a real patient and the need to provide real interventions.

Computer/Constructed Simulation

Computer or constructed simulation takes place when a learner progresses through case presentations and scenarios with multiple-choice questions following each piece of information provided. This simulation methodology is often referred to as a "canned course." For example, the American Heart Association uses computer simulation for BLS and ACLS course pre-tests and online training delivery.

An advantage with this type of simulation is that it can be delivered quickly and efficiently with case-based assessment of learner knowledge. However, this method cannot closely examine the decision-making process, lacks dynamic interaction, and only seeks answers in a right or wrong format. To offset these challenges, computer or constructed simulation is often paired with another type of simulated experience. More dynamic, virtual, and immersive computer-based simulations often referred to as "serious games" are being developed to combat this limitation [23].

Virtual Simulation

Similar to computer or constructed simulation, but with a higher level of fidelity, virtual simulation is used as an adjunct to other methods of simulation education to provide learners an opportunity to work through common patient care scenarios. Instead of working through a scenario paragraph or patient information followed by multiple-choice question on a computer, the learner is faced with the questions, tests, interventions, and assessments that they might traditionally use in a patient care setting. The learner is able to select what they might do next from a list of options or series of onscreen buttons. Then, the computer responds by providing them with additional information or performing the intervention they requested.

Fig. 3.3 Screenshot of one of Oxford Medical Simulation's virtual reality training scenarios

The learner can progress through their patient care scenario until a certain objective is met or until the interaction is completed. With some exceptions, virtual simulations have a limited number of choices available to the learner for their actions but aim to allow some amount or variability beyond a multiple-choice right or wrong interaction. These systems can be easily delivered on a large scale and often come with bundled scenarios for learners to perform. Additionally, virtual simulation allows for a significant interaction with the opportunity for feedback. Performance tracking with the order and timeliness of interventions can be integrated for evaluating the learner's decision-making process.

Several different virtual simulation applications have been developed to allow nursing or paramedic assessments and interventions to be delivered in a standardized way to large groups of learners. Virtual simulation has started to take the place of computer/constructed simulation for delivery of pre- and post-test materials for "canned courses (Fig. 3.3)."

Virtual Reality Surgical and Procedural Simulators

Surgical specialties have specialized procedural and skills training needs. Technical skill and operation of surgical tools especially in the realm of interventional procedures such as cardiac catheterization, colonoscopy, endoscopy, or bronchoscopy and any number of open or minimally invasive surgical procedures need to be trained. Computer-based virtual reality simulators that mimic a video game in function, as much as any other training tool, have allowed for increasing expertise

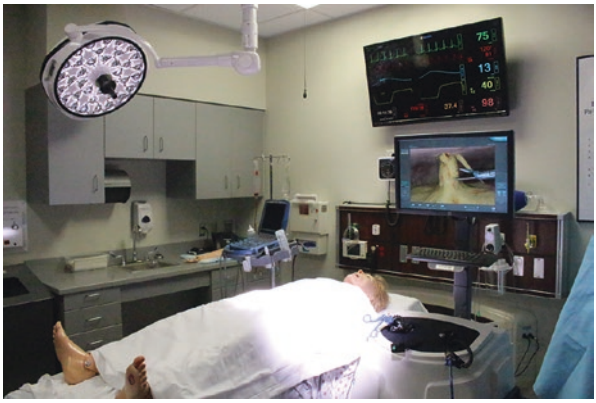


Fig. 3.4 An example of virtual reality surgical simulation (shown on screen below vital signs)

prior to performing a real procedure. These systems use highly realistic computer-generated images with haptics (tactile feedback) and tools interfaces that exactly replicate the actual handles of surgical equipment to provide this training. Given the time and research to develop these tools, it is no surprise that the price is very high for these devices. The training provided can be invaluable, but the maintenance, security, storage, access, and expected supervision can make these tools difficult to use logistically (Fig. 3.4).

Virtual Reality/Augmented Reality

Virtual reality (VR) and augmented reality (AR) are touted as the next generation of virtual simulation [24, 25]. These two distinct tools allow for the creation of environments to transport learners into education settings disparate from the world the learner is currently occupying. This is ideal for education programs that may have limited access to simulation or patient care areas. Both methodologies lower the resource cost of ancillary treatment equipment while providing a potentially dynamic patient interaction that can adjust based on the student's performance.

Virtual reality uses specialized computer equipment to create the visual and auditory simulated world for the learner [26]. These systems are often complemented with another device used to interact within this virtual reality space. Typically, learners wear a headset or goggles and earphones while holding some sort of controller as they navigate the virtual world that is similar to a video game. In this world, the learner progresses through problems while utilizing the tools provided to interact with, assess, and treat their patient.

Augmented reality is similar to virtual reality, but the computer-generated images and environment of augmented reality are superimposed on a real-world framework [27]. This is in contrast to a virtual reality environment where all aspects of imagery and stimulation are artificially created. These two systems have only been allowed to enter into mainstream use since 2014 with companies like Oculus, HTC, Facebook, Sony, and Microsoft bringing initial devices and technology to consumer markets.

Even smartphones now possess the image processing and movement systems to allow immersion into these environments, letting learners look in a 360 ° area, but smartphones do not currently detect movement forward and backward. Google created an inexpensive device called Cardboard that allows any of a variety of handheld phone devices to display three-dimensional VR and AR content to the user by displaying independent images to the left and right eye of the wearer. The phone device inside of the Cardboard viewer can recognize head rotation and will change the display in real time to allow the wearer to view the AR or VR environment.

Augmented reality imagery, as with virtual reality, allows the learner to use specialized graphical display equipment to interact with the world. However, the backdrop of that world is the room the learner is currently occupying. For example, a learner may have special glasses that pair a virtual patient with a task trainer. Then, the student virtually interacts with the patient while performing a physical intervention on the real task trainer. Or a virtual patient is projected into a regular hospital room the learner normally works within, but the patient and the treatment of that patient are virtual. AR systems require the digital recognition of key points of an image to allow the software to project an image on top of the real-world environment and adjust the projected image to match the perspective of the observer. Figures 3.7, 3.8, 3.9, and 3.10 are augmented reality key images that can be observed with the free software application, "Augment El Paso," available from the Google Play store or Apple iTunes store. The QR images in Figs. 3.5 and 3.6 will link to the download for demonstration of this technology. The images in Figs. 3.7, 3.8, 3.9, and 3.10 demonstrate some of the types of scenarios and training tools that could be created with this technology.

More advances in physical interaction with tools and equipment will be required for full adoption of these tools in training. This type of interaction is call "haptics" and

Fig. 3.5 QR code link to iTunes for Augment El Paso application

Fig. 3.6 QR code link to Google Play store for Augment El Paso application

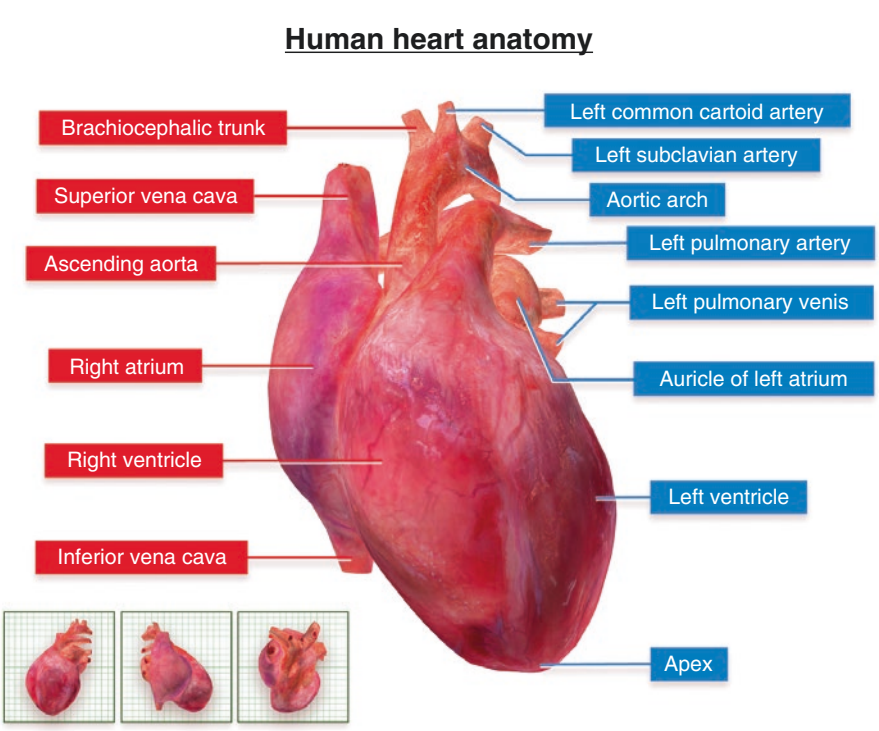


Fig. 3.7 2D image of the heart with augmentation to show 3D representation with movement and labels

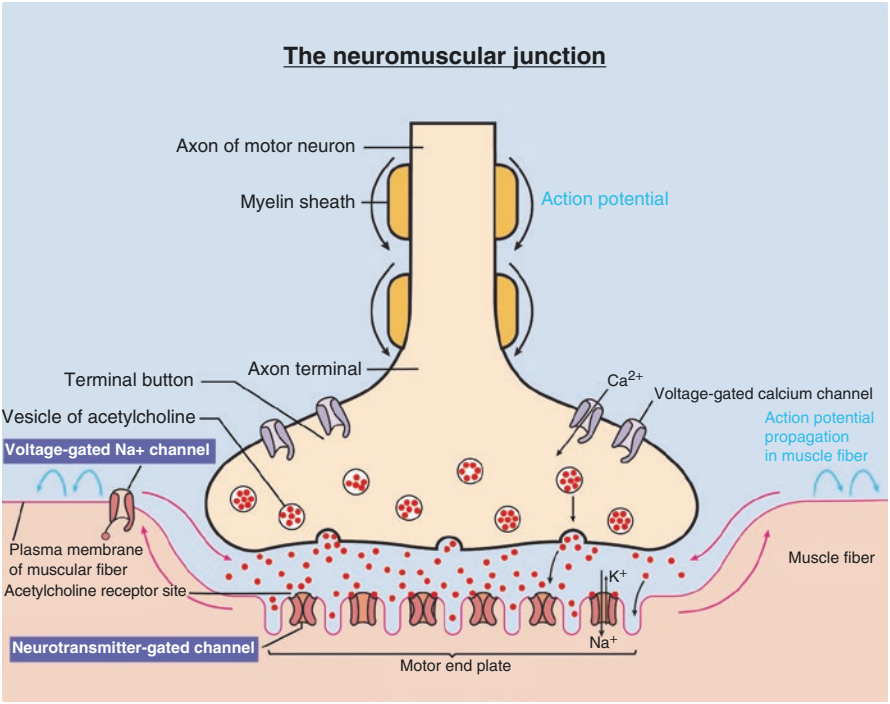


Fig. 3.8 Image of a neuromuscular junction with augmentation that shows an animation with narrative description of each step

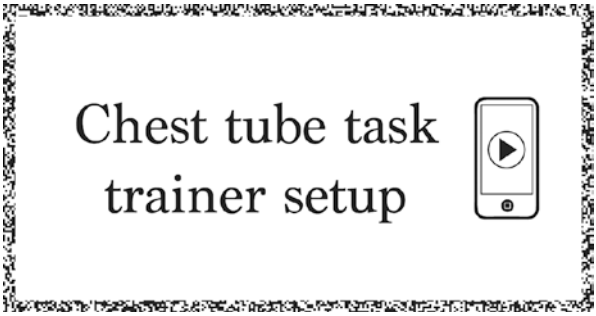


Fig. 3.9 Descriptive key image that was built with augmentation that will link to and play a video describing the use of a chest tube task trainer

describes the physical touch and sensory interaction with a virtual system [28]. Both AR and VR require graphical design and image creation equipment, but the subtle differences of the two greatly impact the overall use of the technology. VR systems like the HTC Vive and Oculus Rift can be disorienting to some as the sensation of movement by looking at an artificial image without the physical sensation of movement detected by the body can cause discomfort to some users in the form of motion sickness [29].

Either of these systems could be used in nearly any patient care arena to create high-fidelity scenarios based on the technology available. Particularly with virtual reality, the limits are simply imagination, processing power, and imaging technology. Yet, these systems do not allow much room for improvisation in the case of a

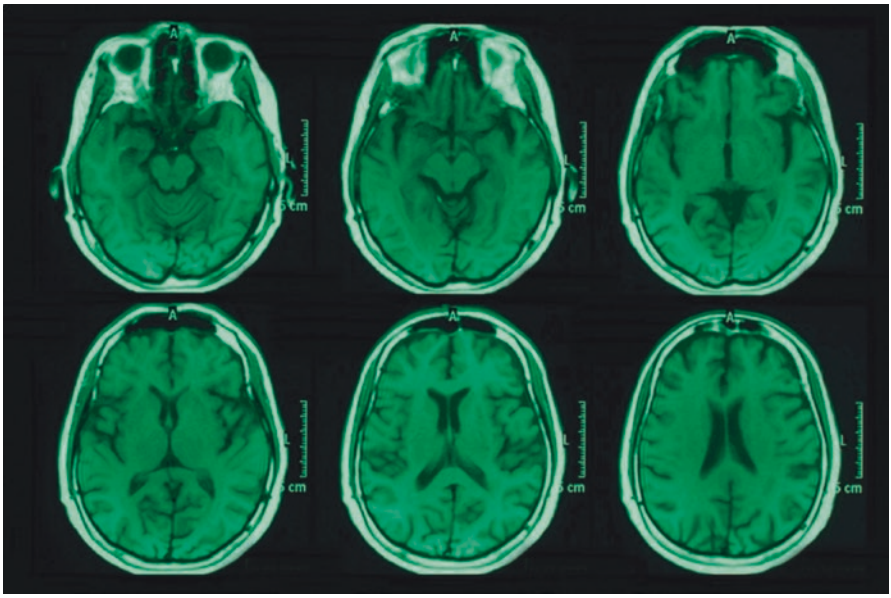


Fig. 3.10 Graphical representation of a magnetic resonance image (MRI) of a brain that with augmentation will display a 3D computer-generated representation of a brain and color highlights of some of its sections

malfunction. Therefore, if the system fails, learners would have to cancel or reschedule the simulation. Further, additional resources and support for proper operation and maintenance are required for ongoing operations after a huge cost for initial setup.

Separate from AR and VR, equirectangular video recording allows for playback of a fixed location video recording, but the viewer can see all directions at any point in time depending on where they look [30]. Specialized camera recording equipment and motion tracking headset displays, like a smartphone, are required but are another way that technology-enhanced simulation and displays may enter the realm of simulation. Code scenarios or busy and hectic clinical environments could be recorded in this manner and then replayed for a group of learners even using their own device to allow focus on the individual roles, team dynamics, and communication in a manner not possible with simple single point of view video recording.

Moulage

Moulage is the use of different cosmetic and modeling techniques to create a physical appearance that replicates a specific medical condition and presentation [5]. Moulage may include painted or powdered makeup to change skin's appearance, the application of a prosthesis to create or enhance physical findings, or the use of improvised devices to create the visual manifestation of certain conditions. It can be done inexpensively and simply, depending on what effect is being created. For example, a combination of purple, blue, red, and black cosmetics blended properly can create a "bruise," or a simple line drawn in natural tones can create an old scar

on the skin of a manikin or standardized patient. The use of props in moulage can add additional realism, such as when an improvised tracheostomy is placed on a simulated patient. No matter the moulage method or intended effect, adding moulage to a simulated learning scenario provides learners with physical manifestations to locate and observe during a simulated examination. Upon doing so, they should ask more probing questions about their patient's history or condition. This creates an opportunity to reinforce the actual examination rather than cursory or vocalized examinations. However, it is better to not employ moulage at all than create an unfinished or unrealistic effect. If done poorly, moulage can ruin the realism of a scenario or give learners inappropriate reference points when examining future patients because it does not accurately represent the condition presented.

Auditory Simulation

Auditory simulation is the art of using sounds to immerse the learners in the care environment being simulated. Examples of auditory simulation may include the beeping of monitors, alarms from various medical equipment, traffic sounds, hospital overhead paging systems, or even battlefield, helicopter, or ambulance noises. Auditory simulation is an important part of creating a high-fidelity simulation environment that can help learners adapt to some of the distractions that may exist in their care areas. However, if students are not yet at a level that can accept distraction while learning, auditory simulation can also introduce undue stress that may steer them away from desired objectives. Audio simulations can also be used to educate providers and develop empathy for patients who experience auditory hallucinations such as in schizophrenia or other psychiatric disorders [31, 32].

Visual Simulation

Visual simulation, beyond the inherently visual elements of almost every simulation methodology, is the addition of visual components that immerse learners in provider environments with the advantage of becoming accustomed to using some of the visual tools that are often found in care environments, such as treatment algorithms, medication calculations, anatomy posters, phone lists, and call sheets. While visual enhancements add to the enhanced fidelity of patient care environments, they can be overwhelming to entry-level learners or may inadvertently lead learners to think they are being given clues to their patient's condition. Therefore, the objectives and learners for each simulation need to be considered when determining additional visuals.

Olfactory Simulation

When approaching the highest levels of simulated fidelity, offering smells consistent with the care area and the patient condition can create essential elements of realism [33]. There are many low-cost ways to simulate smells related to the care areas and to certain patient conditions, allowing for easy inclusion into a scenario.

For example, olfactory simulation may be something as simple as using a particular cleaner that is often used in care areas or may be as involved as creating the peculiar burnt almond smell of gas gangrene. There are even some companies that specialize in creating commercial-grade smell sprays for medical simulation use. However, olfactory simulation can be hard to achieve when looking for particular simulation-specific smells. Some smells are also hard to keep "fresh" and may dissipate rapidly. This makes it difficult to appropriately maintain for future patient scenarios. Certain smells are sometimes difficult to clear out of a space when resetting for a different scenario. Further, since smells easily spread to neighboring workspaces, consider those in the surrounding area. As always any added sensory stimulus or prompt should enhance the educational or learning objective of the case.

Audiovisual Equipment

Audiovisual equipment is an important adjunct to simulation that allows for the recording and reviewing of a simulation scenario. Audiovisual systems could be installed systems, portable systems designed specifically for simulation, or something as simple as web cameras or chat applications to observe and record remotely. If a visual recording shows a learner performing or not performing a certain intervention or exam, what has or has not taken place is clear. Therefore, audiovisual equipment has the advantage of being incredibly low on bias when being used for debriefing, for resolving any contested performances, or for providing expert modeling of a procedure or skill. This can be an integral part of scaffolding learner education and helping build capable and reflective practitioners. Unfortunately, audiovisual equipment is often expensive with needs for ongoing support and maintenance. As a learning tool, sometimes facilitators make the mistake of relying on video review when a more interactive method of debriefing may be more appropriate.

Hybrid Simulation

Hybrid simulation is the combination of two or more different simulation methodologies to create a desired scenario. Most commonly this is seen as a mix of task trainers with manikins or standardized patients. An advantage of hybrid simulation is the ability to tailor to specific objectives with the flexibility to engage expensive high-fidelity, high-technology manikin features at a lower overall cost. This allows for programs to provide high-fidelity experiences without the large upfront cost of an individual or special use full-body manikin. Therefore, hybrid simulation has many applications when educators who enter into more complex care scenarios require the portrayal capabilities of multiple methodologies, such as multiple task trainers being used to supplement several different skills in a manikin or standardized patient based scenario. However, if implemented poorly, this methodology can lower a simulation's fidelity by requiring a greater suspension of disbelief on the part of the learner. Further, ineffectively designed hybrid simulations can add a level of complexity to the

"simulation logistics" that require the learner to adapt to particular circumstances in training which may not exist in practice. Some hybrid simulation systems are sold as a unit incorporating degrees of virtual simulation with task trainers. This allows for a more realistic tactile experience when performing certain invasive procedures.

Conclusion

A nearly endless number of simulation tools exist, from full-body patient simulators to task trainers of specific body parts, computerized virtual reality training scenarios to tabletop case-based roleplaying exercises, and real and simulated instruments and clinical care tools. No one device or concept is better than any other. The final benefit of each is related to the educational need, the cost and budgeting constraints of the system, and most importantly, the design and implementation into the training environment. Knowing what tools are available and what they can and cannot do will help the simulation program to make the most efficient and effective decisions about how to design and run an educational session.

References

1. Durant W. Story of philosophy. New York: Simon and Schuster; 1961.
2. Cook DA, Hamstra SJ, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Comparative effectiveness of instructional design features in simulation-based education: systematic review and meta-analysis. Med Teach. 2013;35(1):e867–98.
3. McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003–2009. Med Educ. 2010;44(1):50–63.
4. INACSL-Standards-Committee. INACSL standards of best practice: simulation operations. Clin Simul Nurs. 2017;13(12):681–7.
5. Lopreiato JO. Healthcare Simulation Dictionary. Rockville: Agency for Healthcare Research and Quality; 2016.
6. Rehmann AJ, Mitman RD, Reynolds MC. A handbook of flight simulation fidelity requirements for human factors research. Dayton: Crew System Ergonomics Information Analysis Center Wright-Patterson AFB OH; 1995.
7. Beaubien JM, Baker DP. The use of simulation for training teamwork skills in health care: how low can you go? BMJ Qual Saf. 2004;13(suppl 1):i51–6.
8. Schoenherr JR, Hamstra SJ. Beyond fidelity: deconstructing the seductive simplicity of fidelity in simulator-based education in the health care professions. Simul Healthc. 2017;12(2):117–23.
9. Muckler VC. Exploring suspension of disbelief during simulation-based learning. Clin Simul Nurs. 2017;13(1):3–9.
10. Dwyer T, Searl KR, McAllister M, Guerin M, Friel D. Advanced life simulation: high-fidelity simulation without the high technology. Nurse Educ Pract. 2015;15(6):430–6.
11. Cohen SR, Cragin L, Rizk M, Hanberg A, Walker DM. PartoPantsTM: the high-fidelity, low-tech birth simulator. Clin Simul Nurs. 2011;7(1):e11–8.
12. Laerdal. Important Product Information SimMan Classic, ALS Skillmaster 4000 and ALS SkillTrainer 200 June 4, 2018. Available from: https://www.laerdal.com/gb/docid/49382374/Important-Product-Information-SimMan-Classic-ALS-Skillmaster-4000-and-ALS-SkillTrainer

13. Chiniara G, Cole G, Brisbin K, Huffman D, Cragg B, Lamacchia M, et al. Simulation in healthcare: a taxonomy and a conceptual framework for instructional design and media selection. Med Teach. 2013;35(8):e1380–95.
14. Bowman SL, Standiford A. Enhancing healthcare simulations and beyond: immersion theory and practice. Int J Role-Play. 2016;6:12–9.
15. Barrows HS. An overview of the uses of standardized patients for teaching and evaluating clinical skills. Acad Med. 1993;68:443.
16. Clapper TC. Role play and simulation. Educ Dig. 2010;75(8):39.
17. Adam Blatner M. Role playing in education. Retrieved December 2009;30:2009.
18. Westerville EC. Role playing: an educational technique. Marriage Fam Living. 1958;20(1):78–80.
19. Haigh C, Hardy P. Tell me a story – a conceptual exploration of storytelling in healthcare education. Nurse Educ Today. 2011;31(4):408–11.
20. Srinivasan M, Wilkes M, Stevenson F, Nguyen T, Slavin S. Comparing problem-based learning with case-based learning: effects of a major curricular shift at two institutions. Acad Med. 2007;82(1):74–82.
21. Thistlethwaite JE, Davies D, Ekeocha S, Kidd JM, MacDougall C, Matthews P, et al. The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME guide no. 23. Med Teach. 2012;34(6):e421–44.
22. Bianchi L, Gallagher EJ, Korte R, Ham HP. Interexaminer agreement on the American Board of Emergency Medicine oral certification examination. Ann Emerg Med. 2003;41(6):859–64.
23. Susi T, Johannesson M, Backlund P. Serious games: an overview. Skövde: Institutionen för kommunikation och information; 2007.
24. Marescaux J, Clément J-M, Tassetti V, Koehl C, Cotin S, Russier Y, et al. Virtual reality applied to hepatic surgery simulation: the next revolution. Ann Surg. 1998;228(5):627.
25. Reznek M, Harter P, Krummel T. Virtual reality and simulation: training the future emergency physician. Acad Emerg Med. 2002;9(1):78–87.
26. Székely G, Satava RM. Virtual reality in medicine. BMJ. 1999;319(7220):1305.
27. Vallino JR, Brown CM. Interactive augmented reality. University of Rochester, Department of Computer Science; 1998.
28. Basdogan C, De S, Kim J, Muniyandi M, Kim H, Srinivasan MA. Haptics in minimally invasive surgical simulation and training. IEEE Comput Graph Appl. 2004;24(2):56–64.
29. Ohyama S, Nishiike S, Watanabe H, Matsuoka K, Akizuki H, Takeda N, et al. Autonomic responses during motion sickness induced by virtual reality. Auris Nasus Larynx. 2007;34(3):303–6.
30. Lee H, Tateyama Y, Ogi T, editors. Realistic visual environment for immersive projection display system. Virtual Systems and Multimedia (VSMM), 2010 16th international conference on, IEEE; 2010.
31. Yellowlees PM, Cook JN. Education about hallucinations using an internet virtual reality system: a qualitative survey. Acad Psychiatry. 2006;30(6):534–9.
32. Sideras S, McKenzie G, Noone J, Dieckmann N, Allen TL. Impact of a simulation on nursing students' attitudes toward schizophrenia. Clin Simul Nurs. 2015;11(2):134–41.
33. Kent SJW, Kent FH, Brown CW, Morrison IG, Morse JC. Should we add smells in simulation training? A systematic review of smells in healthcare-related simulation training. BMJ. 2016;2(1):19–22.

Simulation Center Personnel

4

Pamela Andreatta

Introduction

There are many types of simulation centers and the staffing required to optimally support the mission of any center will largely depend on its size, diversity of users, educational aims, institutional goals, and funding model [1–8]. Simulation centers may be privately or publically funded; non-profit or for profit; unaffiliated (independent) or affiliated with a hospital, medical center, university, institutional department, commercial enterprise, governmental or non-governmental agency. Simulation centers may range from small, discipline-specific initiatives within a department to large national and international enterprises that support all aspects of ability development, research, and credentialing in clinical, surgical, team, logistical, and operations performance domains. Although less comprehensive than large-scale multidisciplinary centers with broad scope, small centers – such as those with surgical trainers situated in a call room or airway and line placement trainers organized in a patient bay for use by clinicians on an ad hoc basis – still require personnel to support their successful uptake and impact. This chapter will address the personnel requirements for simulation centers of all forms, with indications for which roles are essential and which roles are flexible for small- and medium-sized centers.

There are three personnel roles that all centers will need, regardless of their size: designated executive administration (e.g., executive director, director, manager, etc.); technical operations support (e.g., coordinator, technologist, technician, etc.); and educational assistance (e.g., instructors, trainers, facilitators, etc.). The responsibilities for these roles (and others) are delineated further in

P. Andreatta (✉)
Institute for Simulation and Training, University of Central Florida College of Medicine, Orlando, FL, USA

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_4

this chapter; however they collectively serve to cover the managerial and administrative considerations, technology and operational management tasks, and instructional and training efforts for the simulation programs a center supports. Larger centers will likely require these primary roles to be subdivided into more discrete functions, especially if the center supports multidisciplinary programs and further still if it supports interdisciplinary programs across specialties and institutions.

The scale and scope of technology implementation in a simulation center will determine the degree of expertise and extent of support required to adequately integrate and leverage technological capabilities to greatest effect [7]. This is especially important to consider given the rapid development of foundational simulation technologies, such as human patient manikins and computer-driven surgical trainers, but also supporting technologies such as integrated audio-video hardware and software systems designed to enhance training and debriefing events. Virtual reality applications and augmented reality systems require specific skill sets, as do 3-D printing systems that are changing the way simulation facilitates both procedural and task training. It is essential to minimally consider, and optimally project, the technological needs of current and future simulation programs when determining the personnel requirements for a center.

Ultimately, the number of personnel and the distribution of their qualifications will depend on the mission and scope of the simulation programs that will be supported by the center, the expectations of the center's stakeholders, and the funding model that underwrites the foundational expenditures for its operations [8]. Therefore, before hiring staff for a center, it is important to determine the center's short-, medium-, and long-term goals so that a strategy is developed for assuring optimal personnel coverage within the fiscal constraints of a center's operational budget. There are several important considerations for determining staffing requirements, including whether the needs and budget of the center require full-time, part-time, contract, or ad hoc volunteers to meet the job functions. Establishing the work scope and effort requirements for center operations will help determine whether cross-training personnel to perform multiple roles is an option, or whether deep expertise is required to fulfill particular responsibilities. Clarifying administrative, financial, and operational management work allocations, as well as any marketing efforts required to promote the center, will help determine if these personnel should be employed by the center, shared with other institutional groups, or contracted on an as-needed basis.

The primary aim of staffing a simulation center is to provide the expertise and personnel necessary to meet the mission and objectives of the center's stakeholders. It is imperative for these to be delineated and carefully considered early in the planning stages, before hiring personnel, designing space, and purchasing equipment. This will assure the best possible approach to staffing to meet a center's overall goals within its operational and budgetary resources. It is important to note that simulation center personnel may function in multiple capacities and share the responsibilities of many roles.

Personnel

Executive

Executive Director

The executive director role may alternately be referred to as director, administrative director, or similar. He or she is ultimately responsible and accountable for the decisions associated with center operations and how they meet its established mission and objectives. The executive director will coordinate and communicate with the center's stakeholders, as well as with external agencies and professional organizations to assure the center aligns with, and contributes to, best practices in simulation-supported training, instruction, assessment, and research. The executive director will help establish and oversee policies and procedures for the center. He or she will also assure that any requirements for accreditations, certifications, credentialing, and regulations are met, documented, and distributed as necessary. Most executive directors either oversee the financial management of the center, or perform those functions as part of their role. At minimum, the executive director will authorize procurements, align expenditures with budgets, and prepare an annual report of center activities and expenditures for all stakeholders. Financial management may also include fundraising activities, grantsmanship, negotiating service contracts with potential clients and industry partners, and participating in institutional philanthropic efforts. Many executive directors also participate in community engagement and outreach activities, such as tours, open houses, ceremonies, and speakerships at healthcare events. Executive directors will likely manage the professional personnel associated with the center. If the center has a steering committee, the executive director may chair that committee.

Steering Committee

Simulation centers support a wide variety of missions and objectives; however they all have constituent stakeholders who are committed in one form or another to their success. Although not considered center staff, a steering committee comprised of decision-makers, influential stakeholders, and relevant institutional executives is critical to the ongoing success of any simulation center. These personnel provide guidance on overall strategic direction, program development, resource allocation, budgeting and staffing recommendations, and procurement decisions. The composition of the steering committee may include designated representatives from constituent groups, senior administrative and financial leadership, chairpersons of specialty departments or disciplines, patient safety or risk management executives, community members, industry partners, and others with significant interest and valuable expertise pertinent to the center's operations. Simulation center steering committees are often chaired by the center's executive director but may also be chaired by another decision-maker within the organization, such as a risk management officer, clinical affairs executive, or dean of medical or nursing education.

Education

Education Director

Most simulation centers support one or more aspects of education, whether they be the acquisition of foundational knowledge, development of mastery in clinical and surgical skills, teamwork and communication, or maintenance of those abilities once acquired. An education director is essential for assessing instructional needs, developing learning objectives, determining instructional strategies, and integrating those strategies into existing curricula. Education directors collaborate closely with the educators to design instructional events, sequences, and activities, and to specify requisite equipment and supplies for implementation. Many simulation center education directors work closely with their peers in nursing education and medical education in academic and hospital contexts. They might also collaborate closely with the education departments of medical and surgical device companies and other industry partners. Other simulation education directors may work closely with the healthcare education arms of governmental and non-governmental organizations. All will support the educational aims of their specific simulation center. Simulation center education directors will likely have an advanced degree in educational leadership, instructional design, educational psychology, teaching and learning, or similar. Although a foundational understanding of healthcare is helpful, expertise in human learning and strategies for developing mastery performance in individuals and teams is essential, as is the ability to collaborate closely with clinical and surgical educators and other subject matter experts. If the center is large enough to support full-time educators, assessors, or debriefing facilitators, the education director will likely be responsible for managing those staff.

Educator

Educators – who may also be referred to as faculty, trainers, instructors, or facilitators – are an essential component to successful simulation centers. Educators may be in full-time staff positions, but more often they are part-time and even ad hoc personnel with applied expertise in a given clinical, surgical, or health professions domain. Educators primarily facilitate instruction during simulated events, which might also include operational management of simulators and facilitation of debriefing activities following a simulated event. Educators may support the development of simulated scenarios; selection of modalities for simulated activities; and the design requirements for models, moulage, and other accouterments to increase a simulation's fidelity. Educators work closely with the operational staff to assure the authenticity of the activities relative to the real targeted healthcare environment. Educators often serve as liaisons with applied practice groups, which helps inform the need for specific simulation-supported training, assessment, or development efforts.

Assessors

The uses of simulation-supported assessment continue to grow, and its applications in high-stakes evaluations require assessment specialists [9–11]. Assessors are

highly trained professionals who design, develop, or implement assessment instrumentation designed to measure performance in simulated and applied clinical, surgical, and health professions contexts. Like educators, assessors may inform the modality and fidelity requirements for simulation-supported assessment events. They will also liaise with stakeholders associated with determining performance criteria, credentialing, regulatory, and certification requirements. Although assessors may have expertise in the performance domain they are assessing, it is critical that they have a deep understanding of performance measurement, instrumentation, and associated data management systems. Assessors will likely have advanced degrees in human factors, neuroscience, educational psychology, or cognitive science.

Debriefing Facilitator

Debriefing facilitators support the critical role of debriefing after a simulated training event that typically includes interdisciplinary team management of manikin-facilitated patient care [12]. These may be emergent, urgent, or general patient care activities wherein clinicians from multidisciplinary specialties coordinate their actions to diagnose, treat, and stabilize patients, who are represented by manikin simulators or standardized patients. Debriefing staff may include the educators tasked with supporting a simulation event, or they may be staff designated to facilitate the debriefing event itself. Debriefing personnel should be well versed in debriefing principles and methodologies, as well as the foundational requirements for clinical and patient management associated with the simulated event. As such, clinical experience in the domain of interest is highly desirable for debriefing personnel. However, this function may also be supported by clinical personnel working collaboratively with experts specializing in facilitation and debriefing strategies.

Standardized Patient Coordinator

The education director may oversee the integration of standardized patient programs within a center; however if the program is large or routinely active, this effort may require the addition of a standardized patient coordinator [13]. Standardized patient coordinators organize events associated with standardized patients, including their implementation for research, training, and assessment. This includes the identification, recruitment, training, and in some circumstances credentialing of standardized patients for simulated events. Standardized patient events may include training, research, or assessment activities, all of which require definition of designated patient roles and recruitment of personnel to fulfill the role responsibilities of the designated patients. If the scope of a standardized patient program is especially large, the center may have a standardized patient director to manage these functions with the support of one or more coordinators.

Content Experts

Content experts are highly experienced and educated professionals with deep understanding of a performance construct of interest. For surgical domains, these would be surgeons with patient expertise in their specialty. For critical care, these would be

physicians and nurses with substantial indisputable knowledge and demonstrable abilities. For performance assessment, these would be psychometricians with definitive expertise in measuring performance attributes in a performance domain. Content experts are indispensable for simulation center functions but are typically associated with consultancies or ad hoc utilization for a specific programmatic or functional need. Although they are valuable in the contextual realm for which they are employed, they are largely associated with design and development efforts rather than ongoing implementation of simulation-based activities.

Operations and Technical Support

Simulation center operations and technical support functions are largely provided by healthcare simulation technology specialists (HSTS). These specialists often serve multiple functional roles and require diverse skill sets, depending on the breadth of practice and needs of the simulation center itself. Although it is desirable to have a team of HSTS personnel working collaboratively to meet the operational and functional needs of an active simulation center, many centers are only supported by a few individuals with the capacity to perform all of these roles. This chapter focuses on the role categories associated with operational and functional requirements for a simulation center, while recognizing that there may be a substantial gap between the requirements for a large, multi-site, multi-specialty simulation center, and those for a small, single-site, single-specialty center. This topic is further addressed in Chap. 10 of this text.

Operations Director

The role of operations director is one of the most critical in any simulation center. Larger simulation centers, and those with a multidisciplinary scope, will almost certainly require an operations director to organize activities, serve as liaison between the center's executive leadership and operations staff, implement administrative and operational decisions, and direct facilities management functions. An operations director will coordinate schedules for center functions, equipment usage, personnel support, procurement and purchasing, and logistical considerations associated with instruction, assessment, research, tours, meetings, and other events deemed necessary by the center's stakeholders. If the center supports simulation events that occur outside the boundaries of the center itself, such as within clinical settings or field operations, the operations director will also be responsible for managing logistical considerations for those activities. Operations directors will track expenditures, oversee procurement, manage stocking and inventories, and determine cost structures for space utilization, equipment usage, and off-hours staffing support. He or she will manage rental agreements, service and maintenance contracts, and vendor relationships with instrument and equipment suppliers.

Typically operations directors will oversee a center's operations staff, including coordinators, technicians, technologists, modelers, and administrative assistants who may aid in tasks associated with an operations director's responsibilities [14].

For larger centers, this may include assuming an ancillary role with a human resources department to assure that center operations are in compliance with institutional policies, procedures, and regulations for employment, compensation, time off, and health and safety assurances. This is especially important if a center hires or coordinates with unionized personnel, who often have additional contractual requirements. Operations directors are typically responsible for scheduling personnel, which may in and of itself be a significant level of effort for a large center staffed by part-time and occasional personnel, especially if there are organizational overtime restrictions. Operations directors may have healthcare experience, but they will surely require education and experience in business operations and financial management.

Coordinator/Manager

Larger centers and those that manage multiple multidisciplinary and interdisciplinary programs will likely require one or more coordinators – alternately referred to as managers – to manage daily operations. Coordinators are highly experienced managers who have excellent time management skills, technical expertise, and the ability to work across disciplines with creativity, patience, and insight, frequently under pressure. They typically manage access to facilities, equipment, supplies, and in some situations logistics associated with transport to in situ clinical spaces, surgical theater, or field sites. Coordinators work with operations directors to maintain accurate utilization records, financial ledgers and procurement transactions, inventory and accounting records, and equipment maintenance contracts. Coordinators will typically maintain schedules for center utilization and in some centers may oversee staffing of specific program areas. They often serve as liaisons between other operational staff and the operations director and frequently are able to provide cross coverage in performing multiple roles within center operations when necessary.

Information Technologist

The core functions of most simulation center activities revolve around an integrated, robust, and reliable information technology (IT) infrastructure. Information technologists are professionals with expertise in defining, specifying, establishing, maintaining, and upgrading the core IT equipment and services. These individuals facilitate the coordinated implementation of computerized simulators, audio-video systems, data capture and assessment instrumentation, integration of ancillary equipment outputs (e.g., fluoroscopy, anesthesia machines), streaming services between rooms and off-site locations, projection and presentations systems, mobile device support, and other technologies as they arise to support the center's mission and objectives. If the center conducts research, the information technologist will also be responsible for assuring the integrity and security of data, as well as subject identity and privacy controls. IT staff will collaborate with almost every constituent stakeholder of a simulation center, and therefore, in addition to technical expertise, they should have the ability to communicate effectively with individuals from multiple disciplines, even if those individuals are not technologically proficient.

Simulation Technologist

Simulation technologists are specialists who program, set up, and operate simulation equipment for use during simulated events. These personnel are critical for centers with a wide variety of high-technology simulation equipment, such as human patient manikins, computer-based surgical trainers with haptic feedback interfaces and advanced 3-D graphics, virtual and augmented reality systems, computer-supported task trainers, mobile and field-situated simulation events, and immersive environments such as a cave automatic virtual reality environment (CAVE). The simulation technologist will program manikins and software controls for other educators, troubleshoot simulators that are not operating as expected, perform simulator maintenance, install software updates, and coordinate with information technologists to assure connectivity of simulators and clinical equipment with a center's IT infrastructure. Simulation technologists will prepare and implement resources for a center's events so that they are supported by necessary simulation and medical equipment (e.g., operating room lighting, anesthesia machine, etc.), equipment integration (as necessary), functional software systems that are aligned and tested for the intended purpose, and a contextually accurate environment to assure the realism of activities.

Control Room Technician

Control room technicians are vital to the successful implementation of simulated events, especially those that include clinical management of manikin and standardized patients, and team-based scenarios. These events often require remote management of simulators, as well as operational management of audio, video, documentation, and streaming equipment and software. Control room technicians will operate video and audio capture from a variety of feeds (ceiling-mounted cameras, local and head-worn cameras, lapel microphones, localized microphones, etc.) and may distribute the feeds to adjacent rooms or networked locations. They will also record inputs for debriefing, data collection, or archival purposes. Many control room technicians provide media editing and annotation service. They may also distribute media during events (e.g., diagnostic imaging) and may serve or coordinate the role of a speaking manikin. Control room technicians will monitor connectivity and the integrity of recordings through simulated events. They will likely assist in the setup and testing of the simulated environment to assure its functionality, security, integrity, and reliability. They may also make recommendations for the specifications and positioning of audio, video, and other imaging capture devices, as well as media storage and editing software.

Simulation Technician

Implementation of activities and events within a simulation center requires ongoing coordination, setup, implementation, takedown, and maintenance of facilities, equipment, and supplies. Simulation technicians facilitate activities and events by managing inventory and availability of beds, gurneys, chairs, tables, lighting, scrub sinks, curtains/dividers, linens and gowns, clinical equipment

(e.g., 12-lead ECG, laryngoscope), clinical and surgical instruments (e.g., scalpels, forceps), medical supplies (e.g., catheters kits, gloves, gauze), and simulated treatments (e.g., medications, fluids, oxygen). They will set up and verify the configuration and operation of equipment and resources to be used during planned activities, and likely collaborate with educators and other staff to test the feasibility of protocols or scripts when events are developed. Often simulation technicians will help orient new users to the simulation spaces by informing them what they can expect from the simulators, how the simulators function, what they are able and unable to do with the simulators, and where they will find the resources they need for their work. During events, simulation technicians may provide resources (e.g., central line kit), operate ancillary equipment (e.g., fluoroscopy), or serve as ancillary clinical support personnel (e.g., lab services). They will coordinate with control room technicians to assure the activities and events flow as planned or troubleshoot and remedy any problems that occur. Simulation technicians handle the deconstruction and cleanup after events, including safe management of sharps and biohazards, waste disposal, laundry, resetting facilities, cleaning and restocking reusable resources, and determining inventory that requires procurement for future events. They will also perform routine cleaning and maintenance of simulators and equipment after use, and alert operations management of any problems that require professional maintenance or repairs.

Developers/Modelers

Developers and modelers are engineers, computer scientists, and master craftsmen who work to design and create accessory adjuncts that enhance the realism of simulated contexts. They may develop anything from patient-specific virtual reality systems to customized moulage for manikins or standardized patient applications; from 3-D printed models with nano-sensor measurement systems to artificial intelligence-supported augmented reality platforms; and more. If a center supports work in highly specialized areas, they may require staff to design, develop, and produce detailed simulation models, environments, or measurement devices to fulfill their aims [15]. Developers and modelers will collaborate closely with subject matter experts, researchers, educators, and assessors, depending on the specific efforts they support.

Administrative Assistants

A large center or one that conducts a significant amount of outreach or engagement with external constituents may employ administrative assistants or clerks to provide support where needed, such as greeting visitors, escorting tours, managing sign-in processes, distributing information, ordering refreshments, preparing rooms and common areas for utilization, and handling administrative tasks as needed. Busy centers may require full-time administrative assistants; however, part-time staff, job-sharing, ad hoc personnel, and volunteers, especially students and retired health professionals who are interested in healthcare simulation, easily support this role.

Clinical

Director(s): Medical, Surgical, Nursing, and Health Professions

Given that simulation centers support human performance associated with the provision of clinical, surgical, and health professions care, it is imperative to have one or more directors with expertise in the requisite health services for ongoing consultation, strategic planning, and formulation of best practices that transfer to applied practice. They are also important contributors to curriculum and instructional planning, especially if instructional activities include plans to utilize cadaveric specimens, animal models, or standardized patients [13, 16]. Clinical and surgical accuracy is paramount to developing and implementing simulation-supported curricula, and the more applied expertise the clinical directors have in their respective disciplines, the more likely they will be able to provide exemplary guidance in formulating simulated contexts that develop transferable abilities to applied situations. Clinical director positions may be formal or informal, shared between several individuals or designated as a full-time role. The staffing configuration will largely depend on how best to meet the needs of the center's stakeholders while maintaining adherence to a budget. Although these directors are a critical component of successful simulation centers, they are also quite expensive relative to other personnel, and it is therefore challenging to retain them on a full-time, consistent basis. Despite this challenge, simulation centers largely focus on developing the abilities of health service providers, and therefore this expertise is an indispensable part of center staffing.

Research

Director

If a simulation center intends to conduct research, a research director will be instrumental in managing the associated regulatory requirements, processes, protocols, monitoring, documentation, and data management systems. In addition to institutional review board (IRB) administration requirements, a center's research may require adherence with regulations from the FDA, DoD, DOE, Joint Commission, specialty boards, or other organizations with legal or governmental oversight authority. In addition to experience with research administration, research directors should have a deep understanding of qualitative and quantitative research methods, data collection methodologies, data management systems, research reporting, and grantsmanship. Research directors will also require expertise in determining the level of fidelity required to support specific simulation research objectives and may collaborate with subject matter experts, assessors, educators, IT staff, and relevant technologists within the simulation center to determine optimal strategies for assuring successful research outcomes. In addition to collaborating with external researchers and research coordinators who use the simulation center for their projects, a research director may develop a program of research for the center itself. Whether supporting the research of others or a

center's own program, a research director will oversee the activities of research assistants performing their work within the simulation center. The research director will also liaise with research investigators to manage challenges that arise as a result of research activities within the center, such as breeches to protocol, security, or data integrity.

Research Assistants

Research assistants may be employed by a simulation center directly; however they are more frequently associated with a specific research project supported by the center's facilities and equipment. Research assistants handle administrative tasks, such as greeting, briefing, securing subject information, managing consent processes, distributing and accounting for subject compensation, and completing documentation. They are also responsible for assuring data collection, integrity, and security in adherence with specified protocols.

Summary

Simulation centers may have diverse scope and serve numerous and wide varieties of stakeholders, all of which will influence the requirements for staffing center operations. These requirements may change over time, increasing or decreasing, or shifting entirely as the center's mission expands, contracts, or otherwise transforms from one focus to another. It is important to periodically review personnel requirements, resources, and staffing allocations to assure that the center's operations remain aligned with its mission and objectives. Involving a steering committee of stakeholders in these decisions is essential to assure an alignment between a center's contributions and the needs of its community of practice. Determining the roles and responsibilities associated with the center's mission and goals will serve to align the need for specific personnel with requirements for resource allocations, minimizing excessive or extraneous costs that could undermine long-term success of a center. Careful and deliberate staffing decisions demonstrate a commitment to overall excellence that ultimately benefits a simulation center and its stakeholders over time, through strong return on investment outcomes.

References

1. Heinrichs W. Running simulation centres: the academic and the private (commercial) approach. Simul Healthc. 2006;1(3):188.
2. Huang GC, Sacks H, DeVita M, Reynolds R, Gammon W, Saleh M, et al. Characteristics of simulation activities at North American medical schools and teaching hospitals: an AAMC-SSH-ASPE-AACN collaboration. Simul Healthc. 2012;7(6):329–33.
3. Tuoriniemi P, Schott-Baer D. Implementing a high-fidelity simulation program in a community college setting. Nurs Educ Perspect. 2008;29(2):105–9.
4. Kobayashi L, Shapiro MJ, Sucov A, Woolard R, Boss RM, Dunbar J, et al. Portable advanced medical simulation for new emergency department testing and orientation. Acad Emerg Med. 2006;13(6):691–5.

5. Edler AA, Chen M, Honkanen A, Hackel A, Golianu B. Affordable simulation for small-scale training and assessment. Simul Healthc. 2010;5(2):112–5.
6. Shaikh FM, Hseino H, Hill AD, Kavanagh E, Traynor O. Mobile surgical skills education unit: a new concept in surgical training. Simul Healthc. 2011;6(4):226–30.
7. Qayumi K, Pachev G, Zheng B, Ziv A, Koval V, Badiei S, et al. Status of simulation in health care education: an international survey. Adv Med Educ Pract. 2014;5:457.
8. Scerbo MW, Murray WB, Alinier G, Antonius T, Caird J, Stricker E, et al. A path to better healthcare simulation systems: leveraging the integrated systems design approach. Simul Healthc. 2011;6(7):S20–S3.
9. Michelson JD, Manning L. Competency assessment in simulation-based procedural education. Am J Surg. 2008;196(4):609–15.
10. Geis GL, Pio B, Pendergrass TL, Moyer MR, Patterson MD. Simulation to assess the safety of new healthcare teams and new facilities. Simul Healthc. 2011;6(3):125–33.
11. Moorthy K, Munz Y, Adams S, Pandey V, Darzi A. A human factors analysis of technical and team skills among surgical trainees during procedural simulations in a simulated operating theatre. Ann Surg. 2005;242(5):631.
12. Dismukes RK, Gaba DM, Howard SK. So many roads: facilitated debriefing in healthcare. Simul Healthc. 2006;1(1):23–5.
13. Pascucci RC, Weinstock PH, O'Connor BE, Fancy KM, Meyer EC. Integrating actors into a simulation program: a primer. Simul Healthc. 2014;9(2):120–6.
14. Bailey R, Taylor RG, FitzGerald MR, Kerrey BT, LeMaster T, Geis GL. Defining the simulation technician role: results of a survey-based study. Simul Healthc. 2015;10(5):283–7.
15. Foot C, Host D, Campher D, Tomczak L, Ziegenfuss M, Cohen J, et al. Moulage in high-fidelity simulation – a chest wall burn escharotomy model for visual realism and as an educational tool. Simul Healthc. 2008;3(3):1–5.
16. Walsh RM, Bothwell JD. Simulated angioedema in a fresh frozen cadaver: a novel teaching model for airway training. Simul Healthc. 2015;10(6):378–80.

Finding the Right Simulation Personnel

5

Wendy Z. Thomson

Introduction

The healthcare industry today is quite financially volatile with rapid changes in reimbursements both from private and government sectors that impact their ability to generate a profit. The cost from the point of identifying the need to hire an employee until that person is fully functioning in a productive role can cost an organization from 21% to more than one time an annual salary thus making the selection of the right person for the job extremely important [1]. For healthcare organizations to thrive in today's economy, finding and retaining the best employees is important, especially when competing with larger organizations with larger budgets for top talent. When considering the fact that simulation-based education and training is mostly a nonrevenue-generating program with a clear cost that impacts profits, it must be asked how can healthcare organizations find the right talent for simulation-based education and training roles. Pató (2016) stated "the right employee with the right competences in the right conditions, in the right place, in the right time, at the right cost, at the right employer can bring competitiveness to the company" [2]. Finding, selecting, and onboarding simulation personnel is no easy process, and finding someone with the right skills and qualifications should be a long-term strategy that can be tied to facility performance metrics and improved patient outcomes. How does an organization address finding the right person for simulation-based education when there are few educational pathways to identify and no standardized set of competencies to create a job description? To answer this question, a simulation center must begin by being deliberate, thoughtful, and clear on the who, what, and why of hiring simulation specialized personnel.

W. Z. Thomson (✉)
VA Rocky Mountain Regional Medical Center, Aurora, CO, USA

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_5

Organizational Structure

Staffing a simulation program is no easy task. Simulation programs, large and small, can achieve greater productivity and reach their strategic goals and outcomes by properly matching an organizational structure to their mission, vision, and programmatic needs. An organizational structure delineates lines of communication, policies, authority, and responsibilities. Creating an appropriate organizational and simulation structure and function demonstrates how the roles, power, and responsibilities are assigned, controlled, and coordinated and how information will flow within the organization. If a simulation program resides within a larger organization, then all operational activities including reporting structures and strategic plans and goal will fall within that larger organization's business model. Therefore, it is also important to consider the needs of the larger organization when defining the required roles and job positions that will support the simulation program. If there is not yet an established structure, then it is recommended to review the organizational infrastructure of other simulation centers to identify potential ways to determine expected simulation roles and responsibilities.

At its highest level, an organizational structure is either centralized or decentralized [3]. Most commonly used is the centralized leadership model where there is a defined chain of command. Centralized systems have a hierarchical structure where employees are at various levels within the organization and each level is tiered, one above the other. There is no confusion in hierarchical structure as there are superiors and subordinates with authority and responsibilities that are clearly defined flowing from the top down.

The centralized organization is broken up based on the specialization of its workforce into departments (Fig. 5.1). It is a pyramid shape that is very organized with a high degree of formality in routines, rules, and procedures designed for efficiency, but may do so at the expense of innovation [3, 4].

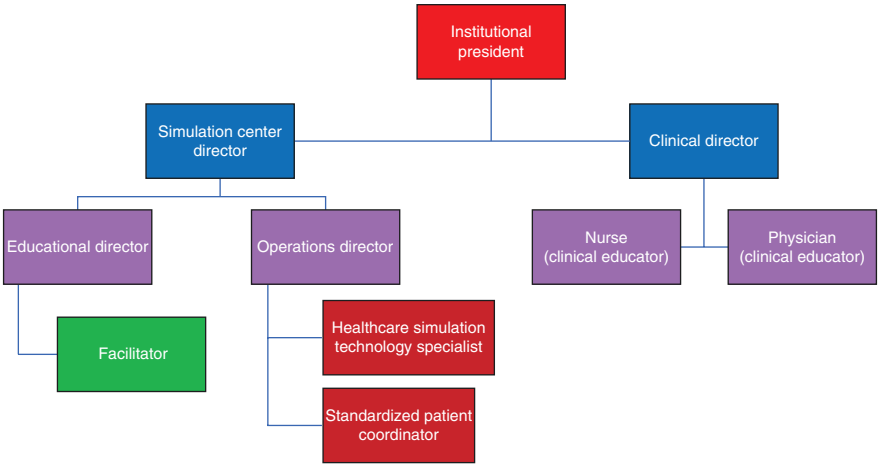


Fig. 5.1 Example organizational chart demonstrating a hierarchical structure

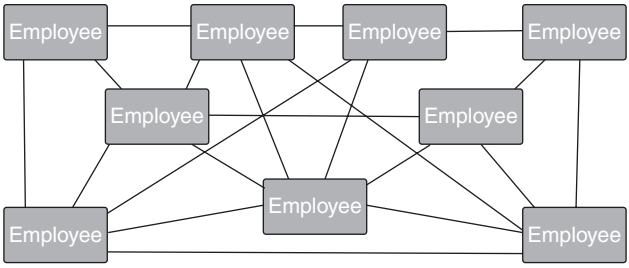


Fig. 5.2 This is an example of a flat organization where all employees have direct access to one another for communication and shared decision-making

Flat organizations, on the other hand, are decentralized structures and rely on flexibility and autonomy to realize organizational goals (Fig. 5.2). Flat organizations are more unstructured and encourage employees to be creative and find out-of-the-box solutions for problems. Communication in flat organizations is informal and much of it entails face-to-face meetings. Most middle-management levels and their functions are eliminated bringing the top management in direct contact with the frontline employees making for faster response time to changing conditions and customer preferences [4, 5].

To select the best organizational structure, decide the best way to arrange the jobs so the strategic goals of the center can be accomplished. The right arrangement allows for the best use of resources and establishes lines of communication and fruitful working relationships. These organizational designs can also be mixed and blended to find the best parts of each to create a customized structure [3].

Once the organizational structure is determined, the process of who will need to be hired, from management to staff, and what qualifications will be necessary can be outlined. Start with defining simulation roles and responsibilities required to meet the mission and vision of the larger organization, if one exists. Consider your existing personnel and determine what gaps there are in the day-to-day operations of the simulation program. If there are experts in clinical care, such as what to do when a patient begins to deteriorate, but no experts in hardware deterioration, such as when the manikin's respiratory rate is programmed for 16 and there is no rise and fall of the chest, the simulation-based education (SBE) experience comes to a screeching halt. If situations like this have happened, then this should identify the need for a person with a technology and simulation background. If there is audiovisual equipment, and a department that supports that equipment, but there is no support for manikins or task trainers, once again the personnel requirements will be narrowed to fill that missing role.

Ultimately, a job analysis must be performed so desired positions can be identified and appropriate job descriptions can be created. As tempting as it may be to simply hire someone known to the center or the first person who interviews, doing so can be a mistake. Taking the time to figure out staffing needs by performing a job analysis should be done before a position is posted. Once those needs are identified, only then can a candidate be found to fill those needs.

INACSL Standards of Best Practice: Simulation℠ Operations

One tool that can be used to begin a job analysis is the INACSL Standards of Best Practice: Simulation℠: Operations standard [6]. This *standard* states "All simulation-based education programs require systems and infrastructure to support and maintain operations," and the associated criteria outline the requirements necessary to meet the standard. The staff needed to operate an SBE program must understand and apply skills of business, education, and technology to support and promote achievement of goals and outcomes of the simulation strategic plan [6].

The standard also recognizes that formal education programs are emerging in colleges and universities. However, graduates are few, if any, so prior experience and knowledge in moulage, data collection, audiovisual equipment, manikin operations, and other areas "can be substituted when competency and proficiency can be demonstrated" [6].

Job Analysis

After understanding the needs of the simulation center, the organizational structure, and the needed roles, then a job analysis can begin. A job analysis is the process of understanding the requirements of the job being filled and identifying what kind of specific knowledge, skills, and abilities (KSAs) or general traits and behaviors are important to fill the position needed [7–9]. This is described in Fig. 5.3. The job analysis also identifies what kind of personality, experience, and education is ideal. The data from a job analysis provides information used in job descriptions, selection criteria, interview guides, and performance evaluation criteria, as well as potential pay scale or range. Failure to complete an accurate job analysis may result in an

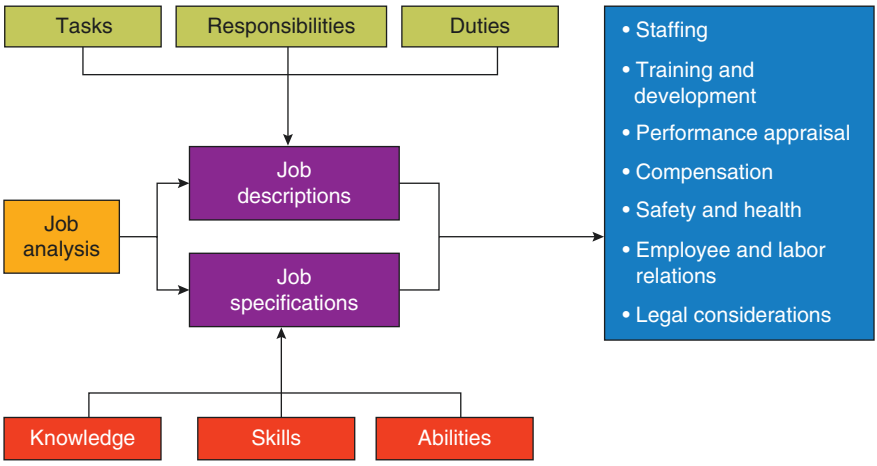


Fig. 5.3 Outline of the process in performing a job analysis

inappropriate and imprecise job evaluation, potentially leading to an employee mismatch, turnover, increased costs, and/or loss of talent [9].

There are no federal laws that require a job analysis; however, several laws require job information that cannot be obtained without some systematic study of the job [10]. For example, the Americans with Disabilities Act (ADA) requires employers to determine what parts of a job are essential such that if considering a disabled applicant, the employer only focuses on the essential job functions [11]. If some part of the job is not essential and the person is otherwise qualified, the employer may have to change or redesign the job so that the disabled person does not have to do it. Another example supporting the need for a job analysis is in the Equal Pay Act where one has to understand the nature of the jobs held by men and women before one can render a judgment about whether the jobs are the same [12]. A thorough job analysis can address these legal requirements.

Reviewing position descriptions from other entities can be very helpful with starting a job analysis. Discussing with subject matter experts (SME) for input and looking at performance standards and occupational studies that identify appropriate eligibility requirements for a specific position are also recommended and can help to validate a review. A task list will show the job-related activities that must be completed for a position, while the KSAs will describe characteristics that are needed to complete those tasks. A SME can help prioritize and rank order the list to determine what would be entry- or prerequisite-level requirements for a candidate applying to a position [13]. For example, some roles may require advanced cardiac life support (ACLS) certification, whereas another role may have it as optional or preferred.

The list of tasks and KSAs should not be so restrictive that they exclude candidates who might reasonably have the ability to do the job or present artificial barriers to employment [7]. The list needs to be practical in the sense that they are obtainable in the general labor market and should address KSAs and the "soft" skills (i.e., characteristics, values, and work ethics) required at the time of hire that are tied directly to the job duties. KSAs that can be obtained on the job should not be factored into the requirements.

Be sure there are not too many KSAs and traits that overwhelm the role responsibilities such that either no one qualifies for the position or the work cannot be completed. This can set a new hire up for failure. Divide up the skill sets, or at least remember one position may require different skill sets from another position as needs evolve within your program. Do not assume that a previous job description will automatically meet a current need. Needs and roles change rapidly, especially with new technology requirements or changes in company focus [14, 15].

Consider those times when it was thought "I wish I knew how to (*fill in the blank)*" or "I wish I had someone to (*fill in the blank).*" Talking to people – in and outside of the organization – who already have some of those roles or competencies can help identify how to fill those gaps. Asking others to identify and suggest competencies or determining how to translate specific needs into competencies will determine the actual gap. Observing someone in similar jobs as they perform a task

or conduct that role can demonstrate what is needed. What areas of knowledge are they using? What skills are they performing?

Use a questionnaire or survey that asks or describes certain practices and procedures needed in order to carry out the task or perform the role in the best possible way. Ask about credentials; how were those skills acquired? Was it through formal education, as needed training, or on-the-job experience? Gathering data will help to show a clearer picture of the requirements needed for someone to be considered the perfect candidate [8]. Giving this type of survey to stakeholders, supervisors, employees, and coworkers for input can help with validation. Simulation-specific resources in this realm include the INACSL Standards of Best Practice: Simulation[sm] the Society for Simulation in Healthcare's (SSH) accreditation guidelines, and The Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS) resources for additional competencies and domains necessary for a successful healthcare simulation technology/operations specialist [16–18].

Job Description

Once the job analysis is complete, the information can be used to draft a job description [2]. Most organizations have a job description guide or template that must be used. Involve the human resources (HR) department from the larger organization in this process if possible. HR will typically help perform the job analysis as well as facilitate translating the job analysis to an appropriate job description. A job description specifies the general responsibilities of a position along with some of the specific duties to be conducted by the role [2]. The title for the position and any special skills, training, or credentials required should also be listed. Since most roles and positions are unique to an organization, do not adopt preexisting job descriptions if they were not generated from a role-specific job analysis. Instead tailor the information to meet the specific needs of the position being sought.

A determination about whether the position is full-time, part-time, per diem, or temporary must be decided as well as supervision and reporting expectations. An inclusion of any special physical skills is required up front, like moving an 80-pound manikin. This may be important when considering accommodations for candidates with physical disabilities. Do not forget to determine if the position is salaried or hourly. These are often the easiest parts of a job description to determine.

The most difficult part of the job description is determining the activities from the job analysis that are *essential requirements* of the role and which are *nonessential*. Employees want to know what they are supposed to accomplish; a good job description provides that. The essential requirements must be measurable and job related. Avoid language such as "ability to" or words such as "excellent" or "advanced level" because these cannot be measured. Use words such as "demonstrated" or "documented experience" (see Table 5.1 for examples of measurable job-related essential requirements and responsibilities for a variety of simulation positions). Allowing colleagues and other SMEs to review the job description to provide input and feedback is a recommended practice.

Table 5.1 Example features of an effective simulation job description

Examples of measurable job-related essential requirements and responsibilities
Coordinate the evolution of a state-of-the-art simulation center that supports the vision and mission of the department and the parent organization
Three years *documented experience* in training adults on a variety of simulation-based computer software applications in either a corporate or educational environment
Documented experience in simulation-based education, training, facilitation, and coordination
Demonstrate an engaging and respectful leadership style
Collaborate with local, regional, and national stakeholders identifying simulation-based education and training opportunities
Ensure the simulation laboratories provide an environment that supports "best practice" experiential learning activities
Develop and maintain independent intellectual pursuits, including research, that enhance teaching effectiveness
Attend all faculty/staff university, school, and departmental meetings
Conduct long-range planning as it relates to teaching/learning excellence and the use of instructional technologies
Coordinate the acquisition and upgrading of simulation supplies/equipment and projects future needs in consultation with faculty members

Educational Degrees

Paths to higher education degrees related to simulation-based education and training are just emerging. Associate degree programs for healthcare simulation technology specialists and a bachelor's degree in health sciences with a specialization in simulation in healthcare education now exist. There are also numerous master's and doctoral degrees with an emphasis in simulation-based education also springing up. Unfortunately, graduates from these programs and other programs that will eventually open are not yet abundant. It may be necessary to consider being more open to a variety of degree requirements for an open position. A human resource department can suggest minimum educational requirements to provide the KSAs for a robust candidate pool.

When considering the variety of roles needed in a simulation center (Chap. 4), the organizational structure to support the mission and vision of the program, and the completed job analysis, there must be a correlation between success on the job and the level of education required for the position. If a healthcare background is required, does it need to be a registered nurse (RN), paramedic, military corpsman, or medical physician? Rememberr, salary potential increases with the educational requirements for the position. Can the role be successful if the degree is in information or instructional technologies, or must it be related to audiovisual technologies? If the salary range does not support a specific degree, determine what the minimal degree requirements are for entry into the position. Always keep in mind what is *required at the time of hire* as KSAs that can be obtained on the job should not be factored into the requirements. The key is whether the requirement is truly necessary to do the job. To make it clearer, if educational degree is required for a position, the degree requirements would need to be specifically job related, and demonstration of

that specific knowledge, skill, and training from the content of the degree should directly correlate to successful job performance.

Background and Experience

Once the degree requirements are determined, correlate the content of the degree to the job analysis and job description to determine the KSAs that can be considered *equivalent experience or in lieu of work experience* if potential candidates do not have the requirements. It may be determined that there are no substitutions or equivalent experiences for a required degree. However, knowing that the field of simulation is full of professionals that are self-taught or come with on-the-job experience, consider the correlation between the two. While a degree may be preferred, some combination of coursework and experience or extensive and related on-the-job experience may be acceptable for candidates. For example, a mechanic may have the ability to repair and maintain your costly equipment with appropriate coaching, mentoring, and training; a videographer may have the transferable audiovisual skills necessary to support the audio-video technology of the simulation center. Commonly a bachelor's degree may be required, masters preferred; but frequently 5+ years of relevant experience may be substituted in lieu of a degree level.

With a detailed list of tasks, job responsibilities, associated tasks, and specific competencies, a candidate can be asked appropriate questions during the interview to elicit their ability to be successful if hired into the position [16, 19]. The job description should include measurable criteria ensuring that competency and proficiency related to the required KSAs are demonstrated by the candidate at some point. This time may be within 6 or 12 months of hire, during any probationary or review period.

The Interview

There are a variety of ways to interview simulation candidates. As the field of human resources has evolved, so has the hiring process. There have been outlines and rating scales, note-taking during interviews with ratings after, dimensional rating scales with interview panels, interview guides and summary forms, behavioral anchored rating scales, and even a job analysis-based interview schedule. There are interviews where interviewers can select from a variety of questions eliminating the need to ask each candidate the same standardized question and a combination of methods such as situational interviewing where the same questions are used for each candidate along with anchored scales and an interview panel to record and evaluate responses.

Literature supports that interview validity depends on the content of the interview and how the interview is conducted [20]. Situational interviews are shown to have higher validity than behavioral interviews, while structured interviews are more valid than unstructured interviews [21]. Lastly, one-on-one interviews with

multiple interviewers are more reliable than panel interviews [22]. So, when preparing to interview simulation staff, consider structured, situational, one-on-one interviews with multiple interviewers as the best predictor of job performance [23].

In situational interviewing, the candidates are asked to respond to a specific situation they *may face on the job*, whereas behavioral interviewing asks a candidate to describe how they *responded to a situation in the past*. The situational interview questions are designed to draw out more analytical and problem-solving skills as well as describe how a candidate might handle problems with short notice and minimal preparation. The situation should be about something they may face in their new role at the organization.

The hiring process and selecting the right person for a facility is not an easy task. Even in the best of circumstances, with hiring firms and other measures and hiring models, there is significant variance in an applicant's fit, worth, and ultimate contribution to the organization. Some candidates work out and others do not. Beyond the quantitative data that informs hiring decisions, there are interpersonal processes or emotions that create subjective impressions which are strong drivers for hiring decisions [24, 25]. These emotional decisions do not necessarily correspond to the candidate's résumé, qualifications, and skills yet are often used to sway the direction of the decision-makers. Merit is difficult to ascertain from a paper résumé. Interviewers often rely on their *gut* to compare and evaluate candidates at the job interview stage. Interviewers are most often not human resource specialists or trained in the necessary evaluative rigor of the hiring process, so the trade-off is who will fit in with the culture and social atmosphere of the organization. If this is not someone you can see yourself working with day in and day out and there is no spark or chemistry during the interview, then this candidate, although highly qualified, will not be the top choice for hire.

Legal Considerations During the Interview Process

More than 40 years after the enactment of fair hiring laws, candidates still are asked questions that are illegal, insulting, and irrelevant to job performance [26]. Any questions that imply or otherwise require a candidate to reveal his or her age, race, national origin, gender, religion, marital status, or sexual orientation are off-limits. Any question that asks a candidate to reveal information about off-limit topics without the question having a job-related basis will violate a variety of state and federal discrimination laws. Some organizations require specific training on the employee hiring process, so be sure to check with human resources before any interviews begin. The keys to avoiding problems and/or consequences will be ongoing education and consistent interviewing processes and selection practices.

Ask candidates about only the essential skills and qualifications required to perform the job (see Table 5.2 for examples of employer questions or behaviors that can violate fair hiring laws). Interview questions should be designed to determine a candidate's capability to perform the essential functions defined for the job. Focus inquiries using job-relevant language, and don't make assumptions about a

Table 5.2 Examples of employer questions or behaviors that can violate fair hiring laws

It is illegal for an employer to	Examples	Solutions
Publish a job advertisement that shows a preference for or discourages someone from applying for a job because of their age	A help-wanted ad that seeks "recent college graduates" or "females only apply" or "must be less than 50 years of age"	Don't discourage people from applying that may be completely qualified unless the position depends on it
Discourage someone from applying for a job because of their ethnicity or cultural background	Reliance on word-of-mouth recruitment by its mostly African-American workforce	Post the position in as many appropriate sites including places like monster.com or indeed.com, etc., where potential candidates do the searching
Ask if you have ever been arrested	Arrest records are private and fortunately should not preclude someone from being hired	Ask if you've ever been convicted of a crime. If that crime substantially relates to the position, like a sex offender seeking employment in a school, then not offering the job is appropriate
Ask if you have children	Having or planning to have children is not an employer's right to know	Ask what hours you can work or are there responsibilities that may prevent you from traveling

candidate's ability or disability. Questions cannot be asked that reveal information that can lead to bias in hiring. Only ask questions that relate to job performance.

Some candidates will volunteer information that you would prefer not to know. The best way to handle this situation is not to pursue it nor to make note of it. Carefully planned questions and a structured interview process that is the same for all candidates will ensure equal treatment of all who apply. Keep the focus on the job requirements and how each candidate has performed in the past. Perhaps most importantly, make fair hiring part of your simulation program, championed from the top down and an integral part of the selection process.

Be sure to check references as there are legal consequences to irresponsible employment. Courts have found employers liable for an employee who was previously convicted of a criminal offense or similar problem where they use their employment as a means to commit further crime. For example, a registered nurse (RN) no longer licensed to practice should not be hired into a position requiring an active RN license.

Blocking Bias

More hiring mistakes are made in the first 30 minutes of the interview than at any other time [27, 28]. First impressions, personal biases, stereotypes, and prejudices unconsciously come into play when the interviewer and candidate meet in person for the first time. If an interviewer likes someone during this brief encounter, competency often becomes irrelevant, strengths are magnified, and weaknesses ignored. When there is a negative first impression, the process can be reversed, and the interviewer may seek out negative information. Getting past the first 30 minutes without

making a yes or no decision is critical to increasing assessment accuracy and preventing common hiring mistakes.

Summary

Hiring simulation staff is an important human resource process that takes time and is, in reality, no different than the hiring process for any other positions within an organization. Before assuming that there are adequate candidates for a position, it is recommended to perform a job analysis first to ensure the required knowledge, skills, and attitudes (KSAs) are identified. Take that information, and with the help of human resources, colleagues, and other experts in the field, draft a job description identifying the essential required KSAs. Announce the position in a variety of locations to promote the highest number of qualified candidates. Once candidates are selected, ensure the interview process is structured, situational, and one-on-one with multiple interviewers. Interviewers should have training to reduce legal and ethical concerns and biases that may prevent a good candidate from being hired.

References

1. Boushey H, Glynn SJ. There are significant business costs to replacing employees. Center for American Progress [Online]. 2012 [Cited 2019 April 17]. Available from: https://www.americanprogress.org/issues/economy/reports/2012/11/16/44464/there-are-significant-business-costs-to-replacing-employees/
2. Pató BSG. Formal options for job descriptions: theory meets practice. J Manag Dev. 2017;36(8):1008–28.
3. Siggelkow N, Levinthal DA. Temporarily divide to conquer: centralized, decentralized, and reintegrated organizational approaches to exploration and adaptation. Organ Sci. 2003;14(6):650–69.
4. Anderson C, Brown CE. The functions and dysfunctions of hierarchy. Res Organ Behav. 2010;30:55–89.
5. Morgan J. The 5 types of organizational structures: part 3, flat organizations; 2015 July 5. Available from: https://www.forbes.com/sites/jacobmorgan/2015/07/13/the-5-types-of-organizational-structures-part-3-flat-organizations/-262ed7966caa
6. INACSL Standards Committee. INACSL standards of best practice: SimulationSM operations. Clin Simul Nurs. 2017;13(12):681–7.
7. Beck B, Billing DC, Carr AJ. Developing physical and physiological employment standards: translation of job analysis findings to assessments and performance standards–a systematic review. Int J Ind Ergon. 2016;56:9–16.
8. Guder E. Identifying appropriate sources of work information. In: Wilson MA, Bennett Jr W, Gibson SG, Alliger GM, editors. The handbook of work analysis: methods, systems, applications and science of work measurement in organizations. New York: Routledge Academic; 2013. p. 31–44.
9. Morgeson FP, Spitzmuller M, Garza AS, Campion MA. Pay attention! The liabilities of respondent experience and carelessness when making job analysis judgments. J Manag. 2016;42(7):1904–33.
10. Uniform guidelines on employee selection procedures – no assumption of validity, Public Law no. 60–3.9 Part B Stat. 41 CFR; 1978.

11. The U.S. Equal Employment Opportunity Commission. The Americans with Disabilities Act: your responsibilities as an employer [Online]. 2008 [Cited 2019 April 7]. Available from: https://www.eeoc.gov/facts/ada17.html
12. Equal Pay Act of 1963 – EPA – 29 U.S. Code Chapter 8 § 206(d) [Online]. [Cited 2019 April 17]. Available from: https://finduslaw.com/equal-pay-act-1963-epa-29-us-code-chapter-8-206d
13. Office of Personnel Management. Six steps to conducting a job analysis [Online]. [Cited 2018 June 6]. Available from: https://www.opm.gov/policy-data-oversight/assessment-and-selection/job-analysis/job_analysis_checklist.pdf
14. Hartley DE. Job analysis at the speed of reality. Amhurts: HRD Press; 1999.
15. Schneider B, Konz AM. Strategic job analysis. Hum Resour Manag. 1989;28(1):51–63.
16. INACSL Standards Committee. INACSL standards of best practice: Simulation SM. Clin Simul Nurs. 2016;12(Supplement):S1–S50.
17. Society for Simulation in Healthcare. SSH accreditation of healthcare simulation programs [Online] http://www.ssih.org/accreditation. Available from: http://www.ssih.org/accreditation
18. SimGHOSTS. The gathering of healthcare simulation technology specialists [Online] https://www.simghosts.org/sim/About_Us.asp2018. Available from: https://www.simghosts.org/sim/About_Us.asp
19. Huffcutt AI, Roth PL, McDaniel MA. A meta-analytic investigation of cognitive ability in employment interview evaluations: moderating characteristics and implications for incremental validity. J Appl Psychol. 1996;81(5):459.
20. McDaniel MA, Whetzel DL, Schmidt FL, Maurer SD. The validity of employment interviews: a comprehensive review and meta-analysis. J Appl Psychol. 1994;79(4):599.
21. Salgado JF, Moscoso S. Meta-analysis of interrater reliability of job performance ratings in validity studies of personnel selection. Percept Mot Skills. 1996;83(3_suppl):1195–201.
22. Tran T, Blackman MC. The dynamics and validity of the group selection interview. J Soc Psychol. 2006;146(2):183–201.
23. Kausel EE, Culbertson SS, Madrid HP. Overconfidence in personnel selection: when and why unstructured interview information can hurt hiring decisions. Organ Behav Hum Decis Process. 2016;137:27–44.
24. Wiersma UJ. The four stages of the employment interview: helping interviewers put two and two together. Evidence-based HRM. 2016;4(3):232–9. Emerald Group Publishing Limited
25. Rivera LA. Go with your gut: emotion and evaluation in job interviews. Am J Sociol. 2015;120(5):1339–89.
26. The U.S. Equal Employment Opportunity Commission. Federal Laws prohibiting job discrimination questions and answers 2009. August 8, 2018. Available from: https://www.eeoc.gov/facts/qanda.html
27. Iyengar S. The art of choosing. New York: Twelve; 2010.
28. Frieder RE, Van Iddekinge CH, Raymark PH. How quickly do interviewers reach decisions? An examination of interviewers' decision-making time across applicants. J Occup Organ Psychol. 2016;89(2):223–48.

Professional Development for the Healthcare Simulation Technology Specialist

6

Suzan Kardong-Edgren and Michelle Aebersold

Introduction

The healthcare simulation technology specialist (HSTS) performs a myriad of functions within a simulation center. No single background is required or expected in this position, and no two centers have the same needs. Candidates with a variety of backgrounds and educational levels may be considered and used in this role depending on the simulation center need. On-the-job training and a mind-set to innovate and improve are likely to produce the candidates with the best fit. Even so, most centers will have minimum expected entry-level qualifications for consideration.

Entry-Level Qualifications

Many entry-level positions in simulation technology require applicants to have earned an associate's (AS)-level degree or higher in a related field, such as medical technology, computer science, or life sciences. Those with military experience can receive preference as such individuals are usually comfortable with technology, emergency medical situations, and simulated training experiences.

As the medical simulation field has grown, some universities now offer certificate programs that allow individuals to specialize in simulation, although at this time these programs usually focus on clinical educator aspects. Currently, there are only a few

S. Kardong-Edgren (✉)
Regional Research in Simulation Innovation and Education (RISE) Center, Moon Township, PA, USA
e-mail: kardongedgren@rmu.edu

M. Aebersold
School of Nursing, University of Michigan, Ann Arbor, MI, USA
e-mail: mabersol@med.umich.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_6

degree programs aimed at healthcare simulation technology specialists (HSTSs) including an AS at The University of Akron and Big Bend Community College Oregon, a BS in healthcare education with an emphasis in simulation at Seminole State College in Florida, and the newest offering an AS from WSU Tech in Wichita Kansas. A partnership with Wichita State University will allow the degree students to pursue a bachelor of applied science in either healthcare education technology or healthcare education leadership. While a bachelor's-level degree is common for the position, depending on the job description and requirements, some HSTSs obtain jobs with as little as a high school degree with some associates' coursework.

Advanced Degrees

Individuals interested in higher-level positions may explore advanced level degrees, such as master's or doctorate degrees. Currently, there are several programs that offer a Master of Science (MS) degree in healthcare simulation (interdisciplinary in nature) and MS in nursing education with an emphasis in simulation emerging around the USA. There are also PhDs in simulation and modeling/gaming; however, at this time, these programs do not focus on healthcare simulation. Degrees in health services administration or business administration (MBA) might also be potential advanced degrees of interest to an HSTS. Specializing in computer programming, instructional design, education, leadership, and development would add depth and breadth to an HSTS's résumé and to be seen as desirable by potential employers.

When determining if an educational program will match one's interests and abilities, it is recommended to schedule a meeting with the planned institution's department advisors and prior students. Reviewing the expected gains and actual changes from student experience will help an HSTS determine if additional benefit would come from pursing extra training in this area. Most importantly, the HSTS must consider where they plan to be in the future and determine if the training program under consideration will align with those career goals.

There are a number of funding opportunities available to individuals interested in pursuing graduate-level training in simulation technology. Many graduate programs offer graduate or research assistantship opportunities that provide valuable mentoring in addition to tuition reimbursement and possible stipends. Often these positions involve joining a research team with opportunities for publishing. In addition to the skills and experience gained from participating in research, involvement in published research is a positive addition to a HSTS's résumé and makes the HSTS more competitive in the job market.

Certificates

In addition to formal degree programs, certificate programs are another great way to enhance skills and add to a résumé. Completing certificate programs provides evidence of knowledge and skills to simulation center directors who may be hiring.

Table 6.1 Massive online open courses (MOOCs) of interest to healthcare simulation technology specialists

Course	MOOC
Interprofessional Healthcare Informatics	Coursera (coursera.org)
Games, Sensors and Media (game design iOS)	Coursera
Getting Started with Augmented Reality (beginners – no experience necessary)	Coursera
Introduction to Virtual Reality by Google VR (beginner)	Udacity (udacity.com)
VR Scenes and Objects by Google VR (beginner)	Udacity
VR Software and Development by Google VR (beginner)	Udacity
Introduction to Simulation in Healthcare	Edx (edx.org)
Creating VR Apps (part of a certificate program)	Edx
Supply Chain Management	Edx

There are a number of certifications to consider; some are free; others require a fee. Completing additional coursework or obtaining certificates should be based on its expected impact toward long-term career goals and the current expected impact on employment and position within a simulation center. A combination of certificate courses will likely make for the most well-rounded HSTS in the eight domains identified in Chap. 10 of this book.

One certification option is through massive open online courses (MOOCs). While these courses are free, those seeking to obtain certification must complete the learning activities and submit a fee. There are three main platforms for MOOCs: Coursera, Udacity, and Edx. Some colleges and universities now have MOOCs that can be taken and then transferred for course credits. See Table 6.1 for examples of MOOC courses.

Community colleges also offer adult education courses, and simulation organizations may offer free webinars or online modules to their members. Documenting attendance and course content and incorporating it into a portfolio can be helpful when applying for a position or certification.

Stackable Credentials and Digital Badging

It may be possible in the near future for an HSTS to build credentials in the simulation field by collecting digital badges or stackable credentials. Stackable credentials are outlined by the US Department of Labor as a "sequence of credentials that can be accumulated over time to build up an individual's qualifications" [1, 2]. Digital badges have become one method for demonstrating skills in this manner but are specifically managed online [3, 4]. As digital badges become more common for demonstrating new knowledge and skills for working professionals, the validity of these credentials and badges increases. Badges are being created and awarded by colleges and universities like Carnegie Mellon and Purdue and also companies and institutions like the Smithsonian and Disney-Pixar [5]. In some cases, badges can be considered toward college credit [6]. This may be a new way of learning on one's own time and gathering credits toward an eventual degree.

> SimGHOSTS has developed comprehensive descriptors for simulation technology and operations professionals working at foundational, intermediate and advanced levels across the eight domains of Healthcare Simulation Technology and Operations. This is being used to guide the content of online courses and event workshops. Digital badges are an exciting initiative that SimGHOSTS is currently investigating with tentative plans to implement them in 2019 as a way to document workshop participation and acknowledge achievements. Digital badges appeal to the SimGHOSTS team as a flexible and adaptable feature of a larger training strategy that can be scaled with the activities of our organization. (SimGHOSTS President Scott Crawford)

Certification

The Society for Simulation in Healthcare (SSH) has established a certification program called CHSOS (Certified Healthcare Simulation Operations Specialist) for individuals working in jobs that focus on simulation operations. This includes individuals who are in jobs that are titled HSTS, simulation specialist, simulation technician, simulation AV specialist, simulation coordinator, or many other similar titles. This certification is focused on the aspects of the practice that involve simulation modalities and technologies such as different types of simulators and task trainers, audiovisual equipment, software, hardware, simulation program management, and inventory and supply management. There are also basic knowledge expectations of instructional design and healthcare concepts. This certification demonstrates the recipient has a level of advanced competency in simulation. Two years of experience and a bachelor's degree (or waiver for equivalent experience) are required to apply. References from colleagues who can attest to the experience of the simulation operations expertise of the applicant are also necessary. The certification is a badge of distinction for an HSTS and can help when applying for a job and seeking internal advancement or when a center is applying for accreditation [7].

Another certificate that should be considered for those working in the healthcare simulation arena, which is free and easy to complete, is TeamSTEPPS®2.0. This evidence-based program was developed by the Agency for Healthcare Research and Quality (AHRQ) and the Department of Defense (DoD). The program focuses on optimizing teamwork in organizations through improving skills in communication, collaboration, and other team skills. The training approach leverages the use of short PowerPoints, activities, videos, and simulations. The entire curriculum is available online, and anyone can apply to become a Master TeamSTEPPS trainer by taking an online course offered though a train-the-trainer approach at https://www.ahrq.gov/teamstepps/master-trainer-registration.html. This Master Trainer certification allows individuals to provide the training to others [8].

Organizations

There are several simulation organizations that hold annual events which provide attendees with the opportunity to learn from leading experts, network with peers, exhibit the latest innovative technologies, support industry-wide research projects,

Table 6.2 Major healthcare simulation organizations with conferences and/or continuing education of interest to healthcare simulation technology specialists

Organization	Website
The Gathering of Healthcare Simulation Technology Specialists	https://www.simghosts.org
International Nursing Association for Clinical Simulation and Learning	https://www.inacsl.org
Interservice/Industry Training, Simulation and Education Conference	http://www.iitsec.org
Society in Europe for Simulation Applied to Medicine	http://www.sesam-web.org
Society for Simulation in Healthcare	https://www.ssih.org
Association for Simulated Practice in Healthcare	http://www.aspih.org.uk
Association of Standardized Patient Educators	http://www.aspeducators.org
Canadian Network for Simulation in Healthcare	http://www.cnsh.ca
Simulation Australasia	http://www.simulationaustralasia.com

and better understand current field developments. See section "Attending Conferences" in this chapter to learn more.

By joining and participating in these simulation organizations, individuals can further support their profession, network with peers, and demonstrate volunteer work to potential employers.

The major healthcare simulation organizations at this time include the following:

- The Association for Simulated Practice in Healthcare (ASPiH)
- The Association for Standardized Patient Educators (ASPE)
- The Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS)
- The International Nursing Association for Clinical Simulation and Learning (INACSL)
- The International Pediatric Society for Simulation (IPSS)
- The Society for Simulation Applied to Medicine (SESAM)
- The Society for Simulation in Healthcare (SSH)
- Simulation Australasia (SimAust/ASSH)

See Table 6.2 for other regional simulation organizations around the world. These organizations were established by groups of individuals determined to further develop and support various aspects of the healthcare simulation field.

Organizational Memberships

Some organizations offer paid online membership that provides subscribers with access to advanced resources. SimGHOSTS.org subscription, for example, enables users to access hundreds of recorded conference sessions, an online course library, recorded webinars, document repository, contact database, international forum discussion boards, and more. Each organization offers different membership benefits

with a specific focus, so be sure to examine current options. These resources can assist an HSTS with learning or expanding their knowledge quickly, since there is limited access to professional degree programs at this time.

Attending Conferences

Conference attendance is common and almost required as a simulation professional seeking to stay current or seeking advancement in the field. Attending a conference in a prepared manner and bringing knowledge back to other faculty and staff provide the *lagniappe* (a little something extra) that can make the HSTS a more valued member of the simulation team and can set them apart from the competition.

To prepare for a conference, print the conference brochure well ahead of time, and review the agenda to highlight areas of interest. Following this, it is advised to review course selection and planned activities with a sponsoring program director or other attendees from the same simulation center. This can prevent duplication and ensure new knowledge is attained. Some directors request modifications to an agenda in order to better suit the goals of the simulation program. It is important to consider registering for some sessions that are completely different from an existing background in order to expand knowledge into new domains.

During the event, attendees are encouraged to take notes and photographs to better remember what was learned. These notes can help to relay information back to a team at home. By creating a report and presenting it to coworkers who could not attend, the HSTS can demonstrate a return on the investment for attendance. This type of sharing will also encourage a director to support future attendance.

While at the conference, the HSTS should carry and distribute business card to follow up with the other simulation champions who have shared interests or ideas. When given a card, it is recommended to immediately take little notes about the person and why they are important – so that it is easy to remember some details after returning home the following week. Reaching out the following week will demonstrate interest and help to maintain the new relationship. Once a written communication has been sent, it will save the email address and create a searchable reference for the connection. If preferred, applications like CamCard can be used to scan business cards directly into an electronic form for export later. Be sure to double-check the text conversion as these programs can sometimes misread the card.

Taking photos and engaging in social media conversations like those on twitter with official event hashtags can provide another method to network with peers as well as find hidden gems of leading content.

Another way of optimizing networking opportunities at a conference is to volunteer. Most conferences have opportunities to volunteer for short blocks of time for specific projects. Volunteering supports the event and is the best way to connect with conference organizers. These volunteer opportunities may be through committees or special interest groups.

Presentations

After attending several conferences and knowing what to expect, consider submitting an abstract and presenting. Presentations can bring credibility and increased professional recognition to a simulation center, its personnel, and the education being offered. This recognition can potentially bring more opportunities such as grant funding or more qualified people wanting to work at the center. Presentations and publications on a résumé or LinkedIn page add to professional credibility and stature in the field thus improving the potential for future advancement.

The key to getting a presentation accepted is writing an abstract that will meet peer-reviewed requirements. The abstract will describe the planned discussion content and suggest its relevance to the proposed audience. This is a skill that must be learned and is most easily acquired by working with an experienced abstract writer. By deconstructing abstracts successfully accepted in previous conferences, a writer can better match the unique style for the conference audience. For HSTS content, consider exploring previous abstracts from SimGHOSTS or SimOps. Table 6.3 has abstract evaluation criteria for two simulation conferences as a reference when beginning the writing process. Strict adherence to abstract guidelines and appropriate completion of each portion of the submission will help the reviewer in scoring and advocating for a submission. An empty section may receive a zero score and hurt the final reviewer score. It is advised to reread the directions and double-check all sections before submitting. An abstract may be reviewed with hundreds of others for a limited number of presentation slots, so it is important to be thorough.

Some of the most common simulation operations abstract topics include manikin programming, general innovation, moulage, product analyses, educational innovations, or adaptations. Abstracts that include data often score higher and are more likely to be accepted. Check with the center, school, or hospital institutional review board (IRB) for the potential need for approval for the collection of data (see Chap. 16 for additional details). The center director or faculty may be able to help with this process. It is always better to seek IRB approval, even for a quality improvement project, because someone may want to eventually publish the data. IRBs cannot give retrospective permission after data has been collected.

Table 6.3 Example criteria for simulation technology abstracts and presentations at two major conferences

Conference	Criteria
SSH-IMSH conference has a call for technology innovations	This area is a great place to present work that is not research based but is more about new products or innovative use of an existing simulator. The criteria that the abstract is evaluated on is: how the challenge was met, did it use simulation in a new and innovative way, was there some measurement of the success of the project, and could it be adapted to others. You can go to ssih.org for more information.
INACSL Conference	This conference also accepts abstracts for non-research presentations, which could be something around the use of technology. The evaluation criteria will focus on evaluation of technology and how it was used for learning.

Once a poster or an oral presentation is accepted to a conference, it is important to highlight the work in the best manner possible. Check to see if your program has a standardized logo, branded PowerPoint, or poster template. If not, there are many good written resources and YouTube videos demonstrating how to design a poster presentation or PowerPoint slides. Keep in mind that many large institutions have design guidelines to assist with everything from specific colors or fonts to use, and how or where logos should be placed.

Determine the length of the oral presentation. A good guideline is to plan for one slide per minute and save 5 minutes at the end of the talk for questions. Only use bullet points for text, and limit the total number of words on a slide or poster section. Graphics or other visual aids should assist with delivery of the message. The design and appearance of the work should support the main body of information that is being delivered audibly. Colors that contrast will help the audience to easily see the presented text or graphs. Once the slides are developed, test them in a room similar to where the presentation will take place to see how they look "on the big screen." Practice your presentation with the slides out loud beforehand to reduce nervousness and fine-tune the script. An oral presentation is a performance, and it should be both informative and entertaining.

Publications

Publishing a research article is another way to advance your career. Publications in leading journals are considered to be even more valuable than providing oral presentations. Unlike a one-off presentation, published works are indexed and available for future review by others. To find topics, consider your passions, and then research previous articles to find gaps in the literature. Studies should build upon previous research to further explore specific areas not previously understood. Those still seeking ideas are encouraged to get in contact with a journal editor or research group to inquire about needed research within the field.

The work involved in producing such content is arduous and may take months or even years to complete. By connecting to authors who have previously been published, they can act as a guide and also support a project with their experience. Often journal editors require several rounds of revision before the final document is accepted. A response of "revise and submit" may seem discouraging, but actually shows that the content and concept have merit. Adherence to the journal's guidelines, reviewing previously published works, and asking colleagues to review a manuscript before submitting will help improve the chances of acceptance.

One unique angle for the HSTS to consider for publication is through *MedEdPortal* (https://www.mededportal.org/). *MedEdPortal* publishes original high-quality, well designed, tested, evidence-based scenarios online. Simulation scenarios published in *MedEdPortal* are considered scholarly products and are rigorously peer-reviewed. *MedEdPortal* also has a faculty mentoring program, for novice writers. See https://www.mededportal.org/about/facultymentors/ for more information.

Portfolios/Résumés

LinkedIn is a great place to promote a professional résumé and build a digital network of individuals who can attest to the knowledge and skills presented there. An HSTS can build an online network and promote themselves by adding details of current and previous position responsibilities, citations, awards, and accolades. LinkedIn can function as a digital résumé and business card. An electronic file with the equivalent pieces of information, such as examples of innovations and examples of supporting documentation, may suffice, but a professional LinkedIn page is almost expected in the workplace today. It is a good practice to place a LinkedIn address on a résumé.

Those applying for new positions should still create a professional-looking résumé, free from spelling mistakes or other grammatical errors. While the format is open to interpretation, the font, spacing, punctuation, and layout should remain consistent throughout the entire document. Friends and colleagues can review a résumé for mistakes and can also help in performing a mock interview. While a résumé can usually remain the same between applications, an application and interest letter should be employer and position specific. A résumé serves as the first impression to human resources or a director, and so it should be perfect. The document should highlight strengths and capture a reader's attention in the first few moments of review.

An HSTS should consider listing their top five strengths to attract a reader's attention. Strong action verbs will help to describe accomplishments not just responsibilities. Employers want to see what was actually accomplished, not what was assigned. Previous work experiences listed should be relevant to the position that is being sought. Recent employment and experience is more important than very early or unrelated positions [9]. It is recommended to keep a résumé to one page, if possible, with a custom cover letter on top describing specific interest in the position. The font should be easily readable and the margins reasonable. The *Harvard Business Review* has additional tips at https://hbr.org/2014/12/how-to-write-a-resume-that-stands-out [10]. See Fig. 6.1 for a sample résumé.

John Doe
80 Road Name Dr., Chicago, IL 12345
123-234-3456
noreply@gmail.com

EDUCATION

University of Illinois – Champaign-Urbana 1982-1987

Stevens Point, Wisconsin

- Bachelor of Science with Honors

Certified Healthcare Simulation Operations Specialist 2015-Current

Society for Simulation in Healthcare (SSH), Certificate #12345678

SIMULATION SKILLS

AV Systems

- Created initiative system including all new cameras, computers, and software to enhance Educational Management Systems (EMS) which ran and maintained for six years. Some experience with B-line.

Manikins, Task Trainers

- Extensive experience with Gaumard products [Hal (adult, pediatric, baby), Susie, Noelle] including maintenance and repair. Moderate experience with Laerdal (SimMan), and some experience with CAE products. Experience with task trainers for all levels of learners.

Learners

- Pre-healthcare students, Nurses, PA's, NP's, medical doctors, and first responders

EXPERIENCE

Simulation Specialist/Laboratory Materials Supervisor 2010-2014

Tech State University

- First full time simulation Specialist at Tech State University.
- Program, test and run simulation scenarios working closely with College of Health Sciences as well as community partners to achieve desired learning outcomes.

Fig. 6.1 Sample résumé for a healthcare simulation technology specialist

- Analyze simulations and decide equipment and moulage needed. Manage and install computer upgrades. Perform maintenance and inventory updates.
- Conducting research, evaluating new equipment, and creating innovative ideas to meet technological needs.

Simulation Operations Specialist 2014-Current

State Simulation Network

- Run multi-patient, interprofessional, multi-location simulations at various facilities throughout Idaho.
- Provide technical support for continuing education (CE) workshops including running simulation scenarios.

Simulation Technician 2015-Current

State University

- Program and run simulation scenarios working with nursing department to achieve desired learning outcomes.

PROFESSIONAL DEVELOPMENT

SSH-IMSH Presentations

Tips and Tricks for Manikin Operations on a Budget 2017

Showcase: Resealing and Repackaging of IV Fluids Bags 2017

Operations Wizardry on a Budget 2016

State Symposium Presentations

Tips and Tricks in Simulation Operations 2016

Lights, Camera, Action – Technology, Set-Up, Moulage & Organization Tips to Consider When Beginning Simulations 2014

SimGHOSTS

Sim Busters: Set-up, Run, and Judge Simulation competition to determine the best Simulation Specialist. 2016

Sim Busters: Set-up, Run, and Judge Simulation competition to determine the best Simulation Specialist. 2015

Publications and references by request.

Fig. 6.1 (continued)

Table 6.4 Healthcare simulation technology specialist professional development websites and online resources

Website	Description
HealthySimulation.com	Free resource website with thousands of articles and hundreds of videos, bimonthly newsletters, job listings, and more
Thesimtech.com	Online hub for sharing ideas and information for all things related to medical simulation
Halldale.com *Medical Training Magazine*	Professional resource magazine that regularly covers simulation as a means to improving healthcare training
wiki.Behindthesimcurtain.org	Wiki focusing on the professional development and the development of the profession of healthcare simulation technology specialists
Debrief2learn.org	Aims to improve healthcare outcomes by fostering effective feedback and debriefing practices
Simulationpodcast.com	A hi-fidelity podcast about healthcare simulation

Free Additional Website Resources

There are several free resource websites for those interested in learning more about healthcare simulation. Industry-leading websites are shared in Table 6.4.

References

1. Ganzglass E. Scaling "stackable credentials": implications for implementation and policy [Online] www.clasp.org: Center for PostSecondary and Economic Success; 2014 [updated March 21, 2014; cited 2018 June 18]. Available from: http://www.clasp.org/resources-and-publications/files/2014-03-21-Stackable-Credentials-Paper-FINAL.pdf
2. Employment and Training Administration. Training and employment guidance letter no. 15–10. In: Labor UDo, editor. Washington, DC: U.S. Department of Labor; 2010.
3. Alliance for Excellent Education. Expanding education and workforce opportunities through digital badges. [Online] http://all4ed.org/wp-content/uploads/2013/09/DigitalBadges.pdf; 2013
4. MacArthur Foundation. Digital badging [Online] https://www.macfound.org/programs/digital-badges/2018. Available from: https://www.macfound.org/programs/digital-badges/
5. Carey K. Show me your badge. The New York Times. 2012 November 2; Sect. Education Life.
6. Leaser D. Northeastern University + IBM: turning digital badges into academic credentials will create opportunities and better college graduates [Online] https://www.ibm.com/blogs/ibm-training/northeastern-university-ibm-turning-digital-badges-academic-credentials-will-create-opportunities-better-college-graduates/; IBM. 2017 [updated September 27, 2017; cited 2018 June 11, 2018]. Available from: https://www.ibm.com/blogs/ibm-training/northeastern-university-ibm-turning-digital-badges-academic-credentials-will-create-opportunities-better-college-graduates/
7. Society for Simulation in Healthcare. CHSOS [Online] http://www.ssih.org/Certification/CHSOS; 2018 [cited 2018 June 11]. Available from: http://www.ssih.org/Certification/CHSOS
8. Agency for Healthcare Research and Quality. TemSTEPPS 2.0 Online Master Trainer Course [Online] https://www.ahrq.gov/teamstepps/master-trainer-registration.html; 2017 [cited 2018 June 11]. Available from: https://www.ahrq.gov/teamstepps/master-trainer-registration.html
9. Isaacs K. Resume tips for technology professionals [Online] https://www.monster.com/career-advice/article/resume-tips-for-technology-pros: Monster.com; [cited 2018 June 11]. Available from: https://www.monster.com/career-advice/article/resume-tips-for-technology-pros
10. Gallo A. How to write a résumé that stands out. Harvard Business Review [Internet]. 2014 June 11, 2018 [cited 2018]. Available from: https://hbr.org/2014/12/how-to-write-a-resume-that-stands-out

Simulation Curriculum Development, Integration, and Operations

7

Lori Lioce and Amelia S. Lanz

Introduction

This chapter will provide the healthcare simulation technology specialist (HSTS) with information to understand basic educational concepts which affect simulation curriculum development, share examples of simulation processes, and discuss a simulation operation framework. The design of simulation curriculums should align with sound educational practices and simulation evidence in order to consistently deliver effective simulation experiences and support learning outcome measurement.

Educational Concepts

A good simulation curriculum, as most experienced HSTSs and simulation educators will tell you, begins with awareness of concepts for curriculum development. These concepts require a clear process to ensure the design and implementation of educational activities achieve desired and pre-planned curriculum needs. Running simulations "on the fly" or making simulations up without evidence-based standards creates a chaotic environment which can lead to ineffective teaching, reduced learning, and poor collegial relationships. This includes blaming others for a failure to plan and even shaming the learner for not anticipating what the staff or facilitator is thinking. Failure to plan is unfair to the learner and those you support, potentially increasing anxiety in yourself and your peers [1].

L. Lioce (✉) · A. S. Lanz
College of Nursing, The University of Alabama in Huntsville, Huntsville, AL, USA
e-mail: asl0007@uah.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_7

Regulations

Curriculum awareness begins with identification of regulations and governing standards. Every setting has accrediting bodies, and depending on the purpose of your simulation facility, one or more sets of standards may apply. Being familiar with these standards can help make more informed decisions and aid in focusing the curriculum and design for day-to-day operations. Curriculum program administrators, deans, or directors can help provide copies of strategic plans, program outcomes, and/or student learning outcomes. A well-informed HSTS must be aware of the global perspective and influence of who sets the requirements for curriculum and outcomes in their setting. This will aid in a comprehensive understanding of how simulation fits into the overall program mission and vision.

Broadly, in academia, there are both national and regional accrediting bodies which provide oversight and require clear program objectives and monitoring of program outcomes. For example, in the United States, the Department of Education and, in most other countries, the Ministry of Education provide quality oversight and accreditation for academic programs [2–4]. Healthcare facility accreditation in the United States is supervised by an independent, not-for-profit organization called The Joint Commission, still often called JCAHO (pronounced Jay-co) which stood for the Joint Commission on Accreditation of Healthcare Organizations. The Joint Commission accredits and certifies nearly 21,000 healthcare organizations [5]. Separately, professional societies identify the scope and standards of practice for each profession and identify specific professional competencies. Simulation center accreditation standards have been developed by different organizations around the world which can be used widely in curriculum development including those by the Society for Simulation in Healthcare, the Association for Simulated Practice in Healthcare, and the Society in Europe for Simulation Applied to Medicine [6]. Even if a center is not going to seek accreditation, these evidence-based criteria serve as an important guide. The HSTS should monitor the accreditation criteria and standards for updates as the science of simulation continues to evolve [7].

In educational settings, privacy is also governed by the Family Educational Rights and Privacy Act (FERPA) (20 U.S.C. § 1232 g; 34 CFR Part 99). FERPA is a federal law that protects the privacy of student education records and may apply to simulation [8]. It is therefore necessary to obtain participant consent for audio/video recording and use. Thoughtful planning and conversations with stakeholders will guide development of your own consent forms and should include use, access, storage, maintenance, and destruction of audio/visual simulation files and pictures. A policy should be in place to ensure consent is obtained with every new group of learners. Beyond this, if external use of any video or images is planned, a separate permission for use should be sought from any individuals who are identifiable. Special circumstances like this may come up if individuals have encountered stalkers, family discord, or work in government or law enforcement, for example.

Curriculum and Development

Curriculum is a term that is often used to describe a regimen of courses that must be taken to complete a program of study. Curriculum can also be viewed in a much broader sense to encompass the experiences, assessments, evaluations, and collaborative relationships that are interwoven into an instructional program [9]. As an evidenced-based learning strategy, simulation can be used to support many curricular goals and objectives and can be applied using a variety of strategic methods in many settings. For example, institutional settings sometimes use a method called in situ simulation that features scenarios conducted in actual patient care areas rather than in a simulation laboratory. The overarching goal may be to identify and remediate system-level breakdowns to ultimately improve safety and quality [10]. In academic programs, certain competencies must be achieved by students as stipulated in the program's objectives. Simulation is one tool that can be used to support and even demonstrate the attainment of these outcomes. Ultimately, simulation can be used as an integral part of an existing curriculum or as an entity that features its own curricular design.

The process of curriculum development may be organized using a systematic approach or using a curriculum model. Common components typically include defining the need or problem, determining learning objectives and outcomes, developing strategies/content to achieve the desired outcomes, implementing the instruction, and then evaluating outcomes. The six-step model configured by Kern, Thomas, and Hughes for medical education is one such example and is discussed further in Chap. 13 [11]. This approach has been used to guide the development of various simulation programs. Another instructional model, PADDIE, is discussed at length in Chap. 12 [12].

In the curriculum development process, HSTSs and simulation educators will need to consider factors that are unique to simulation. One question to address is: "Which simulation format will be used to best achieve the learning objectives?" Will high-fidelity simulators, standardized patients, or computer-based simulations be used? Also, what clinical case or scenario will best capture the objectives of the simulation experience?

Another important concept for the HSTS to understand is that simulation is an active learning strategy that engages the individual and focuses on situations as they would occur in real life. The theoretical roots for this type of learning are grounded in constructivism. Constructivism describes knowledge as being constructed through interaction with the external world [13, 14]. Knowledge is produced as individuals adapt to and organize their experiences. Individuals in practice-based professions must have more than theoretical understanding; they must know how to apply knowledge in real-world settings. Bringing together action, theory, and cultural context in the simulation experience provides these elements when the process is well designed. Thus, a solid curriculum framework is needed to meet accreditation standards and support the use of clinical hour credit which is often given for clinical experiences.

The implementation of any simulation curriculum will require a team effort. Planners, educators, participants, and technology specialists alike need to understand the value that simulation can bring to a program and the comprehensive detail-oriented support required. Well-informed teams and participants will better support a quality simulation curriculum [15]. Many organizations support the use of simulation as a learning tool and evidence to substantiate its effectiveness is well established (see the links listed below).

- SimGHOSTS (https://www.simghosts.org/)
- Society in Europe for Simulation Applied to Medicine (https://www.sesam-web.org/)
- Association for Simulated Practice in Healthcare (https://aspih.org.uk/)
- Agency for Healthcare Research and Quality (https://www.ahrq.gov/)
- Society for Simulation in Healthcare (http://www.ssih.org/)
- National Council for State Boards of Nursing (https://www.ncsbn.org/)
- National League for Nursing (http://www.nln.org/)
- The International Nursing Association for Clinical Simulation and Learning (https://www.inacsl.org/)
- National Organization of Nurse Practitioner Faculties (https://www.nonpf.org/)
- Accreditation Council for Graduate Medical Education (https://www.acgme.org/)

Role of the Needs Assessment

Ensuring simulation meets a specified need prior to investing time and money into development is crucial and may be overshadowed by an individual's passion for a particular topic. Often the HSTS should have a basic understanding of where the simulation fits into the curriculum to allocate resources for development. Identification of short-term or long-term support will allow staff to make decisions regarding planning, archiving, and evaluating a simulation to be sustained by the program, whereas, if a simulation is a one-time experience, resource allocation can be streamlined.

Standards of best practices in simulation design stipulate that a well-designed simulation program begins with a systematic needs assessment [15]. A formal needs assessment should be comprehensive and conducted to clearly identify factors that are relevant to the program's goals or, even in some instances, to pinpoint a problem where simulation can provide a strategic solution. Many instructional design models feature criteria that can be used to conduct a needs assessment. An informal needs assessment may identify needs from testing results, limited clinical exposure, introduction of new content, or curriculum planning priorities. Typically, such needs assessments are completed by program administrators, steering/curriculum committees, and educational directors and will prioritize curriculum development and identify simulation needs.

An initial step in the assessment includes a thorough analysis of the problem or task to be accomplished. Is there a gap between current performance and the desired

performance? Does data exist that exposes the problem? In some instances, a problem is perceived, but more evidence is needed to generate a clear picture. As an example, a survey might be conducted to determine the perceived learning needs of personnel. Likewise, an organization that employs the graduates of an academic institution may help define areas for clinical improvement. A task force or expert panel may be convened to investigate an issue or more clearly identify a need. Simulation, as previously noted, could even be used as a tool to determine a gap in skills, knowledge, or performance.

Regulatory and accrediting standards should also be taken into account when conducting a needs assessment [15, 16]. In academic settings, for example, accrediting bodies often specify the need for a clear link between simulation and course-to-program objectives. In other words, it should be clear how simulation is helping the learner achieve the program's defined outcomes. Therefore, when a simulation is being designed for a structured course, it is important to consider the desired learning outcomes and determine how the simulation will fit the need that is described in the course's objectives.

A needs assessment should include consideration of the learners. Once a programmatic need and goal has been identified, who will be the target audience? Will the simulation need to focus on individual or team functions to meet the identified need? The educational and practice level of the learner should be considered to help focus the design. For example, a simulation for entry-level workers or students will need to be designed differently than one that is created for experienced professionals or even more advanced students. In addition, logistical factors might place constraints on the simulation program such as manpower, scheduling, and facilities.

The needs assessment should follow a systematic process. Various methods may be used and chosen to fit the purposes and context of the situation. Many situations will call for unique and even creative approaches to analyzing and determining needs [15]. In any case, to design a simulation program that will be effective in achieving the desired goals, the needs assessment should provide the foundation for planning. Table 7.1 lists examples of content that may be considered in a needs assessment based on the INACSL Standards of Best Practice: Simulation^{SM}: Simulation Design.

Overall the major concept regarding needs assessments is to ensure that each simulation is purposeful and focuses resources to areas that have an intended purpose. This will save development time and overall money in integrating simulations that are meaningful and long lasting.

Table 7.1 Examples of content that may be considered in a needs assessment based on the INACSL Standards of Best Practice: Simulation^{SM}: Simulation Design

Underlying cause of concern (e.g., root cause or gap analysis)
Organizational analysis (e.g., strengths, weaknesses, opportunities, and threats analysis)
Surveys of stakeholders, participants, clinicians, and/or educators
Outcome data (e.g., from pilot testing, previous simulation-based experiences, aggregate healthcare data)
Standards (e.g., certifying bodies, rules and regulations, practice guidelines)

Outcomes and Objectives

Methods to determining appropriate learning objectives are well explained in many resources. These objectives are very important because the formal or informal needs assessment identifies the objectives. The simulation design all the way through the evaluation should correlate back to the objectives. This helps keep everything clear, focused, and concise operationally and educationally. Objectives must be specific to the appropriate educational level of the learner. If expectations are too high, it may set the learner up for frustration and failure. If too low, the simulation may fail to engage and challenge the learner. If an interprofessional simulation is planned, it is important consider the learning needs and levels are unique to each group that is participating. It is a good practice to have common learning objectives as well as objectives specific for each profession [17].

SimGHOSTS' online *Fundamentals of Training and Education* for Healthcare Simulation Technology Specialists module states:

> Educators, clinicians, and researchers utilize outcome measures to determine the impact of simulation-based experiences. The Kirkpatrick Model is a commonly used ranking model that evaluates training programs and transfer of learning outcomes. This model depicts four sequential levels of evaluation: (1) Reaction -measures participant's satisfaction with training; (2) Learning -measures knowledge, skills, and attitudes (KSA's) gained from training; (3) Behavior – measures changes that occurred as a result of training; and (4) Results – improving quality and safety; increased return on investment (ROI) following training such as productivity, revenue, and employee retention. [18]
>
> Objectives are the guiding tools to facilitate achievement of simulation-based outcomes and the hallmark of sound educational design. Objectives may be broad or specific as a blueprint for simulation design. Bloom's Taxonomy provides a framework for developing and leveling objectives to meet expected outcomes [19]. The taxonomy classifies three domains of learning: cognitive, psychomotor, and affective. Each learning domain has a hierarchical taxonomy applicable to simulation activities. The revised Bloom's Taxonomy hierarchy progresses from the lower level objectives – remember and understand – to the higher-level objectives – apply, analyze, evaluate, and create. These verbs provide structure and communicate the KSA's the participant is intended to achieve as a result of participating in a simulation activity. [20]

Performance measures are another common term used in educational settings to operationalize objectives. These measures are the blueprint for the expected actions of the learner for each objective. Put simply, they enable progress toward objectives to be measured, may be used to guide progression through the scenario from state to state, and focus feedback/debriefing. When integrated effectively, performance measures allow the facilitator to specifically know when the objectives have been met or unmet. Performance measures can provide a realistic estimate on how long a scenario may take to complete. A few good online resources for objectives, outcomes, and performance measures are:

- How To Develop Targeted Simulation Learning Objectives – Part 1: The Theory [21]
- University Of Central Florida – Introduction to Blooms Taxonomy [22]
- E-Learning Heroes – An Introduction to Bloom's Taxonomy For Instructional Designers [23]

Curriculum Development and Management for the HSTS

The HSTS has an important role in successful attainment of learning objectives and curriculum development. While HSTS roles vary by setting, there are opportunities to create, clarify, develop, standardize, and support learning in all settings. The HSTS provides a unique and vital view of all simulations and may provide standardization of operations and valuable feedback for quality programmatic improvement.

In curriculum development, a method should be identified to consistently organize each simulation experience for each simulation center. Electronic file naming, scenario design templates, and storage locations should be identified. One method for organizing each case is to determine the elements consistently used in a program and use a paper binder system for hands-on delivery of the simulation. This method allows for real-time changes and notes to be added to the case during the simulation and incorporated into the evaluation after the simulation. Not all simulations will have all elements but knowing where to locate the details consistently is essential in daily operations.

An example of a binder setup is provided in Fig. 7.1.

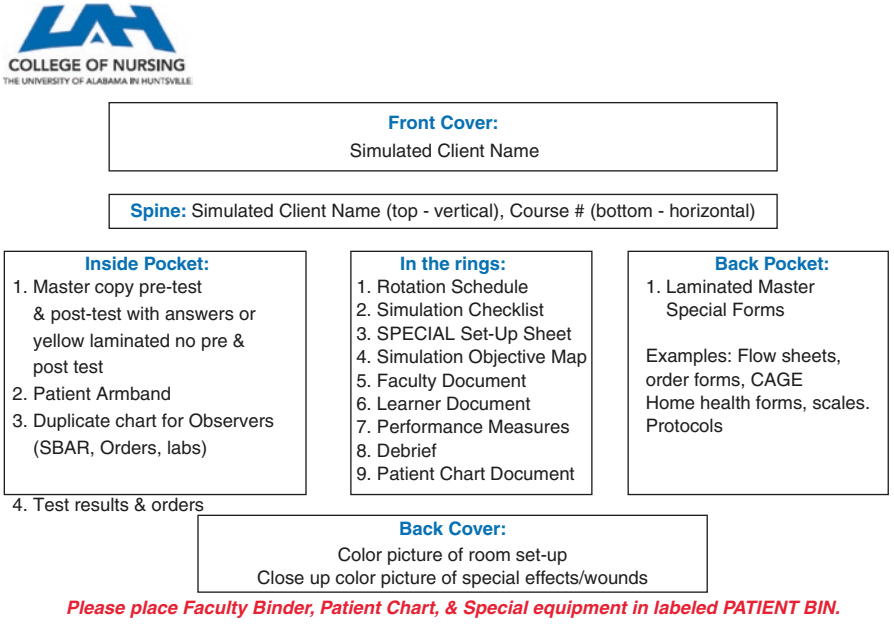
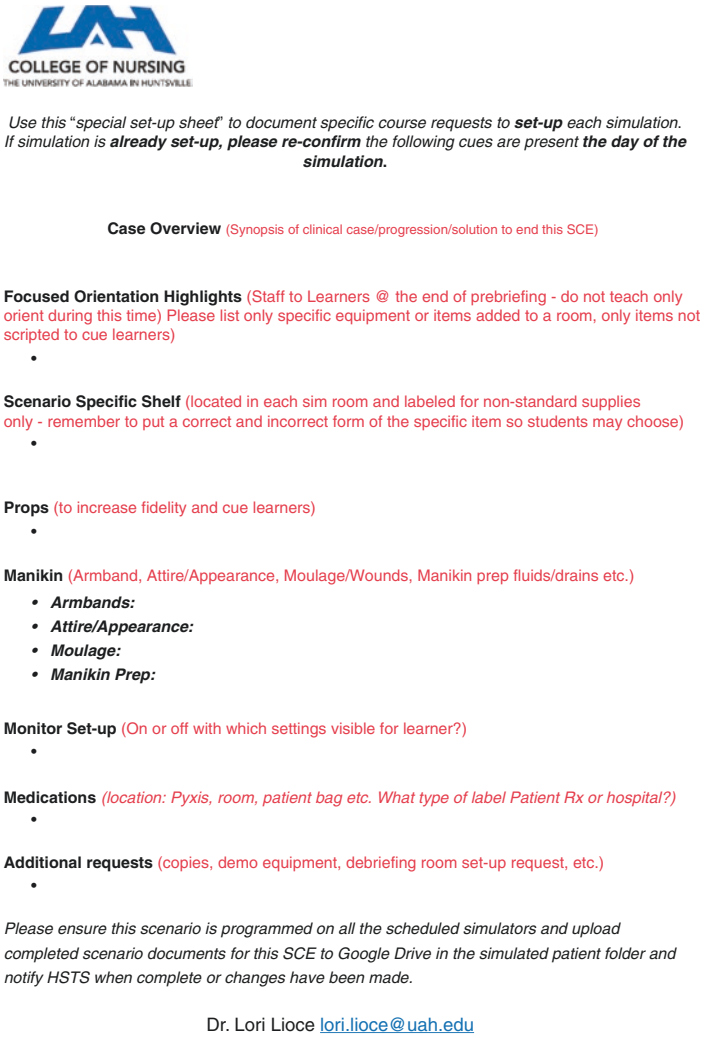


Fig. 7.1 Simulation binder setup. (Provided by Dr. Lori Lioce, University of Alabama in Huntsville College of Nursing)



COLLEGE OF NURSING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Use this "special set-up sheet" to document specific course requests to ***set-up*** *each simulation. If simulation is* ***already set-up, please re-confirm*** *the following cues are present* ***the day of the simulation.***

Case Overview (Synopsis of clinical case/progression/solution to end this SCE)

Focused Orientation Highlights (Staff to Learners @ the end of prebriefing - do not teach only orient during this time) Please list only specific equipment or items added to a room, only items not scripted to cue learners)

-

Scenario Specific Shelf (located in each sim room and labeled for non-standard supplies only - remember to put a correct and incorrect form of the specific item so students may choose)

-

Props (to increase fidelity and cue learners)

-

Manikin (Armband, Attire/Appearance, Moulage/Wounds, Manikin prep fluids/drains etc.)

- ***Armbands:***
- ***Attire/Appearance:***
- ***Moulage:***
- ***Manikin Prep:***

Monitor Set-up (On or off with which settings visible for learner?)

-

Medications *(location: Pyxis, room, patient bag etc. What type of label Patient Rx or hospital?)*

-

Additional requests (copies, demo equipment, debriefing room set-up request, etc.)

-

Please ensure this scenario is programmed on all the scheduled simulators and upload completed scenario documents for this SCE to Google Drive in the simulated patient folder and notify HSTS when complete or changes have been made.

Dr. Lori Lioce lori.lioce@uah.edu

Fig. 7.2 Simulation special setup sheet. (Provided by Dr. Lori Lioce, University of Alabama in Huntsville College of Nursing)

For consult meetings and dry runs (also called piloting), the HSTS should have a list of planning questions, used consistently, to help streamline the process. This meeting is vital to gathering all the information to design and test a simulation prior to integration with learners. A special setup sheet may be used to document and organize requests and can be used for consultation. An example of a simulation special setup sheet is provided in Fig. 7.2.

The HSTS should be prepared to ask questions to guide a planning meeting. What are the concepts or objectives for this simulation? What is the level of fidelity and immersion? The prepared HSTS will provide a menu of options for the requestor, which may include a list of simulations available and an overview of

Tip
When consulting with the simulation educator or testing the design, consider incorporating a purposeful error such an expired medication and a look-alike and sound-alike medication or mixing in several pieces of like equipment so the students have a choice and can test their processes and knowledge. The goal is for simulation to mimic real clinical practice. If we only provide what is necessary for each simulation, we limit the room for learners to make choices and test the safety and effectiveness of their practice in our curriculum.

similar simulations currently in use, and even suggest new design options. The HSTS should be able to review available equipment they would recommend to assist in achieving the simulation objectives/performance measures and scheduling recommendation/availability and be able to demonstrate other equipment or resources to support the simulation.

Compiling this information and common questions into a process that may be used at the initial meeting and dry-run can save valuable time and resources. An example of a dry-run process using the simulation design elements is provided in a checklist in Fig. 7.3.

COLLEGE OF NURSING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

a **SCE Dry-Run Process**

	Set up Dry Run 2 weeks prior to SCE with the Course Manager. Course Manager will coordinate all faculty in the course. Coordinate date/time with Educator.
	Ask if any faculty are new to course or UAH and schedule facilitation debriefing training prior to dry run and implementation. List names and emails here for follow up: _____
	Completely prepare binder (all documents should be received a minimum of 5 days prior to Dry run for review/revision).
	Email confirmation for dry-run to all faculty and Dr. Lioce. Include Dry-Run Agenda w/room/time & documents (5 days prior).
	Ensure everything is prepared and set up exactly as specified on the "Special Set-up Sheet."
	Anticipate and prepare additional items you would recommend to meet objectives.
	Lead dry-run with agenda. Begin with introductions and review objective for this scenario and use of this template. Identify your operational questions ahead of the dry-run and refer to them to guide the discussion.

Supporting Reference and direct quotes:

Lioce, L., Meakim, C.H., Fey, M.K., Chmil, J.V., Mariani, B., & Alinier, G. (2015). Standards of best practice: Simulaion standard IX: Simulation design. *Clinical Simulation in Nursing, 11*(6), 309-315.

Fig. 7.3 Dry-run process (**a**) and checklist (**b**). (Provided by Dr. Lori Lioce, University of Alabama in Huntsville College of Nursing)

COLLEGE OF NURSING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

b

To achieve optimal outcomes, aid in program development and consistency, simulation design standards (Lioce et al., 2015) must be utilized and the following elements reviewed during all dry runs. Please initial each item.

✓	Simulation Design
	1. Needs assessment - confirm the SBE meets the needs of the course/faculty by reviewing the SIM objective map (SOM) (clear & complete)
	2. Measurable objectives
	Review objectives - one by one - clarify if necessary
	Ensure they are measurable during the scenario
	Review concise performance measures; ensure they are knowledge, skills, behaviors, or attitudes which can been seen during this activity; identify where in the scenario they may be measured (states)
	3. Format of simulation - Purpose, Theory
	Modality (platform for the experience) simulated clinical immersion
	Virtual presence, computer-based simulation, virtual reality, procedural simulation, hybrid simulation
	These modalities are achieved using standardized patients, manikins, haptic devices, avatars, partial task trainers
	4. Clinical scenario or case - follow set-up sheet, ask for changes and clarifications- use template if brand new
	• Situation and Backstory
	• Clinical Progression and Cues
	• The script
	• Identification of Critical Actions/Performance
	• Measures
	• Time Frames (fits our standard framework, reservation times, or requires additional time)
	5. Fidelity (create the perception of realism)
	Physical (replicates the actual environment: patient(s), simulator/manikin, standardized patient, environment, equipment, embedded actors, and related props)
	Conceptual (all elements of the scenario or case relate to each other in a realistic way so that the case makes sense as a whole to the participant)
	Psychological (maximizes the simulation environment by mimicking the contextual elements found in clinical environments, for example, an active voice for the patient(s) to allow realistic conversation, noise and lighting typically associated with the simulated setting, distractions, family members, other health care team members, time pressure, and competing priorities. Psychological fidelity works synergistically with physical and conceptual fidelity to promote participant engagement.)
	6. Facilitator/Facilitative approach
	• Confirm formal facilitation training or schedule with Dr. Lioce ***Date of training*** _____
	• Review Framework - tailor review to the need of those present
	• Co-facilitation offer to have an additional facilitator present for support, practice/mentoring
	• Standardize cueing through high level review and summary at end
	• Use the Scripts to dry run the case (which ones are clear/need to revise?)
	• Review vital objective cues are reflectivel of clinical practice - marked and present
	7. Briefing - Review & Recommend introduction of PEARLS to students in their course
	• Confirm debriefing training or schedule for training with Dr. Lioce ***Date of training*** _____
	8. Debriefing and/or feedback
	• Offer Co-debriefing schedule with Dr. Lioce ***Date/Time*** _____
	9. Evaluation
	• Review and give a copy of faculty self-assessment form-complete it and return it to office #349
	• Review Qualtrics link and discuss process for ensuring learner evaluations are completed
	Course managers will receive aggregate report upon request or annually.
	10. Participant preparation - review and place a copy of all learner preparation; follow up with email if necessary
	11. Test of the design - **not a walkthrough**. Complete dry-run at the bedside with all supplies present. Test the design and determine if participant cues are present. Will they see what we think they will see? Are interventions and equipment present and sufficient. Update paperwork and orders for clarity. Everything should lead back to the objectives.

Dr. Lori Lioce lori.lioce@uah.edu

Fig. 7.3 (continued)

Establishing and maintaining a simulation library list are highly recommended. The library list should include patient's name, age, diagnosis, medical concept, and course(s) using that simulation. The library list should be

Simulation Scenario Library								Simulation Tracking		
Original Programmed Simulator	Case Author	Case Name	Date Created	Date Revised	Patient Age	Scenario Name	Type	Couse #	Fall 2017	Spring 2018
PediSim	Dr. Pediatrician	New Palpitations	4/12/17	1/5/18	6	Dehydration and Fever	Assessment	Peds 101	X	
Hal	Dr. John	Shortness of Breath	3/12/16	9/12/17	54	Spontaneous Pneumothorax	Testing	EM Final	X	X

Fig. 7.4 An example of table headers for a Simulation Scenario Library

maintained in a database which can be easily sorted (e.g., Excel, Access). This information will be important as a simulation program expands and when consulting with new facilitators, faculty, or partners. The process of how this library should be used and maintained should be written down and include instructions for how to make additions, deletions, or revisions. If there are restrictions about how a scenario should be used, this information should be noted as well. This written information should allow multiple individuals to follow a consistent procedure for documentation.

Examples:

- Each time a new scenario is designed, the scenario development process will include placing the name and information into the library.
- When a course reserves a simulation, every effort should be made to avoid repeating a scenario for the learners.

The level of programmatic and curriculum detail in such a database may start with development and maintenance of a list of all simulation cases/courses with objectives and performance measures. This list should include the year each case was developed, updated, and where they were used. This will provide an overview of what simulations are available and can aid in consultation.

An example of table headers is shown in Fig. 7.4.

Maintenance of these curriculum documents provides evidence for accreditation, programmatic overview, documents growth, and quality improvement when maintained appropriately.

Scenario design is covered in Chap. 12 and differs operationally from curriculum development. Scenario design is the process to create a simulation experience. Curriculum development is the overall integration of simulation in a program. A Simulation Operation Framework (SOF) includes the process for planning and executing the curriculum to standardize simulation.

An example of a curriculum planning process is provided in Fig. 7.5.

Operationalizing the Curriculum

Once a curriculum planning process has been identified, attention should be focused on the Simulation Operation Framework.

Operationalizing curriculum development may be one of the most challenging, overlooked, and overarching concepts in simulation education. Simulation

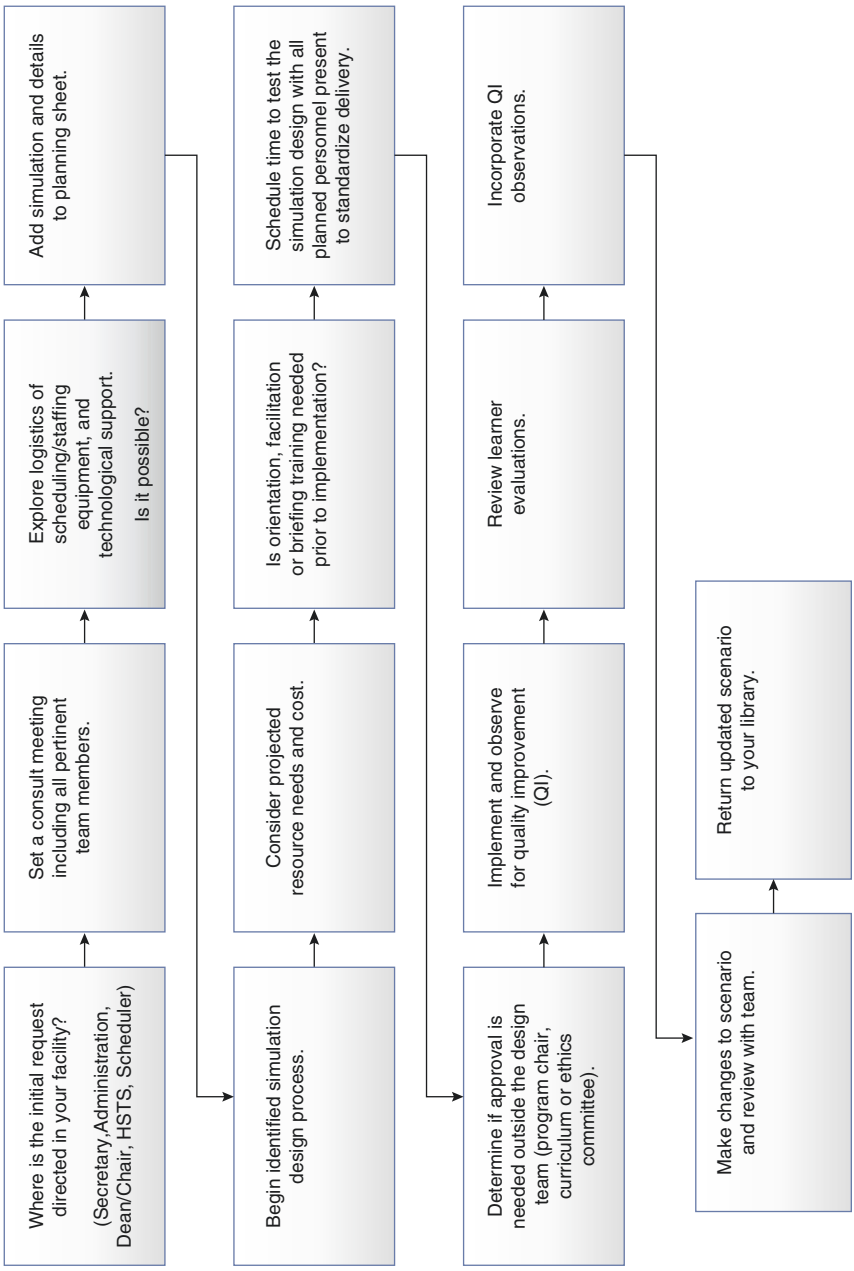


Fig. 7.5 Lioce simulation curriculum planning process. (University of Alabama in Huntsville College of Nursing)

education requires purposeful design to provide a framework for effective achievement of learning objectives and "promotes essential structure, process and outcomes that are consistent with programmatic goals and/or institutional mission" [15]. Simulation operations and standardization of delivery are now an ethical imperative, especially when validating or measuring learning. In an effort to provide solutions for clinical placement and in order to actively engage learners, the field of simulation expanded rapidly. Focus was initially placed on purchasing specific equipment, to build and utilize facilities, and to customize simulation experiences for early adopters. Customer service was vital in integration and adoption of simulation. Often end users would state "I would like to do…," "Can you make it work," and "We would like you to provide technical support only." These types of comments drove early curriculum development and operations in education, but that is no longer the case. Sustainability and consistency have become key as the rapid development of the science of simulation education has evolved and a focus on return on investment (ROI) and outcome measurement has become possible. Valid evaluation methods and tools are widely available, and research is growing. Some currently available tools include the Facilitator Competency Rubric (FCR), Simulation Effectiveness Tool – Modified (SET-M), Simulation Culture Organizational Readiness Survey (SCORS), and Clinical Learning Environment Comparison Survey (CLECS). These tools can be used to assist with evaluation of facilitators, the simulation learning environment, and the curriculum [24–27].

So, how does a curriculum get operationalized? It may be helpful to use a common change theory such as Lewin's Change theory for this process. This theory supports that there are three concepts in change: driving forces, restraining forces, and equilibrium. Making small steps will increase buy-in, improve educator training, and help maintain change and framework adherence as the program grows [28]. It is important not to overwhelm the stakeholders. Start simple, and roll the framework out in phases especially if there is existing simulation program or process. Using a change process, such as Lewin's change process, can be helpful for curriculum integration, policy and procedure changes, or implementation and personnel training. A simulation center has many moving parts, and it can be daunting to manage and deliver valid simulations.

Steps for framework design and implementation:

1. Develop a shared strategic vision for simulation.
2. Customize an operational framework.
3. Prepare a framework proposal presentation for stakeholders.
4. Solicit and integrate feedback.
5. Seek formal approval and adoption from a curriculum committee or administration. Identify who may approve it and how that approval is documented. Where will the document live? When should it be reviewed and revised?

6. Develop and introduce a strategic plan for rolling out the framework – How will the framework be introduced? How will new employees find out about it? Where can they locate the framework? How will it be referenced?
7. Identify and introduce an evaluation tool and quality improvement process with a policy or plan for review and integration of evidence generated by the process.

Designing a Simulation Operation Framework (SOF) which works in your center is vital to consistent delivery of simulation experiences. The framework should provide transparency and unite all roles in simulation so everyone participating in the delivery of the simulation experience can clearly understand the support being provided. For example, at various times during a simulation experience, the staff may not be seen, but are working hard behind the scenes to set the facilitator and learners up for successful experiences. The SOF empowers all personnel involved and helps to build trust between roles when a vision is shared and consistently followed.

An example of an SOF which explains staff support is provided in Fig. 7.6. There are six steps in this SOF:

1. Faculty/staff pre-brief
2. Learner pre-brief
3. Scenario
4. Learner debrief
5. Faculty/staff debrief
6. Evaluations

Each day the items bolded on the sides in Fig. 7.6 are replaced with the detailed information (faculty last name, debriefing room assigned, and scenario, or patient's name).

This SOF is further operationalized in a faculty packet (see Table 7.2) to provide the evidence behind the process and is reviewed in faculty orientation and used in facilitation and debriefing training.

The SOF and faculty packet may be laminated and readily available in each debriefing room for easy reference reinforcing the framework and promoting the best outcomes.

Tip

Development of a master operations calendar with preset reminders for weekly, monthly, quarterly, and annual tasks is vital for sustainability and consistency. Include simulation operation framework orientation with the start of new learners, faculty, and staff; policy review and revisions, maintenance, simulation library updates, staff technical updates; and training, annual planning, and evaluation.

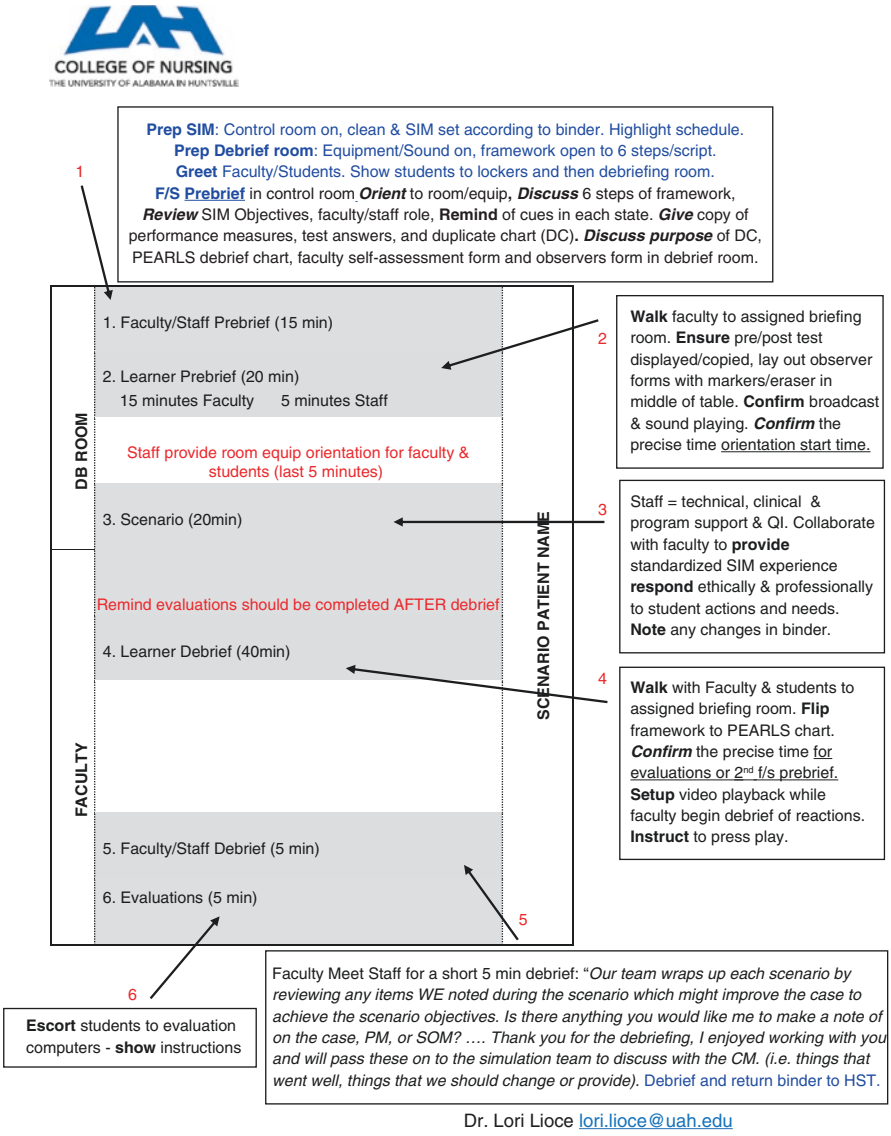


Fig. 7.6 Lioce simulation operations framework detailed staff support. (Provided by Dr. Lori Lioce, University of Alabama in Huntsville College of Nursing)

Table 7.2 Six-page faculty packet

Page #	Name	Purpose
1	Cover sheet and introduction to framework	Provides program reminders, educate simulation users on the evidence base for the operational framework supporting adherence to the standards from SSH and INACSL.
2	Facilitators operational framework	Describes the six-step process. Specifically written for our facilitators/debriefers on our program and equipment to assist integration. Increases adherence to the framework and decreases anxiety about the process.
3	Simulation orientation	Script for the learner brief with prompts for conversations for simulation introduction, teamwork, communication, safety, and equipment overview and orientation. Eases both learner and facilitator anxiety and enables novice facilitators to learn simulation terminology and framework.
4	Simulation agenda	Provides sample single simulation rotation schedule with specific time estimations.
5	Debriefing guide	Overview of PEARLS debriefing script.
6	Observers form	Form to engage simulation observers in active learning and encourage participation in debriefing.

Conclusion

The HSTS has an indispensable role in curriculum development and delivery. Vision, innovation, and technical knowledge can greatly expand and improve educational opportunities. There is room for creativity in curriculum development. Frameworks and process should not stifle this input but provide a supportive environment for innovative engaging education. A process for engaging the HSTS supports better experiences, measurable outcomes, greater efficiency, and increased return on investment. If there is not a clear process in a facility, find a champion (it can be the HSTS), to open a discussion, propose alternatives, and work to initiate this process by setting up meetings to share ideas. These processes must be customized and should guide but not dictate practice.

The HSTS can encourage growth of the simulation program and expand curriculum development by implementing a few simple strategies such as offering brief product demonstrations, smart and brief email teasers, offer quick after-hours open houses to get to know the equipment, build confidence in teaching or to launch new technologies to increase buy-in and support integration, use lunch breaks for continuing simulation education "bites", publicize or highlight successful simulations, provide frequent short "open house" technology showcase. The HSTS should be the in-house expert to investigate, lead, and present the capabilities of new technologies and integration of ideas. These ideas should first be presented to stakeholders in a short written informal proposal to gain momentum and collaborate and formulate ideas with others. The HSTS is the primary simulation champion partnering with healthcare simulation educators to reinforce excellence in simulation by publicly recognizing curricular innovations and celebrating successful simulation in a facility. This will encourage simulation and technology late adopters to expand simulation.

While organizations will build a sustainable program, the HSTS can guide the focus on learner-centered experiences, exploration of thinking, reflection on action, and validation of competency. These are the overarching goals of simulation education. Overall, with effective communication, a customer service attitude, a spirit of inquiry and innovation, as well as an eye for quality improvement, an HSTS can serve to guide and improve a simulation program from an individual scenario across its entire curriculum.

References

1. Lioce L, Graham L. Call to action: ethical awareness in healthcare simulation. J Nurs Healthc. 2017;2(2):1–5.
2. Ministry of Education Y, and Information. About [Online] http://www.moe.gov.jm/about. Government of Jamaica; [cited 2018 June 11]. Available from: http://www.moe.gov.jm/about
3. Ministry of Education of the Peoples Republic of China. The responsibilities of the ministry of education [Online] http://en.moe.gov.cn/About_the_Ministry/What_We_Do/201506/t20150626_191288.html [cited 2018 June 11]. Available from: http://en.moe.gov.cn/About_the_Ministry/What_We_Do/201506/t20150626_191288.html
4. U.S. Department of Education. An overview of the U.S. Department of Education [Online] https://www2.ed.gov/about/overview/focus/what.html - whatis. U.S. Department of Education; 2010 [cited 2018 June 11]. Available from: https://www2.ed.gov/about/overview/focus/what.html - whatis.
5. The Joint Commission. About the Joint Commission [Online] https://www.jointcommission.org/about_us/about_the_joint_commission_main.aspx. Available from: https://www.jointcommission.org/about_us/about_the_joint_commission_main.aspx
6. Purva M, Nicklin J. ASPiH standards for simulation-based education: process of consultation, design and implementation. BMJ Simul Technol Enhanc Learn. 2018;4:117–25.
7. Crawford SB. ASPiH standards for simulation-based education: process of consultation, design and implementation. BMJ. 2018;4(3):103–4. https://doi.org/10.1136/bmjstel-2018-000323.
8. U.S. Department of Education. Family educational rights and Privacy Act Regulations 2009; Jan 23 2018. Available from: https://www2.ed.gov/policy/gen/guid/fpco/pdf/ferparegs.pdf
9. Valiga T. Curriculum evaluation. In: Oermann M, editor. A systematic approach to assessment and evaluation of nursing programs. Washington, DC: Wolters Kluwer; 2017. p. 19–28.
10. Pak KM, Hardasmalani M. A multidisciplinary obstetric trauma resuscitation using in situ high-fidelity simulation. Adv Emerg Nurs J. 2015;37(1):51–7.
11. Kern D, Thomas P, Hughes M, editors. Curriculum development for medical education: a six-step approach. 2nd ed. Baltimore: Md Johns Hopkins University Press; 2009.
12. United States Navy. Naval Education and Training Command Integrated Learning Environment Course Development and life-cycle maintenance [Online] http://www.netc.navy.mil/ile/_Documents/NAVEDTRA136/NAVEDTRA_136.pdf; 2010. Available from: http://www.netc.navy.mil/ile/_Documents/NAVEDTRA136/NAVEDTRA_136.pdf
13. DeWolfe T. Jean Piaget's theory of cognitive development. In: Salem Press Encyclopedia of Health. Amenia: Grey House Publishing; 2013.
14. Hean S, Craddock D, O'Halloran C. Learning theories and interprofessional education: a user's guide. Learn Health Soc Care. 2009;8(4):250–62.
15. INACSL Standards Committee. INACSL standards of best practice: SimulationSM simulation design. Clin Simul Nurs. 2016;12(Supplement):s5–s12.
16. INACSL Standards Committee. INACSL standards of best practice: SimulationSM outcomes and objectives. Clin Simul Nurs. 2016;12(Supplement):S13–5.

17. INACSL Standards Committee. INACSL standards of best practice: SimulationSM simulation-enhanced interprofessional education (Sim-IPE). Clin Simul Nurs. 2016;12(Supplement):S34–S8.
18. Kirkpatrick DL. Evaluating training programs. San Francisco: Tata McGraw-Hill Education; 1975.
19. Krathwohl DR. A revision of Bloom's taxonomy: an overview. Theory Pract. 2002;41(4):212–8.
20. SimGHOSTS. Fundamentals of Training and Education [Online] https://www.simghosts.org/assnfe/Ev.asp?ID=33 [cited 2017 April 11]. Available from: https://www.simghosts.org/assnfe/Ev.asp?ID=33
21. Kuuskne M. How to develop targeted simulation learning objectives – part1: the theory. 2015 June 11, 2018. Available from: https://emsimcases.com/2015/04/21/how-to-develop-targeted-simulation-learning-objectives-part-1-the-theory/
22. University of Central Florida: Faculty Center for Teaching and Learning. Bloom's Taxonomy, June 11, 2018. Available from: http://www.fctl.ucf.edu/teachingandlearningresources/coursedesign/bloomstaxonomy/.
23. E-Learning Heros. An introduction to Bloom's taxonomy for instructional designers, June 11, 2018 [cited 2018]. Available from: https://community.articulate.com/articles/blooms-taxonomy-elearning-instructional-design
24. Leighton K. Development of the clinical learning environment comparison survey. Clin Simul Nurs. 2015;11(1):44–51.
25. Leighton K, Ravert P, Mudra V, Macintosh C. Updating the simulation effectiveness tool: item modifications and reevaluation of psychometric properties. Nurs Educ Perspect. 2015;36(5):317–23.
26. Leighton K, Foisy-Doll C, Gilbert GE. Development and psychometric evaluation of the simulation culture organizational readiness survey. Nurse Educ. 2018;43(5):251–5.
27. Leighton K, Mudra V, Gilbert GE. Development and psychometric evaluation of the Facilitator Competency Rubric. Nurs Educ Perspect. 2018;39(6):E3–E9. https://doi.org/10.1097/01.NEP.0000000000000409.
28. Lewin K. Field theory in social science. New York: Harper and Row; 1951.

The Research Process

8

Stormy M. Monks and Rachel Bailey

Research is defined as "a systematic investigation, including research development, testing and evaluation, designed to contribute to generalizable knowledge" [1]. There are two key phrases in the definition of research that provide a more detailed description of the word. "Systematic investigation" is a hypothesis-driven project, with a specific question or questions to be answered and an a priori (prior) written plan for obtaining data which will test the hypothesis [1]. "Generalizable knowledge" refers to the results of the project having predictive value which can be applied in settings other than the specific one(s) where the data were collected [1]. Research is done in every field of study including medical/health simulation.

Research as a Process

Research is typically described as a cyclic process (see Fig. 8.1). Most research starts with a simple idea or question. A researcher can take this idea or general question, review literature pertinent to the topic, find a theoretical framework applicable to the topic, and solidify a research question. The research question is the most important part of the research process. If the researcher does not know the specific question that needs to be answered, no finding can fulfill the research need [2, 3]. The acronym PICO is often used to indicate the essential parts of a research question: P, problem or patient or population; I, intervention; C, comparison or control; and O, outcome [4, 5]. The research question can be written in the form of

S. M. Monks (✉)
Department of Emergency Medicine, Texas Tech University Health Sciences Center El Paso, El Paso, TX, USA
e-mail: stormy.monks@ttuhsc.edu

R. Bailey
Engineering and Computer Simulations, Orlando, FL, USA

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_8

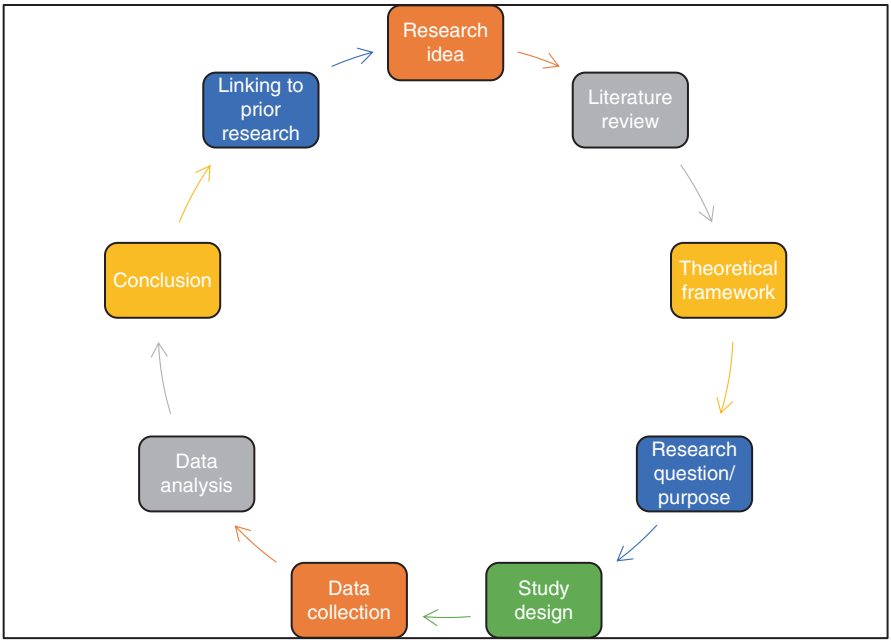


Fig. 8.1 The research process

a purpose statement [2]. For example, the research question, "Can a chest tube insertion simulation activity decrease the infection rates of chest tube placements?", can be turned into a research purpose statement, "The purpose of this study is to examine the effect a chest tube insertion simulation activity on chest tube infection rates."

The research question/purpose/aim/objective will define the road map for the research to be conducted. Specifically, the roadmap is the study design or plan that must be implemented in order to answer the research question [3]. Once the study is designed, study data can be collected and finally analyzed. The data collection and data analysis phases can often be very time-consuming and resource intensive; thus, it is essential to have someone on the research team that is familiar with statistics and interpreting study results. Once results are determined, the research team will proceed with answering the research question. This answer should be linked back to the theoretical framework that was chosen to best fit the study topic [2]. The research team can then move forward by comparing the results with other research that has been done and presented during the literature review. Taking the study results and past research into consideration, the research team must provide conclusions regarding the research. This includes the strengths and limitation of the study as well as areas of future research. The research process begins again with those areas of inquiry. While research might sound redundant and never-ending, the ultimate goal is to continue to expand the knowledge in one's field [3].

Approaches to Conducting Research

There are two main approaches to conducting research. The approach taken is typically decided by the type of research question the researcher is asking. The study design portion/roadmap of the research process is based on the approach chosen. The most common approach is the quantitative, often called empirical or traditional, approach. This approach aims at answering questions about relationships among variables that are measurable. The quantitative approach uses the scientific method and relies on numerical evidence to answer study questions [2, 6]. The qualitative or interpretive approach is known as the approach used to answer questions of phenomena. Specifically, this approach focuses on describing and/or explaining concepts by using words or word themes [2, 6]. This approach is not commonly used in medical/health simulation research, but it is widely used in social sciences research. There is a combination of these two approaches called a mixed methods approach [2, 7]. An example of this approach would be using participant surveys (quantitative) in combination with participant interviews (qualitative) to answer a research question.

The quantitative approach can be further broken down into three different study designs: experimental, quasi-experimental, and nonexperimental [2, 6]. The experimental study design is used when the research question is related to a cause and effect relationship. This design requires at least one independent variable and one dependent variable [2, 3]. For instance the research question would read, "Does _____ clearly cause _____ to change." The main indicator of an experimental design is that the study randomly assigns participant into a treatment group (intervention) or a nontreatment group (control). Researchers should follow the CONSORT (CONsolidated Standards of Reporting Trials) 2010 guideline when reporting randomized experimental research [8]. Quasi-experimental research attempts to control and influence study variables; however, random assignment is not used. Most research conducted is quasi-experimental as random assignment can be very difficult to achieve when planning a study [2, 6]. Nonexperimental, often called observational research, is another type of quantitative study design. Nonexperimental research is not attempting to answer questions of cause and effect; rather, it is descriptive in nature. Nonexperimental research is chosen when variables cannot be manipulated. Often times, this type of research is merely looking for relationships among study variables (i.e., correlational research), associations without definite causation. Evaluation and survey research are other types of nonexperimental research that are used in simulation settings [2]. Evaluation research is described as a process used to determine the effectiveness of a program in terms of meeting the program's goals and objectives. Survey research is the use of questionnaires to answer questions regarding the study population. Survey research is commonly included in other types of quantitative research as a method of data collection [2, 3].

"Good" Research

There are standards that must be met in order to consider a project/study "good" research. These include, but are not limited to, conducting a study based on previous work, based on a theoretical framework, having the study be objective and unbiased, and designing the study to answer a specific question. Prior to starting the design process of one's research study, the researcher must become familiar with existing literature related to the study [2, 3, 6]. For example, if a research team wants to do a translational research project showing how central line deliberate practice affects central line placement infection rates in the hospital, the first step would be to review past literature. It could be that this study has already been done in other hospitals and those studies can provide the information needed, or they can be improved upon. Additionally, it is imperative that research be based on an existing theory or model to enhance validity; researchers refer to this as a theoretical framework [2, 7]. There are several health education and adult learning theories that are applicable to simulation. As simulation research increases, there are new simulation theories being developed. Research should be designed to answer a specific question(s); thus, these questions should be defined for the reader once the literature review is completed. When reading a research paper, the key phrase to look to understand the reason for the study should read, "The purpose/aim/objective of the study is…" [7] Good research should be able to be replicated, validated, and generalizable to other settings [6]. If a research study is developed and reported correctly, others in the field should be able to use it as a template for their own research and have results that are consistent with past research [2]. Additionally, a study should be able to be conducted in multiple settings like various simulation labs and/or hospitals.

Institutional Review Boards

There are governmental policies and procedures that directly oversee research. Specifically, research that is done with human subjects/participants is covered under the Health and Human Services portion of the Code of Federal Regulations (45 CFR part 46) [1]. The Federal Policy for the Protection of Human Subjects, often referred to as the "Common Rule," is the first subpart of the code. Additionally, the code covers additional protections for pregnant women, human fetuses, and neonates; additional protections exist for prisoners and children. The Common Rule provides the standards for obtaining informed consent from study participants, the requirements of institutional review boards, and how to ensure compliance. Every institution that performs research on human subjects/participants should have an institutional review board (IRB) or be affiliated with one [1]. The IRB is a committee composed of scientists, nonscientists, and community members that review research study materials and protocols. They are responsible for assuring that the rights and well-being of human participants as research subjects are protected [1–3, 6, 9]. Human subject research includes accessing the

participant's private information such as their medical information. It also includes when personal information can be linked back to the study subject. Moreover, human subject research occurs when a researcher has contact with or information from all of the following: surveys, questionnaires, individual or group interviews, participant observation, noninvasive procedures, invasive procedures, medical/academic records, and/or educational research [1–3, 6, 9].

There are two main branches of human subject research: behavioral and biomedical research. Behavioral research focuses on the study of a subject's actions or reactions to various stimuli. Biomedical research examines the subject's biological process through observation, experimentation, and testing [1]. Based on the branch of human subject research, the requirements of the researchers are determined.

The Institutional Review Board Process

The IRB process is similar across institutions due to the fact that all IRBs must comply with federal regulations. Most academic institutions have their own IRB committee, but it is possible to apply to an outside IRB if the institution that one is associated with does not have one. In order to initiate a formal IRB research review, the researcher must first be trained in human subject research [1–3, 6, 9]. There are different trainings that will be required by each institution; however, the Collaborative Institutional Training Initiative (CITI) Program - Human Subjects Research course is commonly used across institutions [10]. This course provides a researcher with the imperative knowledge one needs to conduct human subject research. In addition, one can take supplemental courses to further one's knowledge fund. Once the researcher has completed the required trainings, they will be required to submit an official application to the IRB committee for each planned research project. This application will include a research abstract, a list of the study personnel, sponsor and/or funding information, and a full description of the study. In the study description, the study subjects and plans for their recruitment must be defined. Study methods & procedures must be clearly presented, including information on how the consent process will be implemented. Additional topics such as how the researcher will keep the data collected safe, risks and benefits of participation, and subject compensation must also be addressed. The researcher will also need to submit a written research protocol and any additional supporting and recruiting materials. The research protocol provides the introduction to the research topic (literature review), the research question, and the method that will be used to conduct the research. The researcher may also include the anticipated results and conclusions based on their literature review. Moreover, the researcher must submit an informed consent document and explain how the informed consent process will be implemented. Most IRB committees have an informed consent template that ensures consistency throughout the institution. The researcher is responsible for submitting all plans to the IRB prior to any research being done. Once submitted, the IRB committee will review the application and any additional documents [1–3, 6, 9]. The committee is responsible for confirming that the research complies with the Belmont

Report (the document in which the Common Rule was created). This report created the expectation that all research follows three principles: respect for persons, beneficence, and justice [11]. Once the IRB approves the research, the data collection and analysis phase can begin.

Research Write-Up

After the research data collection has been done, the art of writing a manuscript begins. Much of the manuscript has already been written in the protocol submitted to the IRB. A research manuscript is divided into sections. Each section plays an important role to tell the complete story of the research process. Remember to use the CONSORT checklist (Table 8.1) when writing as it provides a framework for what should be included in each section of the research write-up [8].

- *Title* – The title of the manuscript should be eye-catching and memorable. The length of the title should be no more than 10 to 12 words. It should allude to the purpose of the research [2, 3, 9, 12].
- *Abstract* – The abstract is typically written in a five-point structure (introduction/background, purpose statement, methods, results, and discussion/conclusion) with each section being described in one to three sentences. The purpose of the abstract is to summarize all of the sections of the manuscript providing the reader insight to the overall study. The abstract is typically 250 words or less [2, 3, 9, 12].
- *Introduction/Background Section* – The introduction/background section is the portion of the manuscript where the reader is introduced to the topic of the research. This section is based on the literature that was reviewed for the research. It begins with broad topic information and eventually tapers down to very specific information that is pertinent to the research study at hand. This section provides information, but it also points out the lack of information on the topic of interest establishing the need for one's research to expand and enhance the current literature. Additionally, it will inform the reader of the theoretical framework that the research was based upon. As discussed above, the literature review process of research is essential to properly forming the research question/purpose of the research [7]. The last sentence of the background/introduction section transitions the reader to the method section through the purpose statement. The purpose statement is, as the name suggests, a statement that explains the purpose of the research. Common examples of this is are as follows: "The purpose of this study was to…," "The main study objective is…," and/or "The research question was…." The purpose statement is often followed by the study hypothesis; however, stating the hypothesis is not necessary [2, 3, 7, 9, 12].
- *Methods Section* – The method section of a research manuscript provides a road map for the reader to understand how the research study was conducted. The method section should be very specific, leaving no room for interpretation on the part of the reader, essentially allowing the reader to duplicate the research study

Table 8.1 The CONSORT checklist for review of methods in planning and discussion conducting research and study design [8]

Title and Abstract	
	1a Identification as a randomized trial in the title
	1b Structured summary of trial design, methods, results, and conclusions (for specific guidance, see CONSORT for abstracts)
Introduction	
Background and Objectives	
	2a Scientific background and explanation of rationale
	2b Specific objectives or hypotheses
Methods	
Trial design	
	3a Description of trial design (such as parallel, factorial) including allocation ratio
	3b Important changes to methods after trial commencement (such as eligibility criteria), with reasons
Participants	
	4a Eligibility criteria for participants
	4b Settings and locations where the data were collected
Interventions	
	5 The interventions for each group with sufficient details to allow replication, including how and when they were actually administered
Outcomes	
	6a Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed
	6b Any changes to trial outcomes after the trial commenced, with reasons
Sample size	
	7a How sample size was determined
	7b When applicable, explanation of any interim analyses and stopping guidelines
Randomization:	
Sequence Generation	
	8a Method used to generate the random allocation sequence
	8b Type of randomization; details of any restriction (such as blocking and block size)
Allocation and concealment mechanism	
	9 Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned
Implementation	
	10 Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions
Blinding	
	11a If done, who was blinded after assignment to interventions (e.g., participants, care providers, those assessing outcomes) and how
	11b If relevant, description of the similarity of interventions
Statistical methods	
	12a Statistical methods used to compare groups for primary and secondary outcomes
	12b Methods for additional analyses, such as subgroup analyses and adjusted analyses

(continued)

Table 8.1 (continued)

Results	
Participant flow (a diagram is strongly recommended)	
	13a For each group, the number of participants who were randomly assigned, received intended treatment, and were analyzed for the primary outcome
	13b For each group, losses and exclusions after randomization, together with reasons
Recruitment	
	14a Dates defining the periods of recruitment and follow-up
	14b Why the trial ended or was stopped
Baseline data	
	15 A table showing baseline demographic and clinical characteristics for each group
Numbers analyzed	
	16 For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups
Outcomes and estimation	
	17a For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)
	17b For binary outcomes, presentation of both absolute and relative effect sizes is recommended
Ancillary analyses	
	18 Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory
Harms	
	19 All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)
Discussion	
Limitations	
	20 Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses
Generalizability	
	21 Generalizability (external validity, applicability) of the trial findings
Interpretation	
	22 Interpretation consistent with results, balancing benefits and harms and considering other relevant evidence
Other information	
Registration	
	23 Registration number and name of trial registry
Protocol	
	24 Where the full trial protocol can be accessed, if available
Funding	
	25 Sources of funding and other support (such as supply of drugs), role of funders

with the information provided. This section should include many subsections describing the research. These subsections include setting, participants, materials, measures, study design, procedures, ethical considerations, and data analysis. Again, this section provides the reader with the information needed to fully understand how the research was conducted [2, 3, 9, 12].

- *Results Section* – The results section can be described as very bland or tedious. It is simply stating the results of each statistical test run on the study data. The data

analysis section is revisited here by presenting the statistical test and the results of the test. The section often starts with descriptive data and then moves into more complex statistical analysis results. In this section, it is imperative to first address the purpose of the research. This is best accomplished by starting with main study findings and then moving to secondary research findings. Tables, graphs, and figures are often used to present the study results in a more reader-friendly manner. This is not the section where the researcher interprets the data, which is left for the discussion/conclusion section [2, 9, 12].

- *Discussion/Conclusion Section* – This section begins with revisiting the purpose of the research study. There is then movement toward the implications of the research by interpreting the study results. In this section, the researcher makes statements explaining the data presented in the results section as well as connecting the study findings to the literature presented in the introduction. Do not leave the reader to contemplate the research findings, instead provide clear and concise linkages between the study purpose/questions, the results found, and the interpretation of the findings (conclusions). This is the only section where the researcher should use persuasive writing to help the reader come to an agreement with their study conclusions. However, avoid grandiose statements or large leaps between the data and the study conclusions when interpreting the data. The discussion section often includes subsections including study limitations, strengths, areas for future research, and study implications [2, 9, 12].

Research Is Not for Everyone; but Give It a Try

Conducting research is a time-consuming and effort-intensive endeavor. Successful researchers are often trained in research methods and techniques specific to their field of study. However, novice researchers can learn from research mentors and eventually become an independent researcher [2, 12]. It is imperative to remember that research is not a single event or activity; as mentioned several times in this chapter, it is a process. Begin the research journey by attending research presentations, reading research manuscripts, familiarizing oneself with research methods and techniques, finding a research mentor, and developing research questions. These activities will assist not only with the understanding of the research process but with the uncovering of one's part in research. Chapter 16 will address the specific role of a healthcare simulation technology specialist in research.

References

1. US Department of Health and Human Services. Code of federal regulations. Title 45 Public welfare. Department of Health and Human Services. Part 46: Protection of human subjects. Washington, DC: US Department of Health and Human Services; 2009.
2. Cottrell RR, McKenzie JF. Health promotion and education research methods: using the five-chapter thesis/dissertation model. Sudbury: Jones & Bartlett; 2010.

3. Hulley SB, Cummings SR, Browner WS, Grady DG, Newman TB. Designing clinical research. Philadelphia: Lippincott Williams & Wilkins; 2013.
4. Huang X, Lin J, Demner-Fushman D, editors. Evaluation of PICO as a knowledge representation for clinical questions. AMIA annual symposium proceedings, American Medical Informatics Association; 2006.
5. Schardt C, Adams MB, Owens T, Keitz S, Fontelo P. Utilization of the PICO framework to improve searching PubMed for clinical questions. BMC Med Inform Decis Mak. 2007;7(1):16.
6. Cook TD, Campbell DT, Shadish W. Experimental and quasi-experimental designs for generalized causal inference. Boston: Houghton Mifflin Boston; 2002.
7. Rocco TS, Hatcher TG. The handbook of scholarly writing and publishing. New York: Wiley; 2011.
8. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMC Med. 2010;8(1):18.
9. Gastel B, Day RA. How to write and publish a scientific paper. Santa Barbara: ABC-CLIO; 2016.
10. Collaborative Institutional Training Initiative (CITI) Program. 2000. Available from: https://www.citiprogram.org/
11. US Department of Health and Human Services. The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research, National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 45. Washington, DC: US Government Printing Office; 1979.
12. Bem D. Writing the empirical journal article. In: Darley JM, Zanna MP, Roediger III HL, editors. The compleat academic: a practical guide for the beginning social scientist. 2nd ed. Washington, DC: American Psychological Association (APA); 2004.

Infrastructure and Simulation Center Design

9

Ferooz Sekandarpoor, Eduardo R. Luevano, and Scott B. Crawford

Planning

When planning for the creation of a simulation center, the stakeholders and end users must first be identified. Organizing committees should both reflect on the immediate educational needs of currently existing programs and the potential needs of future expansions within the next decade. Many accrediting bodies have mandates for a curriculum allowing for interprofessional education, and simulation centers are frequently called upon to meet this requirement. Having an interprofessional curriculum means there will be multiple disciplines/specialties using the center (e.g., nursing, emergency medicine, surgery, anesthesia, pediatrics, obstetrics and gynecology, family medicine, pharmacy and allied health professionals just to name a few). Gathering input from each potential specialty to capture their requirements at the planning stage will ensure the center is designed to support each program's curriculum.

F. Sekandarpoor (✉)
Faculty of Medicine, University of British Columbia, Vancouver, BC, Canada
e-mail: ferooz.sekandarpoor@ubc.ca; Ferooz@simghosts.org

E. R. Luevano · S. B. Crawford
Department of Emergency Medicine,
Texas Tech University Health Science Center El Paso, El Paso, TX, USA
e-mail: Eduardo.luevano@ttuhsc.edu; scott.crawford@ttuhsc.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_9

Types of information to gather at the planning stages [1]:

- Size of available simulation space
- Number of learners to be supported
- Adjacent classroom space for lectures, briefing, and debriefing
- Necessary office space or common work areas
- Security and access to simulation center equipment
- Amount of storage needed
  - Type and number of simulators
  - Task trainers
  - VR and surgical simulators
  - Disposable equipment for restocking
  - Audio/video cables, adapters, and parts
- Requirements for audio/visual recording and viewing
- Educational technology needs (whiteboards, projectors, TV displays)

A separate consideration for simulation center design is that of in situ or mobile simulation. As discussed in Chap. 3, in situ simulation is an effective, team-based simulation design that allows educational sessions to occur in actual patient care units and hospitals with the benefit of involving the same healthcare team members, equipment, procedures, and processes in a real care environment. This type of training environment can occur in tertiary, regional, or rural hospital sites and even prehospital environments. In situ training creates close to real-life experiences, by allowing training to occur in a natural environment, utilizing existing supplies, equipment, and staff while building or enhancing relationships within interprofessional teams. Despite using existing space and equipment, planning must still occur to decide how and where to perform this type of training and storage or deployment of equipment. Some programs bring training tools into a room on an as-needed basis for training; others may dedicate a room for training as part of a permanent installation. If simulated medications are being used, storage and safety concerns exist about having equipment that is not intended for human use being placed in a real patient care environment. There are also cost and logistic considerations about real equipment being utilized and the concerns related to the Healthcare Information Portability and Accountability Act (HIPAA) if audio or video recording equipment is planned for use in a real patient care environment [2]. Borrowing from the principles of telemedicine, these concerns can be managed, but must be considered prior to implementation.

Typical Simulation Lab Usage

Simulation Room

Simulation labs are generally located at clinical academic campuses or may be integrated into healthcare centers such as hospitals consisting of one or several

dozen individual simulation rooms. Each room can typically accommodate from five to ten students plus one or more educators/facilitators beyond the space required for training devices, such as beds with manikins [3]. These numbers are estimates, and actual use will depend on local logistic requirements and educational practice. Constraining room size will maximize space utilization but may make simulations too crowded for multiple team members to participate. Larger rooms will allow for more learners but that does necessarily translate into effective learning, as learners can miss out on the experiential component if too many individuals are in the room. While more intimate groups are often preferred, the American College of Surgeons Program for the Accreditation of Education Institutes requires at least one space that can accommodate 20 learners at a time for hands on training [4]. These simulation spaces are used by students, residents, and healthcare providers to practice performing clinical procedures within a safe learning environment. Procedures can be conducted on a variety of simulated experiences including standardized patients (actors), task trainers, full-body patient simulators, or virtual patient devices.

Technology is used to support the delivery of clinical skills education by enhancing access to materials that learners can use to prepare, review, and debrief. However, the primary objective and focus should remain on the student's interaction with the simulated patient. As the cost for integrating immersive simulation experiences is high, these spaces should focus on improving communication skills, practicing patient rapport, working in teams, learning new skills and medical procedures, refining the approach to clinical encounters, and preparing students or training providers for their healthcare practice. Textbook learning and lecturing can occur outside of these specialized teaching areas to maximize utilization.

The orientation of the bed or examination table within the room must also be considered. The examination table or patient bed is usually placed such that the foot of the bed is nearest to the observation window of the control room. This helps maintain line-of-sight for the facilitator as most patient procedures occur at the head of the bed. Some centers have designed a layout where the observation room is elevated above the lab space, enabling facilitators to see over the bed. Other centers have specifically designed the room orientation to view the bed from the side and utilize camera angles to fill in obstructions posed by room participants. While no single layout is correct, anticipating the location of learners in the room and understanding the limitations of observation from each location will allow an appropriate design implementation.

The orientation of the patient's head relative to the room in hospital or emergency department rooms is often determined by the ability to place a "headwall" and the associated equipment into the wall space adjacent to it. Common requirements here will include electrical outlets and plumbing fixtures for vacuum and air connections as well as either real compressed oxygen or simulated oxygen from an air compressor. The potential need for audio or video connections that would not normally be considered in a real healthcare environment must also be considered when planning a simulation space.

Tip
Real oxygen is not required for most simulators to function. An air compressor with a separate reserve tank and pressure regulated 15–50 PSI outlet will allow simulated function of oxygen delivery devices by learners and mechanical operation of simulators (depending on manufacture) that use this level of air pressure to function [5, 6].

A remotely placed air compressor in a separate closet or storage facility will decrease noise pollution in the learning environment.

Simulation Setup

Before a learning event, the healthcare simulation technology specialist (HSTS) or educator(s) will set up all necessary equipment while ensuring that disposable items, such as gloves or masks, are well-stocked and test every system to confirm proper function. Upon the arrival of the learners, the educator(s) will provide the learner with relevant instructions, usually in an adjacent debriefing room, classroom, or in the simulation room space. Keeping this room in proximity will improve logistics and flow of participants during the simulation experience.

Typical exercises require 1–2 h from start to finish, including setup and debriefing. During the exercise itself, the learners will interact with and possibly administer medications to, or perform procedures on, the simulator. The learner will typically perform the exercise with at least one other individual. In some circumstances, the educator may have to provide instructions to the learner during the exercise. While observing, the educator is recommended to record and annotate the performance of the learners in order to facilitate an effective debriefing with the learner after the session. The operator and/or educator will observe the exercise through a two-way mirror or from a video capture display in an attached or nearby control room. Such observation is paramount to providing an insightful debriefing, enabling the instructor to discuss and review individual and team performance [7]. The ability to continuously monitor audio and line-of-sight (or video) from the simulation labs must therefore be strongly considered. During the event, facilitators/educators may need to communicate with the simulation participants through an audio system to address lapses in fidelity, communicate as the patient, or simply provide instruction. For some simulation experiences, facilitators/educators will participate in the scenario directly and will therefore require a separate dedicated wireless communication link between the facilitator and HSTS to trigger events during the sessions from within the lab itself. This communication link can also be used to inform the operator when to tag events for review during debriefing, if a video debriefing system is utilized.

After an exercise is complete, a facilitator/educator will debrief with the learner(s). A major point of focus will be the annotated observations that the

facilitator and HSTS made during the simulation event. This debriefing usually takes place in a room outside of the lab so that the simulation space's "realism" is maintained and so that the next scenario can be setup [7, 8].

Simulation and Control Room Requirements

When designing a simulation lab space, special consideration should be taken to ensure that the orientation of the room closely mirrors the clinical environment. This includes having access to an examination table and any medical equipment associated with procedures. This equipment can include headwall systems, portable diagnostic equipment, desks, or supplies from crash carts such as medications or oxygen masks. Just like in a real patient setting, the vital signs monitor should be placed where it can be seen by simulation participants. A whiteboard is commonly available to learners in sim labs for writing down patient information and treatment plans. This medium can allow sharing of information with others in the room and can help observers in the control room review the thought process and plan of the learners. A computer with internet access should be present in the room both to assist with demonstrating educational material and allow access to simulation-specific resources. A speaker phone is another important item to be considered as learners will frequently need to call on other healthcare professionals during simulated experiences. Determining how this phone can connect to your simulation control room is important to consider as well. If there is no need to call phones outside of the simualtion center, internal communication is possible using an IP-PBX-based calling system such as Asterisk or 3CX [9]. However, enabling this phone to call outside numbers can help during trouble shooting sessions with higher levels of technical support. The HSTS must be able to work with vendors and customer support personnel while in the same space as the device requiring support. Similarly, both for educational and diagnostic purposes, having ready access to available ethernet ports or wireless access should be considered to support expandability and additional devices depending on the use of the room and needs of the center.

The facilitator and HSTS should be able to see the simulation space and participants, ideally without being seen. This is often accomplished with the use of a two-way mirror between the simulation room and a control room. Although such glass is effective at achieving their named visual effect, applying a bright light to the control room side of this type of glass will actually defeat its optical properties and allow learners to see through the mirror as though it were just another window. This problem can be mitigated with the use of local light dimming within the control room space or even the use of a less intense red colored light to allow viewing and function within the control room space [10]. If the simulation room and control room are adjoined, the wall between theses spaces will benefit from sound proofing insulation to minimize carryover of conversations between spaces.

Each simulation control space will need to have an audio feed from the simulation lab space it observes so that learners can be heard. This is most

often from wall- or ceiling-mounted microphones. If the control space is shared with another control room, it is recommended that headphones are used to listen to this audio feed so as not to interfere with other simulation learning experiences. Chapter 11 discusses the audio/video needs of a simulation center in greater detail.

An additional audio consideration is the ability to talk through a speaker or existing manikin hardware in a real-time manner to allow natural interaction between the participants and patient. A separate audio cable run to the headwall for this purpose is becoming a common practice in many simulation designs. Some centers have even added a voice modulator for use with this speaker connection to allow the simulation operator to portray different voices or patient types such as male, female, geriatric, or child, regardless of the demographics of the operator.

Some facilitators also find great use in providing directed single room communication to help guide participants on a specific aspect of the case. Depending on the audio system design, this same speaker system can be used to provide overhead paging to an entire center or remotely to a specific room with timing reminders to facilitate logistics and flow of a multigroup simulation session. This type of overhead paging should be different than a manikin-based speaker used to communicate as the voice of the patient.

Debriefing spaces and video debriefing systems should have the ability to immediately replay sessions for review with annotations, and video cueing, enabling the ability to jump to a specific point for review and discussion. Some systems can allow learner access to view recordings of their own interactions for self-reflection and learning either on-campus or off. Access to recordings and the retention of stored items is an institution-dependent decision that should be described in detail in a policy. Some centers may keep a recording for only a few days to a week, while others maintain this data for the entire duration of matriculation of a learner. No correct answer exists, but the potential medical-legal ramifications about retrospective review of learner performance have driven concern for policy by many administrators. Separate from this administrative concern is the infrastructure requirements for long-term archiving and storage of data heavy video files. Each simulation center, if associated with a larger institution, must seek advice from accrediting bodies for specific policies and procedures.

Separate from line-of-sight or video observation of a simulation room, the HSTS and educator frequently want the ability to communicate with a facilitator in the simulation room from the control room via a wireless communication link. In addition to this confidential communication link, the control room observers also need the ability to hear the clinical skills session from the control room and be able to increase, decrease, or mute the volume of this observation.

Design Consideration

A key principle in designing simulation lab infrastructure is flexibility. This reflects the fact that educational and technology requirements will likely change over time as curriculum, clinical standards, and technologies evolve [11–14]. For example, one element of creating a flexible design might include specifying a moderate amount of additional conduit capacity to allow for future changes to wiring needs. Floor boxes are one way to provide this type of connectivity and expansion but usually require planning during a new build for structural reasons because of the significant depth of cutout required for in-floor installation.

The American College of Chest Physicians' Simulation Center planned for future expansion by running a single large channeled floor cutout through the center of all of the simulation rooms and control rooms so that new wires or tubes could be pulled simply by lifting a metal access plate. Wichita Area Technical College integrated an acoustically shielded wall conduit to allow cables and wires to be easily passed and exchanged from the control room to the simulation area (see Fig. 9.1). Dropped ceiling spaces allow for relatively easy access and expansion using cable ladders to suspend and lay new wires, but this is easier if empty conduit and junction boxes can be positioned before construction is completed so wires above the ceiling can be brought down to the wall for termination and use. Having a separate 2-gang box for connection of electrical, audio, video, and networking systems at each control room location will likely provide sufficient space for current and future expansion. More cost-conscious planning may allow sharing of space between these systems, but working with an audio/video design team in advance can help with these determinations.

Given that the simulation labs should closely model their corresponding healthcare environments, each clinical-based room should contain standard amenities like soap and paper towel dispensers and a sink for washing hands and cleaning simulation materials. Such tools are a necessary first step in teaching sterile procedures that require donning gowns and gloves.

The room should also have appropriate architectural design, acoustical treatments, wall and furniture colors, lighting, heating/cooling, power and data ports,

Fig. 9.1 An acoustically insulated wall conduit was installed through the wall between the simulation room and the control room to allow wires and hoses to pass. In this case, the conduit is separating the noise of the compressor used to operate the simulator from the educational environment of the room

and cable pathways to meet both functional and aesthetic expectations of the occupants. While simulation spaces are designed on the principles and function of existing healthcare spaces, designing the rooms and spaces to be slightly larger than a real-life counterpart is recommended to accommodate a group of learners that might not be part of the usual function of the real version of that space.

Movement and Space Requirements

Separate from standard Americans with Disabilities (ADA) and wheelchair access requirements, hallways and doorways need to be large enough to accommodate medical equipment movement into and out of rooms; this includes elevators. A full-sized hospital bed is 40″ × 91″, and even the smaller transportation stretchers are still 32″ × 83″ [15, 16]. Standard-sized office doors and hallway widths do not accommodate equipment of this size. Hallway widths of 8–10 ft are common, and some centers add cutouts along hallways or corridors to allow gurneys or other equipment to be stored or moved out of the main walking areas. To keep public spaces open and free of clutter, and for security reasons, some centers are designed with separate access to simulation rooms for staff and students. A back-access hallway can allow equipment storage and staging without being placed in sight of the learners who will be participating in an event. Some students may see a piece of medical equipment and predict what they are expected to do in an upcoming scenario.

Acoustics

Acoustics of simulation labs are very important to consider during the design stage, as sound transmission may result in future issues with installed audio/video equipment in the labs or cause distractions if there is sound carryover between rooms. It is recommended to consult an acoustical engineer to provide specifics on how to meet Sound Transmission Class (STC) requirements [17].

The goal is that a group of students in adjoining rooms should be able to converse at normal levels without interrupting their colleagues in adjacent rooms. While wall thickness and material choices are one component to this factor, the space above the walls, through the ceiling, and often through gaps or cracks in and around doors may be a consideration as well.

Doors

The extra wide doors (48″) that are required to move patient beds into and out of rooms are often designed in two parts, with a smaller side section to accommodate larger equipment [18]. This extra door segment creates a gap between the doors in addition to the one present along the bottom. Special gaskets or sweeps may be required to fill these spaces (see Fig. 9.2). Door jambs or blocks may also be desired

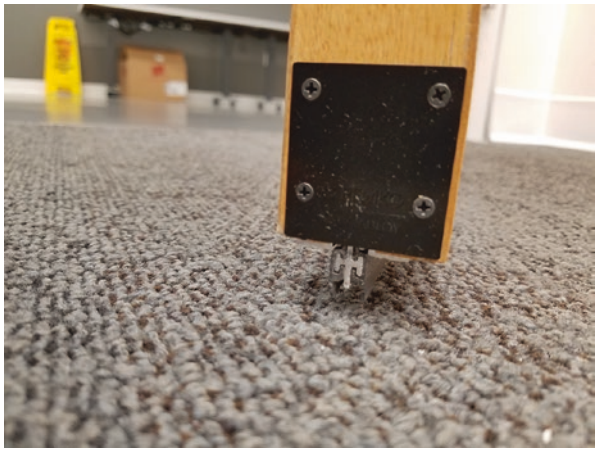


Fig. 9.2 A retractable door gasket is shown on a debriefing room. This gasket helps to decrease sound transmittance when the door is closed

to prevent doors from closing while trying to transport equipment. Additionally, having a door with a window in it may not be advantageous because it would allow outside observers to watch a simulation session that was occurring or may be a distraction for participants looking at activities occurring outside the room.

Flooring Material

Vinyl tile or adhesive flooring materials are common in institutional building settings due to low cost and ease of installation and maintenance. They provide little benefit to sound absorption however, and some centers and spaces have opted for carpet to reduce sound reflection. This poses a separate issue since simulations may use simulated blood or liquid products and even paints or makeup. Some simulation spaces are even sites for wet lab activities using animal and biologic materials. For this reason, a flooring consideration with nonporous easily cleanable surfaces may be preferable even if not acoustically superior.

Room Types

Reception Area

Depending on security arrangements and floor plans of a simulation center, the reception area will likely serve as the primary introduction to a center. This is where participants are greeted and receive direction to simulation or classroom activities. Many centers have benches or chair seating near the reception area to function as a waiting room or gathering point. Frequently this space will show pictures or use a video display to highlight the features and educational offering of the simulation center.

Some institutions now use electronic kiosks to allow learners to sign in for simulation events. This is a popular and efficient option when they are designed well. Some programs have implemented self-designed systems with Google Forms, while others use simulation-specific web-based login systems that use radiofrequency (RF) or other electronic badge readers to streamline the arrival process [14]. To allow use of this technology, an electrical wall or floor socket and wired network port should be available for each kiosk that is planned.

Classroom

As a starting point to a simulation activity that may have many participants or multiple sessions, having one or more classroom spaces to provide introductory information, orientation, or standard didactic instruction is still an important consideration. This room does not need to be immediately adjacent to the simulation lab spaces per say but should be in relative proximity to allow learns to transition from this space to each planned activity easily. This classroom can also serve as a meeting point and area for registration and should accommodate or have a nearby location to store personal belongings during the educational session(s).

Simulated Patient Rooms

This type of room is commonly the focus of simulation center design but is only one component of a simulation and training center's potential activities. The simulated patient room style is generally designed to mimic the look and feel of a specific hospital-based care environment such as an intensive care unit, emergency department room, labor and delivery suite, or operating theater. Smaller rooms that mimic doctor's offices or clinic spaces may be used either for manikin-based training or more commonly with standardized patients. Some centers have even designed specialized mock-ups of radiology, CT, and MRI scanning rooms to address the logistical issues related to patient care during a diagnostic study (see Fig. 9.3).

A typical simulation room for use with a manikin at many medical school ranges in size from approximately 300 to 450 ft^2 (see Table 9.1); some larger rooms may be needed to accommodate multiple manikins or special activities such as operating theaters or obstetrical delivery rooms. An intermediate-sized room approximately 13 ft × 15 ft (195 ft^2) is used by some centers for manikin-based simulation training for up to 6–7 participants. A smaller hospital gurney, instead of a full-sized hospital bed, can allow some additional floor space if needed. A smaller room will limit the number of learners that can be present at one time, especially when considering the additional medical equipment such as

Fig. 9.3 A simulated computed tomography (CT) scanner has been designed into this room at the Khalaf Ahmad Al Habtoor Medical Simulation Center, in Dubai

sinks, medication carts, ventilators, and code carts that must also be present during training. Room size and egress considerations will determine final appropriate occupancy for safety considerations.

Many SP rooms that are designated for remote viewing (without an attached control room) are designed to be between 8 ft × 8 ft (64 ft^2) and 10 ft × 10 ft (100 ft^2), mimicking a standard physician office space [14, 19]. This is adequate for an SP encounter with a couple or learners and an exam table similar to an outpatient clinic room. It has been suggested that increasing the size of this room design to 10 ft × 15 ft (150 ft^2) and adding a one-way viewing space can make an SP room multifunctional and future expandable. A slightly larger room footprint can accommodate a full-body manikin and permit use as a high-fidelity simulation room when needed [13].

Pharmacy

Simulation centers such as the Center for Healthcare Improvement and Patient Simulation (CHIPS) have incorporated simulation space to mimic a retail pharmacy. This type of space allows observation and training of skills such as patient counseling, medication review, and taking and filling phone orders of medications from providers as part of the curriculum. Some programs even have simulated drive-through kiosks to train skills required with interacting with patients in this manner.

Medication dispensing systems are also an important consideration for a simulation space. These devices can occupy a significant amount of floor space and may have specific infrastructure support requirements such as networking or the installation of a camera system of screen capture device for recording of learner activities.

Table 9.1 The relative size and distribution of rooms for several large medical school-based simulation centers [23]

	Simulation center size (ft^2)	Number of exam rooms	Exam room size (ft^2)	Number of sim rooms	Sim room size (ft^2)	Virtual sim room space	Common area size	Medical school class size	Year opened
Western Michigan University	18,650	12	150	10	432		3991	100	2014
Duke	10,170	12	123	3	449		1441	100	2013
Carolinas Medical Center	8230	12	130	6	307		2768	120	2011
Virginia Commonwealth University	13,450	16	123	6	439		449	200	2014
Stanford	14,650	12	125	2	765	3401	846	125	2010
Emory	10,500	16	140	3	614		–	150	2008
Johns Hopkins University	7080	12	130	3	317		2200	150	2006
Washington University	8950	13	95	4	314		571	150	2005
Mayo	6750	6	134	4	367		1194	50	1999

Fig. 9.4 An ambulance that has been installed inside of the Stavanger Acute Medicine Foundation for Education and Research (SAFER) simulation center in Stavanger, Norway to allow in situ type training while still inside the simulation center

Ambulance

Although in situ and field training are common for EMS and prehospital care providers, some centers have incorporated real or mock spaces to allow evaluation and training in the confines of an ambulance (see Fig. 9.4). The special skills and difficulties with providing care in limited space conditions are a very real challenge trained in this setting by some programs.

Therapy and Home Health Evaluations

Many centers have built simple but often fully functional home or apartment environments. These can serve as locations to train and evaluate therapy and home health needs of patients or as a site for in situ training of prehospital care providers to practice lifts, extraction of patients, and rendering care in difficult positons. Some

Fig. 9.5 Shows an apartment-style room inside of the Center for Healthcare Improvement and Patient Safety (CHIPS) at the University of Tennessee in Memphis

Fig. 9.6 An eight-bed ward-style classroom at the Texas Tech University Health Sciences Center El Paso, Training and Educational Center for Healthcare Simulation (TECHS)

designs may offer adjustable counter heights or different styles of door knobs and cabinet pulls to allow specific training across a larger range of potential home conditions. An example home design with these features is shown in Fig. 9.5.

Ward Room or "Skills Lab"

In addition to the audio/video intensive, directly observed, single-patient room occupied by a manikin patient simulator, a large classroom-type room with multiple beds along the sides may be useful in many centers. This style of room is commonly used by many nursing programs to teach and assess procedure and bedside skills. This type of room may not be practical for all types of learners but can allow a mixture of didactic lectures and group skill practice. The bed spaces around the outside of the room may be separated by curtains to still allow some separation between learners. Consider that each bed may still need a nearly 8 ft × 10 ft space inside of the curtain to allow trainees or instructors to fit around the sides of the bed. The same headwall systems as those found in the manikin-based simulation rooms should be planned in these rooms as well and often will include a flat screen display, and audio/video wall port near the head of the bed can be used to display vital signs or instructional content at the bedside (see Fig. 9.6).

The Training and Educational Center for Healthcare Simulation (TECHS) at Texas Tech University Health Sciences Center El Paso has outfitted three beds in each of its ward rooms for expansion and functionality as "high-fidelity" patient rooms. All of these beds are wired with the necessary audio and video connection to view and control these spaces remotely if capacity is exceeded for their existing direct-observation full-body manikin rooms. This is another example of expandability and adaptability that can be considered in simulation layout design.

Clinical/Nursing Station

This area can allow realistic charting and review of simulated notes, charts, and medical records. It can also serve as a storage location for medications and supplies in use during actual simulation encounters. A medication dispensing unit can be utilized in the same manner as in a hospital to secure, store, and monitor equipment utilization. This type of area has been incorporated into many large simulation center designs as a way to mimic the function of an entire hospital floor and not just a patient care room. The Jump Trading Center in Peoria, Illinois and WakeMed Center for Innovative Learning in Raleigh, North Carolina each have built this type of space into their centers' design (see Fig. 9.7).

Standardized Patient Area

Standardized patients (SPs) may be regularly hired employees or intermittent call-ins who come only on an as-needed basis. These individuals will need a locker room-type space to change and place personal belongings and to prepare for their case. Because some simulation sessions may last an entire day with short break periods in between, a space for SPs to sit, relax, or have a refreshment should be planned. This lounge or kitchen space may be part of a larger employee common area, but the changing area should be separate and private from students and

Fig. 9.7 A clinical workspace area with desk, computer for charting and medication, and supply cabinet are shown outside of the simulation rooms at the WakeMed Center for Innovative Learning in Raleigh, North Carolina

learners. Most centers choose to separate their learners and SPs before the start of a scenario to help keep the interaction more realistic. SP pre-briefing or classroom-type areas may also be useful to provide scenario information or prepare these individuals prior to beginning an educational activity. Learners may need their own lab or locker space to store personal belongings during a simulation activity.

Wet Lab

Because a simulation center is part of a multifunctional education and training space, special procedure labs may be planned that use biologic material or specimens. These activities may require a room with specialized ventilation or drainage needs depending on local building and regulatory codes. Because materials are often supplied fresh from butcher shops or grocery stores, a location with a designated refrigerator or freezer space should be made available to preserve materials in preparation for such events. Additionally, disposal systems and practices should be reviewed to allow cleanup at the completion of these activities to prevent dissemination of smells and sanitation hazards. If a local safety services department is available, consultation with this department is advised.

Virtual Reality Task Trainer Space

Larger simulation centers, particularly those that cater to surgical or interventional specialties such as cardiology, obstetrics and gynecology, general surgery, orthopedics, interventional radiology, or gastroenterology, among others, may have a specific need to house and provide access to technologically complex machines to train procedural skills. While most of these simulators can be considered similar in size and user interaction to an arcade-style video game, some can be two to three times this size. A careful balance of security and access must be considered. The specialties that use these training tools are most likely to benefit from access both during and outside of peak business hours and therefore benefit from flexible room scheduling and potentially independent use outside of supervision by simulation center staff. These tools however can cost hundreds of thousands of dollars, and therefore the training and orientation practice and security considerations must be weighed against the benefit of increased accessibility. Some programs place individual machines in a single room or group training devices by specialty or training use. Other centers have opted for a larger open room format with individual workstations (Fig. 9.8) where multiple learners could be independently engaged at the same time. All tools in this type of room would have a single entry and security control point. In this configuration, all training devices could be supervised and monitored by a single instructor or staff member.

Fig. 9.8 This photo shows a large multifunction room that has been designed to house almost a dozen specialized virtual reality and procedural task training devices

Debriefing Room

Each simulation center should have a room to debrief the learners after they finish their scenarios. These rooms are generally designed with a conference-style layout which should be in proximity to the simulation labs. The seating capacity of these rooms will normally match the capacity of the simulation lab. Some centers design this room to accommodate more individuals to allow a second group to observe a team during a scenario and then debrief together. In practice, this means most debrief spaces should accommodate between 6 and 12 persons. A minimum sizing of 8′ × 10′ would be recommended for a group of six learners.

This room needs to have network connectivity and a means of displaying computer audio and video outputs (e.g., a wall-mounted LCD/plasma display with side- or ceiling-mounted speakers). A whiteboard or other writing surface can help when debriefing to create a cohesive take-home message or listing elements of strengths and weaknesses observed. Flexibility is always a consideration; consider having a table and chairs that can fold or be moved. This will allow the room to be used for small group task training, standardized patient evaluation, group work, table top exercises, as well as debriefing.

Storage Room

Storage space is a very important consideration in the overall design plan. The required size for the storage room(s) will depend upon the overall size of simulation labs in a given facility, the number of learners or groups supported, and the different simulation educational tools used. The room must be large enough to accommodate moveable carts and clinical equipment, such as IV poles and ventilators, as well as simulation supplies and manikins. One potential design is to place shelving carts and/or cabinets at a height of 5 ft or higher on one or more walls, allowing large pieces of equipment to be stored below. Six-feet-long cabinets or shelving carts can be used to store additional manikins (see Fig. 9.9). Hallways and multi-use classrooms can be lined with large lockable storage shelves to help with storage needs; but a centralized area is superior for security and the ability to find and manage inventory. Rolling shelving units (see Fig. 9.10) and motorized track-mounted shelf designs have also been implemented as creative ways to improve storage space efficiency. It has been suggested that 10%–25% of square footage be reserved for storage

Fig. 9.9 Five manikins are shown stored in a locking and enclosed storage shelf design

Fig. 9.10 Shows one example of how rolling shelves have been implemented to improve storage capacity for simulation equipment

[13]. This number may need to be as high as 30% if multiple different pieces of equipment are needed to be housed and moved in and out of simulation room spaces to accommodate different learning activities. The ability to separate equipment by specialty or learner type can be important in larger centers or where grants or funding sources are specific to a learner or participant group.

Preparation and Repair Space

Simulation equipment will require setup, maintenance, or outright repair. A well-trained HSTS can provide these services but will require the appropriate workspace and equipment to support these activities. A room with good ventilation, a sink, workspace, and tools to perform evaluation and repair should be considered in larger simulation center designs.

Some basic tool and space considerations are as follows:

- Workbench to accommodate a full-size manikin 550 mm × 1800 mm (1.8 ft × 5.9 ft) 38.5 kg (85 lbs) [20]
- Soldering iron- and heat-tolerant work surface
- 3D-printer to create models and replacement parts
- Deep laundry sink for cleanup and material prep
- Generous utility style overhead lighting

Simulation centers will use standard cloth hospital gowns and white bedsheets just like a real hospital. These materials are used both with manikins and standardized patients. Although the same cleaning and infection control standards may not apply directly, each center will need to have a consideration and plan for how to collect, clean, and replenish these resources. Many centers will install a functional washer and dryer to assist with this activity, while others will have a collection location and contract out with a local cleaning company for this purpose.

Offices

While offices are not specifically part of a simulation lab, instructors and staff will need a place to work when not actively engaged in simulation-based education and instruction. Many higher education institutes have begun to look carefully at office space use and size. Having a fixed office space for many part-time or adjunct faculty has been viewed as inefficient by some organizations; and even having dedicated office rooms for full-time personnel has come under review. Cubicles can serve an equivalent function for many faculty and staff with a smaller space requirement. Some universities are now also creating modified communal work areas to foster collaboration. Three zones have been incorporated by some: The first is cubicle or temporary workspace areas for general

typing and individual work; a second allows for open conference table or shared desk space to allow interaction between staff; and a third is a private enclosed table and conference space for group meetings [21]. With this and other models, many institutions are making more efficient use of space in buildings such as simulation centers. When looking for additional space in simulation center design, reviewing the need and design of office space may provide much needed additional space.

Control Rooms

There are many configurations for control rooms used in monitoring and controlling full-body manikins in a high-immersion simulation space. A control room can be a single room space or one of several small desk cutouts in a long control/access hallway. Control rooms can also be enclosed spaces with shared observation to two or more rooms or isolated cubical-style observation booths without direct access or observation to the simulation room space at all. The pros and cons about space efficiency, cost, access, and acoustics will need to be evaluated by each center and the intended use evaluated relative to the function of the control room and the room it is observing.

Single Room Control

A minimum of 118 ft^2 is recommended for a single control room space to allow for two people, workspace furniture, an equipment rack, an acoustically treated closet, and adequate storage [18]. A two-way mirror should look out toward the feet of the stretcher or exam table and provide an unobstructed view of the entire room. An elevated control room space relative to the simulation room can assist with this design feature. See Fig. 9.11 for an example of a single control room paired with a single simulation room design plan.

Space for an equipment rack should be planned to allow the greatest flexibility when selecting an audio/video solution for recording. Depending on the amount of equipment to be installed, the rack may be half size or full size. A standard full-size equipment rack has an external width of 23.6″ (600 mm), height of 78.74″ (2000 mm), and a depth of 40″ (1000 mm). A full-size rack will accommodate 42 rack units (42U). A half rack has the same footprint (length and width), but a smaller height, and could be designed to fit under a raised desk. A control room must have some type of security access control due to the cost of the equipment it contains. Some centers will be able to control access to a single hallway that allows access to all control rooms, while others may have individual control room doors that open into a public hallway space with standard keyed or electronic locks.

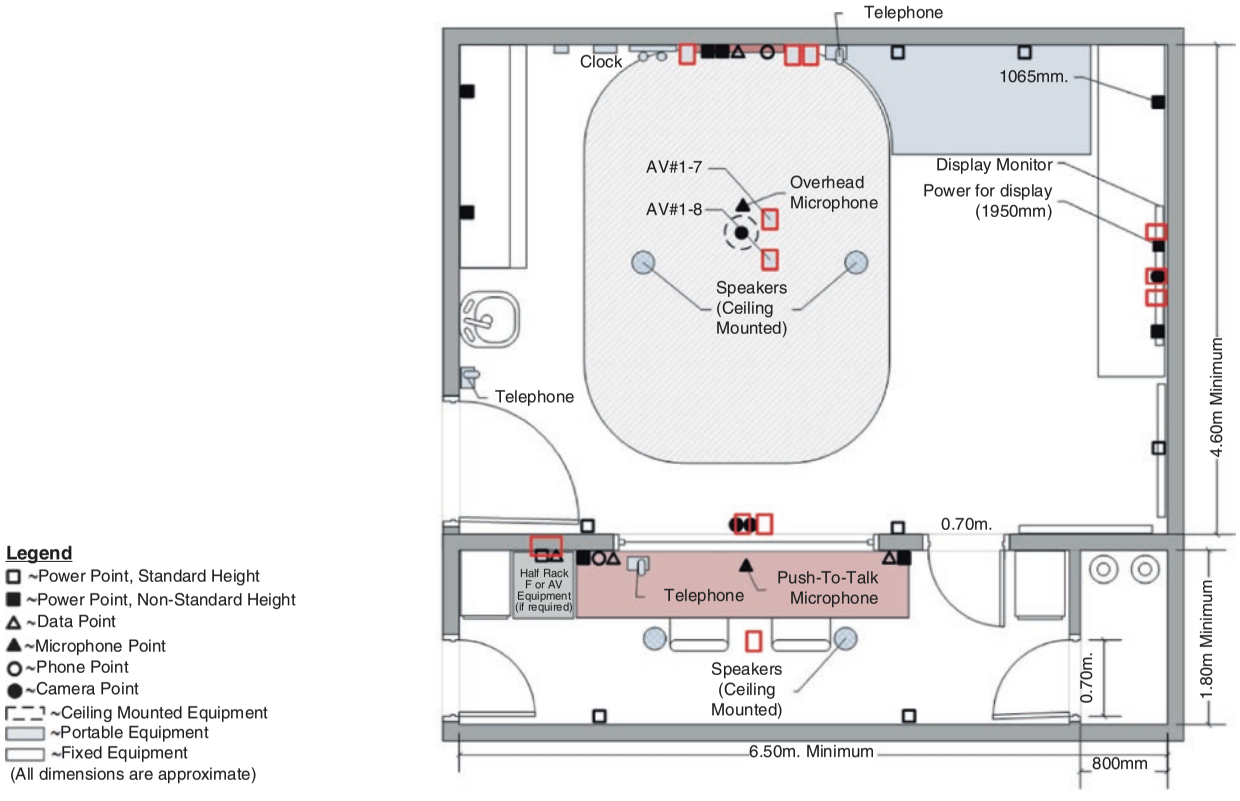


Fig. 9.11 Shows a schematic drawing of a simulation room with a single paired control room that would allow for direct observation, audio/video equipment, and a small amount of storage

Multiroom Control Room

A single control room that observes two or more simulation rooms is another option that can allow for some space savings due to overlap of shared floor space. Shared control room spaces suffer from increased noise problems, and control room occupants must use headphones in place of ceiling- or wall-mounted speaker systems to isolate room audio and decrease noise. This system is one of the most common with many variations (see Figs. 9.12 and 9.13).

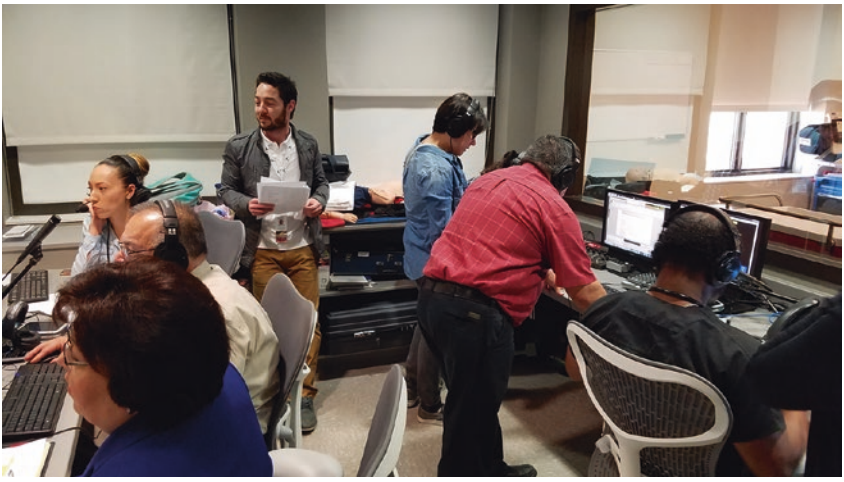


Fig. 9.12 Shows a control room design with a pairing of two simulation rooms with a single control room. This design is much smaller than that of Fig. 9.13 but still allows multiple individuals to directly observe and listen with the aid of headsets

Fig. 9.13 The SingHealth Duke-NUS Institute of Medical Simulation in Singapore utilizes a design with a large control room that serves four distinct simulation lab spaces. The large space helps to reduce noise between control stations

Remote Access Control Room

While a direct line-of-sight control room space seems ideal, there are centers that have implemented remote-control-only viewing stations. These systems utilize only camera-based observation. This control room design can allow installation into existing room spaces without floor plan redesign. While easy for retrofitting of existing spaces, this system design has significant limitations and additional technical implementation considerations. Each control/observation space will need two independent computer systems; one to control a manikin simulator, and the other to view and control the camera system. With newer IP-based A/V systems, it is also likely to have some lag or delay in what is observed and may or may not have the same delay in audio if the controller is trying to listen or talk with participants in the room. This control system is a common design feature for standardized patient (SP) room areas. One-way glass isn't routinely used, or needed, in large-scale SP programs where the SP also serves as the evaluator. Outside of this specific use, it is the recommendation of the authors to avoid this design style if planning a new system or center.

HVAC and Heat Load

Simulation Labs

Ventilation should be appropriate based on intended clinical uses. For instance, cooling systems should be designed for a heat load from the specified equipment and a team of four to ten participants performing intensive work inside the simulation labs for 1 or more hours with all doors closed. An individual temperature control within each room is encouraged. This is especially important when students are working in smaller groups with a patient. The location of air registers in the room should be noted during the A/V design as the hum and rumble generated from these systems can cause problems with noise and voice transmission if they are located in proximity to ceiling-mounted microphones.

Server and Electronic Equipment Rooms

Simulation centers should plan to have a centralized audio/video or networking "server" closet. The central location will help with electrical wire transmission limitations for network and audio/video equipment. Even with audio/video equipment in each control room, a separate space is needed to make connections between rooms and to house equipment like distributive paging equipment, hard-drives for video recording, and computer database systems. This room will want high security control and will need additional cooling to prevent equipment from overheating. Cooling systems for this type of room space are not standard and must be designed specifically for the room and equipment where they will be placed. Both the cooling capacity and electric supply requirements must be carefully planned to prevent problems during installation and operation of equipment.

Cabling and Installation Infrastructure

Specific features and needs for audio and video cabling and infrastructure will be covered in greater detail in Chap. 11; computer networking is covered in Chap. 14. Cables will need to be run from the control room to the walls, ceiling, and floors of nearly every room in the simulation center to allow control and operation of simulation equipment. Reviewing the design and implementation of other centers and discussing with audio/video vendors early in the design process is recommended. Dropped ceiling spaces are somewhat forgiving for expansion and retrofitting, but nothing is better than correct planning. Remember that in addition to standard hospital tools and equipment available at the head of the bed on a headwall, many additional power, network, and audio/video connections should also be considered. Additional conduits and electrical boxes may need to be installed in these spaces during construction for existing and potentially future expansion.

Some specialized room designs, especially operating rooms, may have directional overhead parabolic lighting or television displays on ceiling-mounted booms. Other bed or room spaces may have patient lift and assistance devices to safely train the transfer of bariatric patients. Both of these systems require additional bracing and above ceiling support systems. Additionally, these devices will hang down below ceiling level and may block or interfere with microphones or cameras mounted in their path.

Logistics and Movement

The success of a simulation activity requires not just a well-designed educational curriculum, functioning equipment, and knowledgeable staff but also a facility design and logistical plan to allow each participant to engage and feel welcome at the center. Participants need support to find their activities, space to go before and after each session, and the security that personal belongings and educational materials will be safely maintained between activities. While many learners will develop a routine, and come to understand the expectations of their participation as regular visitors, many learners will be first-time users and will benefit from a certain degree of direction and hospitality. The center's layout and communication plan are important to this end.

Create a Floor Plan

The transition from one simulation activity to the next shouldn't be daunting to a learner. Providing a map or sketch of the floor plan of the facility can help participants get where they need to go. If a digital floor plan does not already exist for a center, one should be generated. It can be referenced for curriculum planning and to help new participants, faculty, and staff to get to know the space. Utilizing signage on walls or floors can also help to direct participants.

A simulation center floor diagram can be designed using any of several applications. Some commonly available graphics design applications to achieve this are:

- Microsoft – PowerPoint
- Microsoft – Visio
- Google Drawings (Free)
- Gliffy (Free)

Once a floor plan is available, it can be used to view and outline planned simulation activities and traffic flow for learners. Try to make the movement of participants go in a single direction, e.g., clockwise or counterclockwise (see Fig. 9.14). Map out the route for each station and define it by:

- Room number
- Title of simulation or activity
- Faculty in charge of the simulation or activity
- HSTS in charge of the simulation or activity
- Type of manikin and/or task trainers

This layout design and review should be part of the scenario planning and piloting process for any large-scale simulation activity. It is also important to test the operation of overhead paging and timing cues if they are planned for the session. An additional design consideration when reviewing the logistics and flow is the foresight to add an electrical connection and an ethernet port adjacent to each simulation room so that computers can be deployed or mounted to collect survey and feedback information from participants immediately after a session. These connections can also be used to provide pre-briefing information and scenario background to participants prior to beginning a scenario. Having computer systems mounted outside of a simulation room is common and expected practice for standardized patient spaces as students are frequently evaluated on their ability to write a note about the preceding encounter upon leaving the simulation activity.

Finance (Profit/Nonprofit)

A fundamental consideration for any simulation facility is sustainability. Whether the center is designated as a revenue center or a cost center, each facility will require enough financing to keep it operating. This cost may end up being much more than the cost of construction [1]. Thus, a long-term business plan should be part of the initial design and startup consideration. This business plan should emphasize the client types, course requirements, or learner curricula and, most importantly, define a plan for financial sustainability.

A cost center financing system is common for many simulation programs that are part of larger institutions. This designation indicates that the resources, staff, equipment, and daily operational costs will be supported by the larger hosting institution(s).

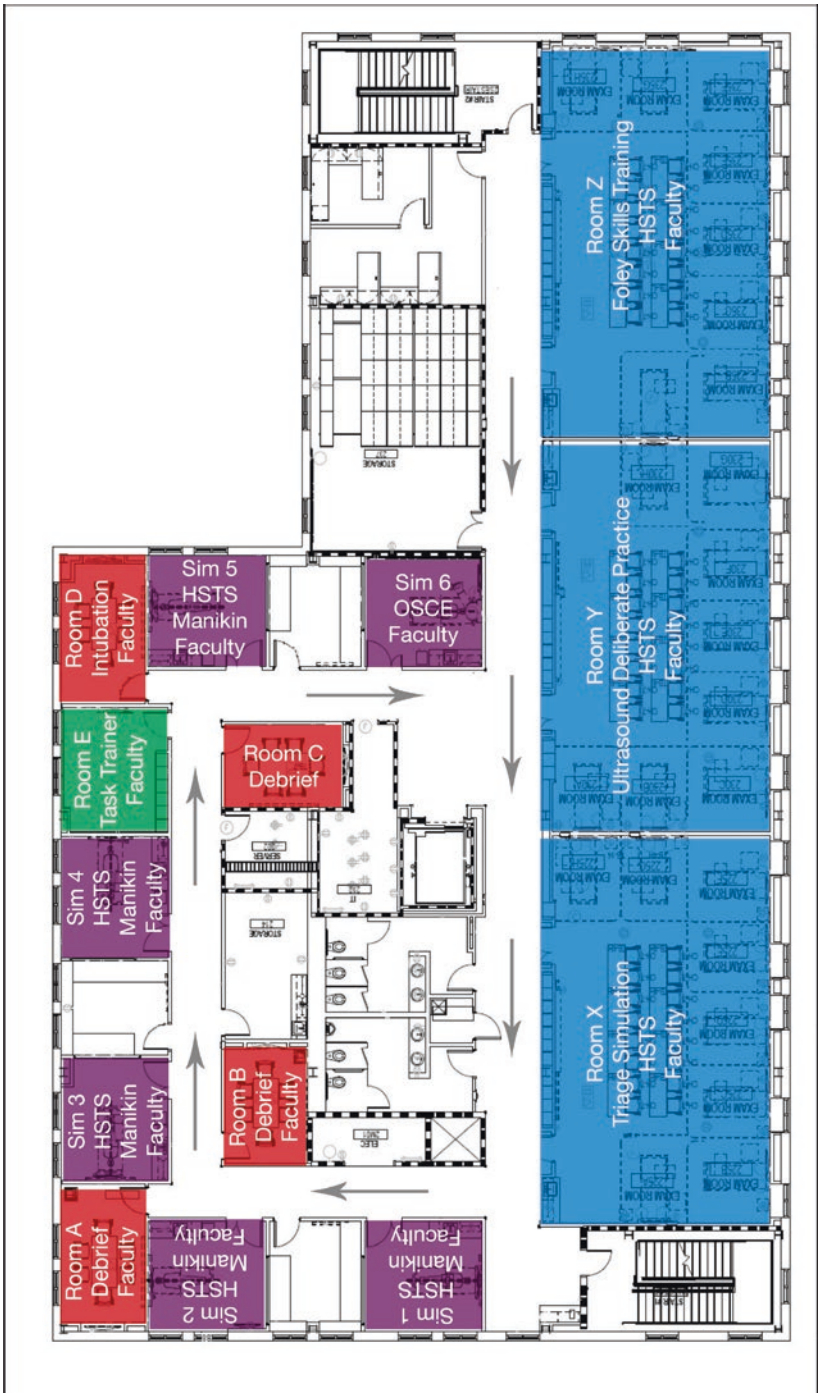


Fig. 9.14 Example floor plan and session transition layout with activity descriptions and listed personnel and equipment needs for each room

Usually such a designation takes into account that many programs do not generate large amounts of revenue on their own [22, 23]. This does not mean that the center does not charge for its services or that no revenue is generated but that internal funding will usually be required to maintain financially sustainability without reliance on outside income. While some support can be sought through philanthropic donations from individuals, corporations, or even industry sponsors, this is usually not guaranteed. One area of support is commonly found through tuition of an associated medical school or nursing school or from department support of graduate training enterprises [22, 24].

For soliciting and collecting income through philanthropic avenues, the tax status of a simulation center and its parent organization will affect how money can be donated. Entities that are designated as not-for-profit or nonprofit are allowed to receive tax-deductible donations from individuals and corporations. This does not mean that these entities cannot generate revenue.

- For-profit entities operate as a business, where there are owners and stakeholders who expect sustainability and a monetary return on investment once the center has reached a stable level of operation. These entities:
  - Need to generate their own revenue.
  - May not be eligible for tax deductions that entail contributions.
  - Delivery of services is more expensive in order to increase revenue and generate a larger profit.
  - Pay taxes on profits generated.
  - Owner has control of administration and curriculum.
- Not-for-profit (nonprofit) entities are given special governmental tax status where the organization is eligible to receive contributions that are tax-deductible, to an extent provided by federal or state law. Most state educational systems are designated as nonprofit entities, while private institutions can be either nonprofit or for-profit. Under these settings:
  - Nonprofit organizations need to generate money as well; however, delivery of services may be limited due to budget constraints.
  - Need to acquire tax status code of 501(c)(3) – per US IRS.
  - Organizations described in section 501(c)(3) are commonly referred to as charitable organizations.
  - Limited in political lobbying.
  - The intention of its creation must always be fulfilled by the type of service provided and customers served [25].

Capital operational expenses along with floor plans and potential utilization tie directly into the underlying finances and cost for a center. The information in Table 9.1 highlights some of the information already described in terms of room sizes and simulation center layouts. A report put out by SLAM Collaborative also describes some additional metrics related to cost for construction, simulation equipment, and audio/video equipment related to center size [23].

Fees Charged for Classes

One of the fundamental determinations about the financial sustainability of a simulation-based educational offering will be based on the answer to the question "How much is this going to cost?" From a customer view, the business definition of cost can be best described as the amount that has to be paid or given up in order to receive a good or service [26]. This is how much a customer is charged. For administrators, the cost is the fixed or variable expense that they must pay for space, staff, and equipment. The following are the types of questions that will probably be asked by clients or administrators:

Simulation Client
- What will I be charged for this training?
- How much is it per learner?

Simulation Administrator
- What is the cost per manikin utilization?
- What is the cost for supplies used in this course?
- How much staff time will be used?
- What is the overhead (operational cost for the building and utilities)?

The correct answer to these questions will provide the necessary information to determine the true simulation center funding needs, based on the costs incurred and revenue generated. The following operational elements can help to provide comparable and reproducible estimates:

1. Identify square footage of the simulation facility, broken down by each room and common area(s).
2. Calculate the direct cost of the training that includes salaries, fringe benefits, supplies, and equipment.
3. Analyze fixed expenses, commonly referred to as overhead costs, which include administrative support, depreciation, utilities, and maintenance.
4. Calculate variable parameters, e.g., adjunct faculty or standardized patients, supply utilization, and need for variable employees.

Square footage can be measured or calculated from an available architectural floor plan.

The formula used to acquire the square footage of an area is Length × Width = Area ft^2 (m^2).

Example:

A simulation room measures 15 ft in length and 10 ft in width.

$$15\,\text{ft} \times 10\,\text{ft} = 150\,\text{ft}^2$$

In determining the total amount of space utilized for an event, remember that the simulation activity requires the utilization of space outside the simulation room.

There is storage space to support the room, a debrief room used at the end of the simulation, and a classroom to gather and orient the participants. All of these spaces need to be accounted for as well. The overall overhead expense in rent and utilities including common areas must be considered to find out the total cost to maintain operation of space. The overall cost divided by the square footage will give you the fixed expense for the simulation space.

The final units should be Cost/ft^2.

Remember that this calculation should not be for 24-h-a-day-use as it would be impossible for most centers to allow around the clock utilization. Actual utilization for classroom or simulation lab space can be calculated as follows: Utilization = n/d

- **n** – Actual use (the total number of simulation sessions or hours of instruction offered)
- **d** – Potential capacity (The total number of hours where simulation sessions could be offered)

A more practical calculation requires a modification of Cost/ft^2 based on potential utilization during a standard working day and further by actual utilization during that time. Consider that while a single simulation experience may only require 6 h of physical utilization in a particular lab, the setup and teardown time must also be considered. Because of this, it is highly unlikely that you could utilize one simulation lab for two different courses unless the groups are undergoing the exact same training. In other words, 6 h of simulation still requires a room to be booked for a full 8 h a day.

However, while many programs utilize a simulation space for 8 h a day, say Monday–Friday from 8 AM to 5 PM, this still leaves 5 PM to 10 PM weekday nights and weekends for possible expanded services.

Basic Example:

The cost for a 4000 ft^2 simulation facility is $12,000/month. If a program only uses the space for 75% of the available time (i.e., 75% of 20 days a month at 8 h a day or 0.75*8*20 = 120 h). This would work out to (($12,000/120 h) = $100/h). $100 an hour is how much it costs the program to use the space at current capacity. Now let's say the center has four simulation rooms, and each is 150 ft^2, four debrief rooms at 100 ft^2 each, and an 800 ft^2 classroom. The remaining space is for offices, storage, and common areas.

The total space available for specific revenue generation is:

$$\left(\left(150\text{ft}^2 \times 4\right) + \left(100\text{ft}^2 \times 4\right) + 800\text{ft}^2\right) = 1800\text{ft}^2$$

Of the usable 1800 ft^2, it must generate a minimum of $100/h just to meet known fixed expenses.

$$\frac{\$100/\text{h}}{1800\,\text{ft}^2} = \frac{\$0.055}{\text{ft}^2\,\text{h}} = \frac{\$0.44}{\text{ft}^2\,\text{day}}$$

This is what many centers might use for their calculations, but it only covers current expenses and does not accurately represent the technical integration and

function of the highly specialized space, especially considering the high initial investment cost, in addition to maintenance, repair, and upkeep. Because of these requirements, a different cost calculator should be considered. Many audio/video systems are shown to cost over one million dollars for a 10,000 ft^2 facility [23]. Conference room rental costs are a much more accurate price point for a comparison calculation, as a simulation center is most closely related to these highly specialized meeting spaces. The average gross income per square foot per month is estimated between $18.60 and $34.00 for conference rooms [27]. With a 20-day per month utilization, this becomes ($0.93–$1.70) per square foot per day. For the remainder of the calculations, we will use $1.25/$ft^2$ per day.

Once the square footage for each of the offered simulation and classroom spaces has been identified, multiplying the square footage and the cost per square foot per hour will give the hourly room rate.

Formula: $\mathrm{ft}^2 \times \frac{\text{Cost}}{\mathrm{ft}^2 \times \mathrm{h}} = \frac{\text{Cost}}{\mathrm{h}}$

Example:

$$150\mathrm{ft}^2 \times \frac{\$1.25}{\mathrm{ft}^2 \times \mathrm{day}} = \$750/\mathrm{day}$$

$$\frac{\$750/\mathrm{day}}{8\mathrm{h}/\mathrm{day}} = \$93.75/\mathrm{h}$$

Labor Cost

In the educational environment, personnel represent the most precious asset any organization may have. The expertise and educational background of the professional staff can make a substantial contribution to the quality of education experienced by each learner. Therefore, the business plan must consider labor cost. Labor cost can be calculated using the following formula: salary of faculty or staff divided by 2080 (which is the number of hours in a working year) to equate to labor cost per hour.

Example:

Faculty:

$$\$70,000\,\text{annual salary}/2080\,\mathrm{h} = \$33.65/\mathrm{h}$$

Healthcare simulation technology specialist:

$$\$50,000\,\text{annual salary}/2080\,\mathrm{h} = \$24.04/\mathrm{h}$$

Administration:

$$\$35,000\,\text{annual salary} / 2080\,\text{h} = \$16.83 / \text{h}$$

Note: It is imperative that the fringe benefits associated with the salary also be incorporated into the compensation figure if an employer/employee relationship exists.

Capital Equipment Cost

Capital equipment is an important component of simulation training and in many instances is a unique factor that will attract customers to the simulation center. Therefore, capital equipment costs must also be calculated into the total cost associated with each course offered. This cost will depend on the type of capital equipment used. The equation shown here takes into account the overall price of the equipment, including the warranty and the estimated cost of replacement based on the usage and/or depreciation of the equipment over 5 years. The number of years for depreciation will depend on the life expectance of the respective equipment under normal utilization; most manikins have an expected useful life of 5 years based on manufacturer support guidelines.

Total cost of simulator divided by (2080 h × 5 years) = Cost per hour

$$\text{Simulator} + \text{Warranty} : \$100,000 / 10400\,\text{h} = \$9.62 / \text{h}$$

Note: The number of hours must consider the availability of the setting of the equipment before and after the session; therefore the 2080 h may be adjusted.

Supply Cost

The cost of supplies and disposable equipment is also variable depending on the design of the simulation activity and may differ between simulation facilities based on purchasing discounts, subsidies, equipment donation, or equipment salvage and reuse. Two methods to estimate supply costs can be used. The first is to add a fixed cost per learner or add a percentage facility fee to the overall total cost calculated. Determining the correct "standard" cost/percentage for a center must be the result of an accurate financial assessment of all the potential incurred expenses that would be integrated into this type of cost. The second is to count and bill for each supply actually opened and used. This second method is more accurate, but the additional time may not be worthwhile unless a robust inventory system and process is in place.

Here is an example of a complete course offering with calculations shown in Table 9.2:

Table 9.2 Example cost calculation report for a simulation session. This calculation is taking into account personnel, capital equipment, disposable goods, and an administrative fee. The administrative fee is a markup to supplement and support the center's additional expenses

Resource	Cost/h	Hours	Total cost
Faculty	$35	4	$140
HSTS	$25	4	$100
Administration	$20	1	$20
Simulation room	$100	4	$400
Manikin	$10	4	$40
Supplies (fixed)			$50
Subtotal cost			**$700**
Administrative fee	20%		$140
		Grand total	**$840**
Number of learners	8		
		Cost per learner	$105

An acute care simulation course for eight learners will require the following:

(Rounded numbers from the above examples will be used in this calculation for clarity.)

- (1) – Faculty member ($35/h) × 4 h.
- (1) – HSTS ($25/h) × 4 h.
- (1) – Administration ($20/h) × 1 h.
- (1) – Simulation room ($100/h) × 4 h.
- (1) – High-fidelity manikin ($10/h) × 4 h.
- Supplies – flat fee of $50

The total cost for this 4-h simulation session would be $840. This calculation adds in a 20% markup for administrative efforts, although some programs charge up to a 30% markup. The markup used should be the result of careful calculation. This fee helps to support the time in planning, answering calls, registering learners, performing data entry, completing attendance and certification reports, as well as invoicing and responding to any follow-up information for a course. The same formula can be used to calculate the charge for classes that don't use simulation equipment. This is just an example, and each program can choose to modify the prices and fees as appropriate for their situation. These numbers should help give a reasonable example for true estimates of cost for financial sustainability.

References

1. INACSL Standards Committee. INACSL Standards of best practice: SimulationSM operations. Clin Simul Nurs. 2017;13(12):681–7.
2. Us Department of Health and Human Services. Summary of the HIPAA privacy rule [Online]: HHS.gov; [cited 12 June 2018]. Available from: https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html

3. Fernandez R, Wang E, Vozenilek JA, Hayden E, McLaughlin S, Godwin SA, et al. Simulation center accreditation and programmatic benchmarks: a review for emergency medicine. Acad Emerg Med. 2010;17(10):1093–103.
4. American College of Surgeons. American College of Surgeons Program for the Accreditation of Education Institutes Program Requirements [Online]; 2013. https://www.facs.org/~/media/files/education/aei/aei requirements.ashx [cited 2018]. Available from: https://www.facs.org/~/media/files/education/aei/aei requirements.ashx
5. Laerdal. SimNewB directions for use [Online]. Laerdal; 2014. http://cdn.laerdal.com/downloads/f3100/dfu_simnewb_(contains_ipi).pdf
6. CAE Healthcare. METIman® user guide [Online]. CAE Healthcare; 2016. https://caehealthcare.com/media/files/User_Guides/METIman-User-Guide.pdf
7. INACSL Standards Committee. INACSL standards of best practice: SimulationSM debriefing. Clin Simul Nurs. 2016;12(Supplement):S5–21.
8. Crawford S, Monks S, editors. Simulation debriefing: why do we talk about it? Global Institute for Simulation Training – Healthcare and Simulation Education webinar series; March 2017. 2018: Simulation IQ; June 8.
9. Chan CKJ. Board #302 – technology innovation using free software-based IP-PBX system to safely simulate the phone call with real number (submission #9569). Simul Healthc. 2014;9(6):481.
10. Hwan CJ. Darkroom a retro technology for a safer simulation control room. S3 Conference; Singapore, SingHealth Duke-NUS Institute of Medical Simulation (SIMS); 2017.
11. Alinier G. The patient simulator suite: a single dedicated clinical simulator stage surrounded by dedicated control, observing/debriefing, utility and office rooms. In: Kyle R, Murray WB, editors. Clinical simulation: operations, engineering and management. Burlington: Academic Press; 2007. p. 261–5.
12. Seropian M, Lavey R. Design considerations for healthcare simulation facilities. Simul Healthc. 2010;5(6):338–45.
13. Seropian MA, Alinier G, Hssain I, Driggers BJ, Brost BC, Dongilli TA, et al. Building a simulation center: key design strategies and considerations. In: Defining excellence in simulation programs. Philadelphia: Wolters Kluwer Health; 2014.
14. Kutzin JM. Simulation design considerations 2.0: optimizing space and operations. Clin Simul Nurs. 2016;12(6):187–96.
15. Hill-Rom. The Hill-Rom® Advanta™ 2 Bed [Online]. Hill-Rom; 2013. https://www.hill-rom.com/globalassets/website-documentation/english-websites-us%2D%2Dint/beds-us%2D%2Dint/advanta-2%2D%2D-us/advanta_2_brochure_161274.pdf
16. Hill-Rom. Hill-Rom® Transport Stretcher [Online]. Hill-Rom; 2016. https://www.hill-rom.com/globalassets/website-documentation/english-websites-us%2D%2Dint/stretchers%2D%2D-us/transport/197824r1-transport-stretcher-sell-sheet-lr.pdf
17. United States Gypsum Company (USG). Acoustical assemblies [Online]; 2006. http://www.usg.com/content/dam/USG_Marketing_Communications/united_states/product_promotional_materials/finished_assets/acoustical-assemblies-en-SA200.pdf
18. Panero J, Zelnik M. Human dimension and interior space: a source book of design reference standards. New York: Watson-Guptill; 2014.
19. Wells J. Efficient office design for a successful practice. Fam Pract Manag. 2007;14(5):46.
20. Laerdal. SimMan 3G directions for use [Online]. Laerdal; 2011. http://cdn.laerdal.com/downloads/f854/Att_2_to_PRO-ML01-1110-854.pdf
21. Luther A. Stories of Space Management. ERAPPA [Online]. 2016 [Cited 12 Jun 2018]. Available from: https://www.erappa.org/images/conferencepresentations/2016/20161021145941_StoriesofSpaceManagement_Luther_mpf.pdf
22. Tsuda S, Mohsin A, Jones D. Financing a simulation center. Surg Clin. 2015;95(4):791–800.
23. Grochowski CO, Olenick MJ, Ward S. The inter-professional simulation center: opportunities, challenges, solutions. SLAM [Online]. [Cited 2019 April 17]. Available from: http://www.slamcoll.com/articles/Simulation.pdf.

24. Kapadia MR, DaRosa DA, MacRae HM, Dunnington GL. Current assessment and future directions of surgical skills laboratories. J Surg Educ. 2007;64(5):260–5.
25. Internal Revinue Service. Exemption requirements – 501(c)(3) Organizations [Online]. https://www.irs.gov/charities-non-profits/charitable-organizations/exemption-requirements-section-501c3-organizations: IRS.gov; [cited 12 Jun 2018].Available from: https://www.irs.gov/charities-non-profits/charitable-organizations/exemption-requirements-section-501c3-organizations.
26. WebFinance Inc. Cost. [Online]. 2019 [Cited 2019 April 17]. Available from: http://www.businessdictionary.com/definition/cost.html
27. CloudVO. Meeting room business review of shared office space in the U.S. – pricing, utilization & revenue metrics [Online]. 15 August 2015. https://cloudvo.com/wp-content/uploads/2015/08/CloudVO-WhitePaper-MeetingRoomPricesReview081715.pdf

Part II

The Healthcare Simulation Technology Specialist

Healthcare Simulation Technology Specialists

10

Scott B. Crawford, Rachel Bailey, and Kirrian Steer

Role Background

Medicine and technology have coexisted for decades. Each field has collaborated for medical treatments, research, diagnosis, and preventive care. This integration is possible because each respective field has clear objectives and mutual respect for each other's skill set, knowledge, and competencies, which allow both to contribute to the mission. However, the merging of these two fields is a new concept in the education and training of healthcare personnel. Product representatives are now present in the operating room to instruct and guide physicians in the use of new technologies, and information technology workers are on call 24 X 7 to assist with support and maintenance of electronic health records, diagnostic, and therapeutic equipment. The need for support and innovation is no less prevalent in the field of healthcare simulation.

Simulation centers have been a part of training healthcare personnel for over a decade. As simulation training methods evolved and diversified, so did the range of technical expertise required to support these methods. The role of the healthcare simulation technology specialist has been created as an industry recognized position to fill the gap between medical knowledge and technical skill to improve the operation and training within simulation centers.

S. B. Crawford (✉)
Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA
e-mail: scott.crawford@ttuhsc.edu

R. Bailey
Engineering and Computer Simulations, Orlando, FL, USA

K. Steer
Department of Rural Health, University of Melbourne, Wangaratta, VIC, Australia
e-mail: kirrian@simghosts.org

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_10

Healthcare Simulation Technology Specialist (HSTS), aka "Sim Tech," and the other terms presented in Chap. 4 are often used to describe simulation personnel who perform a broad set of roles and responsibilities within a simulation program. This position is difficult to define and characterize mainly because the responsibilities vary depending upon the type of simulation center and the other support personnel who may be available. One of the first attempts to classify this position was in 2008 by the California Community College Economic and Workforce Development Program Health Initiative. This group created a list of role expectations for a position termed "Simulation Technology Specialist" that closely resembles the position still known today [1]. Presently, the roles and responsibilities of a simulation educator, facilitator, or director are more defined and consistent than those of the HSTS. The job descriptions for educator, facilitator, and director are understood within institutions of higher education, and these positions have been a focus of simulation pedagogy. However, this does not mean that a "Healthcare Simulation Technology Specialist" is extraneous or simply a technician who pushes buttons and plugs things in. This chapter will review what is known about this unique role within healthcare simulation and describe how improved knowledge and training for these individuals can improve the quality and effectiveness of healthcare simulation.

Definitions
Healthcare Simulation Technology Specialist: An individual with a diverse set of skills and expertise both technical and administrative related to the operation, support, and delivery of healthcare simulation
Simulation Operations: The job duties related to the overall management, delivery, and function of simulation-based education

The role of the HSTS in healthcare simulation does not fit into a predefined box by most institutions of higher learning. Many human resource departments still do not have a title or job description to accurately portray the daily activities of this individual. Despite this lack of unified understanding, simulation centers routinely cite lack of support staff as a major barrier to the delivery of simulation education. A survey of simulation center directors presented in 2017 found that more than 75% of the 141 respondents were recruiting or had recently hired an HSTS. This survey also reported that only 1.9% of respondents found many well-qualified candidates in the HSTS applicant pool. Not surprisingly, this same survey found that prior training and experience as an HSTS was the most important feature of a new hire [2]. Increased attention on the development and support of this role has occurred from groups like Gathering of Healthcare Simulation Technology Specialists (SimGHOSTS), Association for Simulated Practice in Healthcare (ASPiH), Society for Simulation in Healthcare (SSH) – Simulation Operations and Technology Section (SOTS) – and the International Nursing Association for Clinical Simulation and Learning (INACSL).

Box 10.1
The 2018 SSH Blueprint lists the following CHSOS Domains:

- Concepts in Healthcare Applied to Simulation
- Simulation Technology Operations
- Healthcare Simulation Practices/Principles/Procedures
- Professional Role: Behavior and Capabilities
- Concepts in Instructional Design as Applied to Simulation

SimGHOSTS and SSH-SOTS have both sought to review the job duties for an HSTS. They independently formed two similar outlines. The five-part "Blueprint" (see Box 10.1) created by SSH is used as the basis for formalized testing to become a Certified Healthcare Simulation Operations Specialist (CHSOS) [3]. A system with eight domains was developed by SimGHOSTS and overlaps with the SSH Blueprints but divides the domains further to highlight areas of expertise with greater detail [4].

Although both domain systems encompass the same roles and responsibilities for the HSTS, this textbook will describe them using the eight-domain framework to allow more detailed explanations and individualized knowledge descriptions. The categories are of less importance than the knowledge and skills described by both systems, as this is what makes the HSTS uniquely valuable in the world of healthcare simulation and why continued professional development should be sought for those employed in this role.

Simulation operations is a combination of roles and responsibilities that together outline the administration, management, coordination, and technical facilitation of simulation activities [5]. This set of skills may be made up by one or more persons, but each component is required for sustained functioning of a simulation-based educational program.

The eight-domain model was created using a modified Delphi method at the SimGHOSTS international conference in 2013. Self-identified individuals working within this profession created pooled descriptions of roles and responsibilities. Following this activity, emails were sent out to 30 individuals who reported expertise in one or more of six initially described content fields:

1. Education
2. Audio/video
3. Information technology
4. Medical knowledge
5. Theater and stage
6. Simulation methodology and practice

A workgroup then reviewed the output from this meeting and sent an email survey to the same 30 individuals to create further refined recommendations. The group also attempted to describe a tiered scope of practice from novice to advanced based

on current roles within their centers. A third review came at the SimGHOSTS international meeting in 2014 and refined the topics further.

In addition, a formal needs assessment was conducted by Bailey et al. in 2014 that found the following features of the simulation technician role [6].

The top five listed responsibilities were:

- Equipment setup and breakdown
- Manikin programming
- Software operation during a simulation
- Audiovisual support
- On-site simulator maintenance

While these matched the workgroup analysis of roles during the previous year, involvement in numerous other tasks was also identified in this study and included:

- Inventory management
- Purchasing equipment and supplies
- Assistance in the training activity
- Involvement in research
- Moulage
- Course design

This expanded the necessary skill set into whole center "operations" where management, research, and evaluation were identified as integral components of a healthcare simulation technology specialist within the simulation center. This type of role expansion has led to further confusion about the exact title and need by some centers, but suggests that "Healthcare Simulation Technology/Operations Specialist" may be the same person, but be defined best by whether they function in a purely technical role or take on larger administrative, educational, and therefore operational duties.

Most HSTSs have backgrounds related to these core skills (Box 10.2). The challenge is the specificity of simulation. For example, individuals with a

Box 10.2
The SimGHOSTS domains are as follows:

- Audio/visual technology
- Education
- Healthcare (terminology, knowledge, and practice)
- Information technology
- Management
- Research and evaluation
- Simulation
- Theatrics

background in information technology may be familiar with computer programming or software in general, but likely will not have knowledge about programming scenarios into simulation-specific software. Each manufacturer creates its own proprietary interface and relies on knowledge of human physiology in addition to technical integration. While each system is designed to be user-friendly, one must still be trained or teach oneself to master a given system. Bailey et al. identified that backgrounds of simulation technicians were primarily medical or technical, and regardless of the general background, fewer than 50% of respondents felt well prepared for the simulation technician role. One special category is of note: while only six respondents in this survey identified a background in engineering, this small subset responded unanimously that they felt prepared for the position. Engineers are usually adept at problem-solving and are likely to seek innovative solutions. This study may have uncovered that the characteristics of innovation and self-directed learning are skills that will help individuals to succeed in the HSTS role.

The HSTS role has been used often to fill many gaps that may exist within a center. A running joke at simulation technology conferences was to describe job duties with the phrase "other duties as assigned." This frequent conclusion to a job description was the final catch-all for this role and was often invoked when personnel were asked to create novel experiences or participate in activities outside of their professional scope and background. While the expectations of the HSTS frequently require innovation and self-directed learning, a lack of role delineation and job expectations can lead to early burnout and dissatisfaction within a position [7]. This discrepancy may exist because of a lack of understanding of the specific need for the position or because of an unrealistic expectation of the ability of a new hire to adapt and fulfill the role. An improved knowledge of what should and should not be expected from this individual will help simulation programs to have a realistic expectation and understanding of how to support and develop individuals, and a better appreciation of the educational and technical background required for those looking to become HSTSs.

The Current Role Expectation

Through engagement with the simulation community and consultation with industry manufacturers, SimGHOSTS collected position descriptions and selection criteria for simulation roles around the world. An analysis of knowledge, skills, and experience required in 67 recruitment notices and position descriptions for simulation technology, coordination, and management positions was undertaken over a 3-month period between September and November 2016. The aim was to review and consolidate the definitions and requirements of different simulation roles. The education, certification, and experience requirements were summarized, and the responsibilities described in the position descriptions were categorized into the SimGHOSTS domains of practice for those working with healthcare simulation technology [8].

Based on this review of job descriptions and the previous work codifying the eight domains, the HSTS education requirements were found to be as follows:

An entry-level HSTS requires a high school diploma or equivalent with vocational qualification or health professional certification highly regarded. Examples of relevant qualifications and certifications would be as a medical technician, a clinical assistant, a basic life support instructor, or first responder. An intermediate Healthcare Simulation Technology Specialist would be expected to hold a bachelor-level qualification or equivalent combination of qualification and experience. The qualification is preferred to be from the field of IT, AV, or a health profession. Many programs would accept any field relevant to their program and the specific role to be filled. The most frequently requested certification was as a life support instructor with the majority of programs requesting at least one of the following certifications: basic life support, advanced life support, pediatric advanced life support, or advanced cardiac life support. The only simulation certification requested in recruitment notices was the Certified Healthcare Simulation Operations Specialist (CHSOS) offered by the Society for Simulation in Healthcare, which was listed as a preferred certification for 15% of the positions advertised [1].

As could be expected by the reference to technology in the position title, a significant portion of the HSTS role is in the domains of AV and IT. The typical responsibilities relating to the AV domain from existing job descriptions are:

- Operate or support the operation of digital cameras, video cameras, microphones, audio/video mixer, digital/analog converter, web-based recording software, monitors, projectors, and other related equipment.
- Set up, operate, maintain, and troubleshoot audiovisual equipment used in simulation-based clinical training.
- Perform recording, duplication, mixing, and editing of audiovisual data.
- Manage, store, organize, and archive video recordings including debriefing logs, simulation videos, and other filmed training activities.
- Film and edit educational training videos.

In the IT domain, a healthcare simulation technology specialist may be required to:

- Install, upgrade, operate, troubleshoot, and maintain computer-based equipment and associated infrastructure. This may include simulated electronic medical records, simulation technology, medical technology, and audiovisual equipment.
- Implement, manage, and maintain servers that contain video and classroom content including learning management systems.
- Provide technical support to all users of the simulation center.
- Teach others the safe and correct operation and troubleshooting of technology.
- Ensure security of IT equipment and network to enable confidentiality of data.
- Serve as a liaison with organization's IT department.

This requires that the HSTS has the ability to learn new software and hardware quickly and independently so that he or she is able to maintain high-quality service with minimal disruption to users of the simulation center.

The technology in a simulation center extends to the highly specialized field of simulation technology. A healthcare simulation technology specialist requires comprehensive knowledge of the installation, configuration, operation, and troubleshooting of patient simulators and manikins. Often the HSTS is the only person with a full understanding of the features and operation of a simulation training tool. They provide technical support for all simulation operations including preparation, maintenance and repair of computerized manikins (software and hardware), task trainers, and multimedia peripherals. Responsibilities extend to the maintenance of simulation technology, which involves the cleaning and servicing of equipment in accordance with appropriate procedures or standards, and coordinating repair of simulation equipment in collaboration with manufacturer technical support.

The HSTS must serve as the liaison to facilitate technology use and integration into the simulated scenario during design, development, and delivery. There are new updates to simulation software and a multitude of new technologies released every year. Healthcare practitioners and even most educators cannot be expected to keep up-to-date on these changes, and so the HSTS must seek this knowledge to help the program they support to advance and succeed. This is not because the educator or facilitator does not have the interest or background to understand the device, but that the amount of time and knowledge that is required to fully understand each new simulation tool is prohibitive to many, especially with concomitant clinical or teaching roles.

Technology adoption and use has been described using the technology acceptance model (TAM) elucidated by Davis in 1989 to describe adoption of computer use [9]. Variations of this model have been considered but still come down to some persistent features of what affects an individual's likeliness to use a new piece of technology. Relevant aspects to adoption are related to the features/performance and effort required for use of a technology. In addition, there is also a social pressure component about the need to adopt and use a new technology as well as how someone feels about using the technology, referred to as the hedonic motivation [10]. Specific to higher education, the plan to use these features is also affected by facilitation, i.e., the support infrastructure. Physicians may have a unique view of these factors that describe technology adoption. One study looking at physician adoption of technology found that ease of use was the factor that influenced the use of new technology the least. This finding suggests that this factor is underappreciated by those who have constant and reliable access to assistance in operating technology [11].

It is essential for HSTSs to maintain their technical expertise in order to effectively manage simulation equipment and enforce proper usage and operation by all personnel. It is also essential to maintain current knowledge of simulation equipment catalogs and operation manuals to provide recommendations for budgets and purchase of equipment, supplies, and materials related to simulation. These recommendations should be made based on expected utilization and anticipated or proven

function of each training tool specific to each simulation program. This ensures not only that the equipment purchased will be suitable for the program and facility but that it will also be compatible with pre-existing equipment and planned program growth.

An HSTS creates, organizes, and updates technical documentation materials of best practices for use in clinical simulation equipment and contributes to, reviews, and improves system operations practices within the simulation center and skills laboratory. This may be through reviewing manufacturer-provided manuals or designing checklists and setup and breakdown procedures to ensure consistent operation based on each center's unique equipment and design. An HSTS may also be responsible for maintaining logs for cleaning, maintenance, and routine safety inspections.

Inventory management is another responsibility that is often assigned to the HSTS. This encompasses monitoring and ordering simulation supplies to maintain established levels, tracking inventory, and negotiating supplier agreements. Inventory management needs should be planned with educational staff members to ensure availability of equipment and ensure cost-effective equipment utilization. Inventory tracking and utilization can also help with scheduling of planned periodic maintenance as well as identifying damaged or defective equipment to coordinate repair with minimal downtime.

In order to effectively control a simulation session, the HSTS requires familiarity with common medical equipment and medical procedures and must possess sufficient medical knowledge to envision, implement, and ideally assist with the development of realistic clinical scenarios in consultation with appropriate content experts or educational faculty partners. An HSTS must be able to set up, operate, maintain, and troubleshoot clinical instruments and medical equipment, such as IV pumps, ventilators, and hospital beds. This combined set of skills to oversee and run a clinical scenario may necessitate learning medical terminology, human anatomy/physiology, healthcare documentation systems, universal precautions, and medical procedures.

The HSTS works with all users of the simulation center. Well-developed communication skills are essential for this role. They are required to train faculty and learners in the use of simulation equipment and technology, address large groups of people, and be able to speak with both clarity and detail when disseminating instructions. Most commonly, the HSTS will orient students and faculty to the simulation facility and ensure compliance with the facility policies, procedures, and safety precautions.

The HSTS supports the simulation educator(s) to integrate medical simulation methodologies in curriculum, including education training, skill development, and assessment. The two roles work together to establish a learning environment enhanced by available technologies and their integration into clinical education. The HSTS may assist or collaborate with others to develop, deliver, evaluate, and refine clinical scenarios, case scripts, checklists, necessary literature references to support the education, simulation guides, and videos.

In the staging and theatrics domain, an HSTS creates sensory realism in the learning environment for simulation activities, maximizing creativity by preparing scenario

props, soundscapes, lighting, and scenario moulage. They may also be required to have a working understanding of standardized patient scenarios and be responsible for coordinating a standardized patient program schedule, guiding standardized patients through the simulation process, and often assisting with training of these individuals. In some organizations, the HSTS also performs as a standardized patient, either in person or virtually by delivering the voice and reactions of the manikin. Understanding how to perform this role as an aid to the educational activity requires practice and a larger understanding of the goals and objectives for each scenario.

In the research and evaluation domain, the HSTS may assist in the development, dissemination, and evaluation of metrics and tools to assess effectiveness of clinical simulation and assist in preparation of reports, grant applications, and research by collating data and contributing to resource development. An HSTS may also contribute to or develop presentations for conferences and similar events.

It is common for an HSTS to be involved with additional responsibilities on an intermittent basis. These include planning, preparation, and support of special purpose events such as commercial activities, community engagement activities, and professional development workshops. The HSTS is often required to provide guided tours and information about the simulation center and assist with technology-related communication and marketing platforms such as a simulation program's website and social media channels.

Operations Versus Technology

A distinction now potentially arises where the job expectations of an administrative director or coordinator overlap with the duties of those mainly in the simulation lab space assisting with the operation and delivery of an educational session. Many smaller programs are forced to blur the lines between these positions because of funding or general size, but the expectation for each portion of the simulation center operations need must be considered. One example to describe these required roles is shown in Fig. 10.1. This diagram illustrates that the educational goal of a center requires support in the form of administrative leadership with policies and procedures to guide daily activities, coordinators who help to ensure daily functioning through ordering supplies and scheduling activities, and then technical specialists who assist with scenario delivery, maintenance, and IT/AV setup [5]. However, many centers only have one person to fill all three of these roles. Each simulation center will find how each of these roles best fits the needs and mission of the program, but all three pieces are required on some level and comprise the overall idea of simulation operations.

Some groups describe simulation operations as it relates to a job description. A more functional definition of simulation operations is the coordinated system of people and policies that allows for the sustained function and advancement of simulation activities within a center, regardless of the position or positions involved. Simulation operations is larger than a single person, although a single person may support the function of a simulation program in more than one way [5].

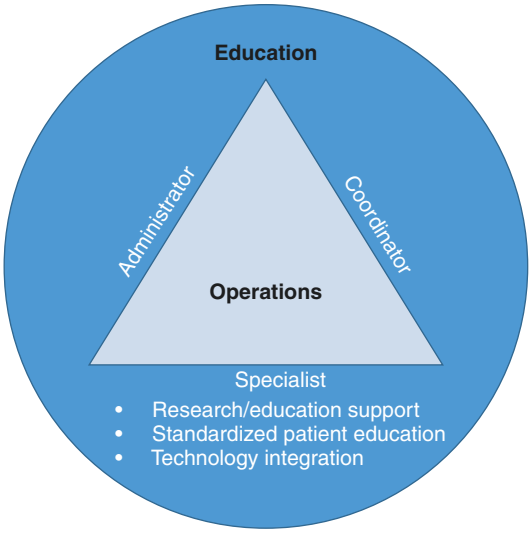


Fig. 10.1 Graphical representation of the three aspects of simulation operations (the administrator, coordinator, and technology/simulation specialist) that are required to support the educational delivery of simulation. These three roles may be performed by the same person

By understanding the larger context of these required domains, the simulation center's organizational structure can better match its need to maintain the function of the programs offered.

Medicine and technology will continue to advance together both in practice and in training. Healthcare simulation technology specialists are an integral part of this symbiosis for simulation-based education and an important piece of the larger role of simulation operations, where education, technology, and administrative expertise come together. More work is required to train and educate those pursuing a career as an HSTS. This training will provide better staffing and therefore better support to meet the gap currently identified in this aspect of healthcare education.

References

1. California Community College Economic and Workforce Development Program Health Initiative. DACUM competency profile for simulation technology specialist; 16 Dec 2008.
2. Forinash K, Monks S, Cohen D, Stanton C, Crawford S, Littlewood K. Simulation operation specialists: an international needs assessment. International Meeting for Simulaiton in Healthcare, Orlando; 2017.
3. Society for Simulation in Heatlhcare. Certified healthcare simulation operations specialist; 2014. [Online]. http://www.ssih.org/Certification/CHSOS/Exam-Information
4. SimGHOSTS. Healthcare Simulation Domain Structure [Online] https://www.simghosts.org/sim/SimGHOSTS_Domains.asp: SimGHOSTS.org; (cited 2018). Available from: https://www.simghosts.org/sim/SimGHOSTS_Domains.asp
5. INACSL Standards Committee. INACSL standards of best practice: SimulationSM operations. Clin Simul Nurs. 2017;13(12):681–7.
6. Bailey R, Taylor RG, FitzGerald MR, Kerrey BT, LeMaster T, Geis GL. Defining the simulation technician role: results of a survey-based study. Simul Healthc. 2015;10(5):283–7.

7. Abramis DJ. Work role ambiguity, job satisfaction, and job performance: meta-analyses and review. Psychol Rep. 1994;75(3_suppl):1411–33.
8. Steer K. SimGHOSTS training plan 2017–18. SimGHOSTS Report: 2016.
9. Davis FD, Bagozzi RP, Warshaw PR. User acceptance of computer technology: a comparison of two theoretical models. Manag Sci. 1989;35(8):982–1003.
10. Venkatesh V, Davis FD. A theoretical extension of the technology acceptance model: four longitudinal field studies. Manag Sci. 2000;46(2):186–204.
11. Hu PJ, Chau PY, Sheng ORL, Tam KY. Examining the technology acceptance model using physician acceptance of telemedicine technology. J Manag Inf Syst. 1999;16(2):91–112.

The Healthcare Simulation Technology Specialist and Audio/Video Technology

11

Todd S. Dadaleares and Scott B. Crawford

When entrusted with the task of designing or supporting an audio/video (A/V) system for a simulation environment, it's imperative to have a detailed needs assessment compiled by the primary stakeholders of the program. The faculty, technical specialists, and directors should all document exactly what they will need to see and hear from their perspective. When operating the A/V system for a simulation environment, it is important to know how to adjust the system to meet the needs of educators and facilitators in the space and explain the capabilities of the system to them. Consider every simulation control room, simulation learning space, classroom, computer desktop, auditorium, and off-site environment when deciding what equipment will be needed and where it should be placed. Consistency of equipment and function will minimize the need for learning and decrease the chances for technical errors for both new and existing personnel to efficiently and appropriately use an A/V system. Different simulation spaces may benefit from specific A/V furnishings [1]. For example, the sight and sound needs for a faculty member reviewing a pre-recorded objective structured clinical examination (OSCE) will be different than the needs of a healthcare simulation technology specialist (HSTS) who is responsible for capturing A/V during a high-fidelity scenario. Furthermore, the technical needs of a skills-based training room will have its own set of media requirements. Planning for the inevitable changes in technology is additionally important as new A/V innovations are being developed and deployed constantly. With so many pieces of specialized gear available to the consumer and professional

T. S. Dadaleares (✉)
Department of Medical Education, Maine Medical Center, Portland, ME, USA
e-mail: dadalt@mmc.org

S. B. Crawford
Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA
e-mail: scott.crawford@ttuhsc.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_11

alike, the choices of equipment and their price ranges are extremely diverse. Understanding the general function and capabilities of each piece of equipment can assist with outlining a plan for eventual upgrades or to enhance function within an existing infrastructure.

Some key questions a simulation design team might ask when planning for or modifying an existing A/V infrastructure include:

- "What must I be able to see and hear during a simulation?"
- "Should the cameras be mounted on the ceiling, on the wall, or on an adjustable stand?"
- "What type of microphones will capture the conversations that take place in a noisy simulation lab?"
- "Do we need discrete control of all video and audio before it is streamed and recorded?"
- "Can I get by using small computer speakers at each standardized patient (SP) station or would headphones be more appropriate?"

During the process of conducting a needs assessment, these and many other questions can spark conversations between team members about why specific technology is paramount for individual areas. The answers to these questions will define the complexity or simplicity of the A/V system. There will always be the lure of the latest/greatest tech toys to consider, but decisions should be tempered by a pragmatic approach toward acquiring equipment that is fully functional for the primary users but not so complex as to be onerous to operate. Always start with the educational or training goals, and then select the appropriate equipment to meet those needs.

Audio

What Is Sound and How Do We Hear?

What we perceive as sound is the oscillatory movement of an object that occurs when a force is applied to it that causes the surface of the object to vibrate. This can be anything from a large rigid surface to a thin string. If you knock on top of a metal tabletop, it makes a noticeable "gong" type of sound. This is because the tabletop is actually vibrating imperceptibly fast and forcing the air molecules all around the table to vibrate at the same rate. This energy from the vibration creates an oscillating pressure wave. The molecules in the air transmit this pressure wave to our ears, where they move the tympanic membrane and create small movements on nerve cells inside the cochlea within the ear that are then detected by our brain as sound [2]. Our ears allow us to hear an incredible variety of sounds, even more than can be naturally emitted by the human voice. When we sing the different pitches in a song, our lungs are pushing out air through our vocal cords that are vibrating from the air moving past them. Small muscles change the tension on the cords and alter the

Table 11.1 Example of familiar instruments and their audio frequency ranges. Note the range of human hearing is 20–20,000 Hz, while human speech ranges from 80 Hz to 500 Hz [2]

Audio source	Lowest frequency (Hz)	Highest frequency (Hz)
Piano	27.5	4186
Female speech	140	500
Male speech	80	240
Compact disc	0	22,050
Human hearing	20	20,000

speed of vibration, thus creating different pitches. A lower note is made by slow vibrations. The faster the vibration, the higher the note perceived by our ear. When struck, the middle A key on a piano vibrates at 440 cycles (vibrations) per second and can be expressed in hertz as 440 Hz. Humans hear sounds from as low as 20 Hz up to 20 kHz or 20,000 vibrations per second. Most of what we need to hear in simulation is speech and voice. Because of this, the 80–500 Hz range is often the most important [2]. Table 11.1 shows examples of frequency ranges emitted by different instruments.

A simulation space could be thought of as a theater, like a performance area for medical practice-play. The physical surfaces, fixtures, and furniture have sound-reflective tendencies and can soften or harden a listening experience. For example, the height of the ceiling will make a difference in how audio events sound. The higher the ceiling, the more distance the sound has to travel from a participant to ceiling microphones, adding a small but perceivable delay to the signal. This is what makes a room sound large or small. Two-way mirrors are extremely sound-reflective, which adds a liveness to the signal, making it challenging to auscultate and record. The control room is a recording studio and should be designed with the best layout and acoustics in mind for control and monitoring. This critical observation and listening environment should not just be built into a former closet space, but rather should be designed to allow for effective critical assessment of learners.

Microphones

The job of the microphone (mic) is to capture the discernible elements of what humans hear and carry that waveform into an amplifier so that it can be heard with enough fidelity as to sound true to life when reproduced by a speaker or headset. There are many different types of microphones, and they all use different methods to convert the air pressure variations of a sound wave into an electrical signal. Each mic is designed to capture specific types of sound both in terms of frequency and location [3, 4]. See Table 11.2 for microphone types and features.

For instance, a handheld dynamic microphone, such as the Shure SM57, would be an appropriate choice for a vocalist or lecturer who will keep the microphone within 6 to 8 inches of their lips during speaking (or singing). This could be mounted on a control room table, and little sound outside of this area will be detected and reproduced. But a condenser microphone, such as an Audio-Technica PRO 45, is

Table 11.2 Microphones types are described here with key features to remember about best uses and function [4]

Dynamic	Small sound catchment area, movement toward or away from its diaphragm will change volume and frequency reproduction.
Condenser (choir)	Able to detect sound from a large physical area, even most soft sounds, requires phantom power (48 V) from specialized equipment to operate.
Boundary (pressure zone microphone (PZM))	Similar to a choir microphone, but mounted on a wall; helps to collect sound from a large area and uses the acoustically reflective surface on which it is mounted to aid in sound detection.
Shotgun (boom)	Microphone used on video and camera equipment or mounted on a "boom" (overhead equipment mounting device) with a very narrow audio catchment area. Sounds from off-axis are diminished.
Lavalier (lapel)	Worn on the collar or ear of the user, this semi-directional microphone helps to capture audio often from a lecturer or singer who wants mobility.

Fig. 11.1 Ceiling-mounted unidirectional and omnidirectional condenser microphones dispersed to capture all sections of the room. Note the "Voice of God" overhead PA speaker is 3 feet away from the microphones

much more sensitive and can capture the crisp details of an audio dense environment even from several feet away.

Condenser microphones (sometimes called condensers) are not meant to be handheld, but instead mounted, as they are much more fragile than their dynamic counterparts [3]. The mounting can be with special handles/hangers or into structures like walls, permanent furniture, or ceilings (see Fig. 11.1). Some condenser mics are designed to capture the audio of environments and can be used appropriately from many feet away to capture large rooms filled with many talking people, like simulation theaters.

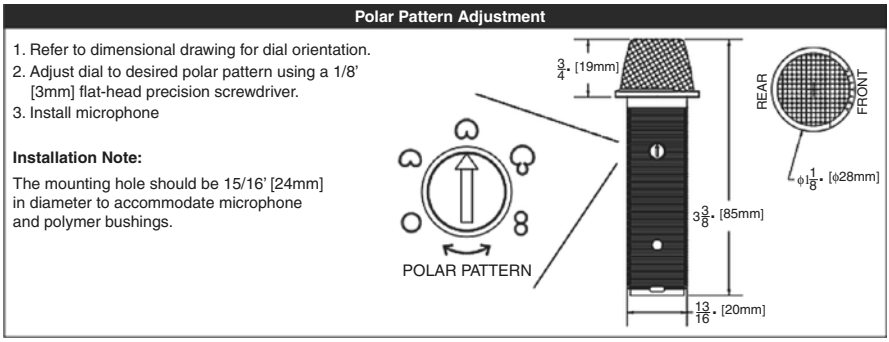


Fig. 11.2 The microphone's polar pattern is shown. Five different directional responses can be set on the mic by turning the very small dial on the side. The best setting for a ceiling-mounted mic is one that "doesn't hear" the sounds above the ceiling like electrical hum and HVAC noise. (Courtesy of CAD Audio)

Every microphone has a directional response called a polar pattern. In simple terms, this is the distance in front of and around a microphone that "hears" the sound-making environment. The direction the sound arrives from relative to the polar pattern "axis" will determine how well it is detected. Once detected by the "diaphragm" of the microphone, it is converted into an electrical signal and transmitted down a cable usually to a mixer or amplifier. Some microphones pick up sound from all 360° around the axis of the microphone (omnidirectional), while others have a directional response only in front of (or under) the mic's capsule (metal or plastic protective shielding). See Fig. 11.2 for examples of polar patterns [3].

For certain rooms, a boom or shotgun microphone may be used, as it can capture sound several feet in front of it while blunting the sound coming into it from the sides. Some simulation centers use a combination of a boom microphone aimed at the bedside and omnidirectional microphones overhead to capture the room sound from different locations. A boundary microphone (also known as a pressure zone microphone (PZM)) is a commonly used microphone in simulation labs that can be installed on surfaces like a wall, ceiling, or tabletop. Boundary microphones feature technology that eliminates sonic interference from reflected sound waves [3]. This is a valuable trait when considering spaces that have reflective surfaces and walls, like simulation operating rooms, emergency departments, and exam rooms. A pressure zone microphones' directional response varies by type and model but can be used in omnidirectional or cardioid mode. In some instances, the audio needs of a scenario reach beyond the confines of the simulation theater and into places in the organization that are not hardwired for microphones. The challenge of streaming and recording audio outside the confines of the simulation theater proper can be accomplished by using wireless microphones. If a scenario calls for some type of transport of a patient from one sim room to a staged space that has no microphones installed, using a wireless microphone on the stretcher may allow for audio even

when movement is planned. A lavalier microphone is meant to be worn, sometimes discreetly, and can be used by a participant in a simulation to allow movement while maintaining consistent audio capture. Lavaliers are best suited to be in proximity to the larynx of the wearer [3, 5].

The fidelity of wireless audio has grown exponentially in the twenty-first century, but often wireless systems are more expensive than their wired brethren. Wireless audio systems function using radio-frequency communication: either ultrahigh frequency (UHF), very high frequency (VHF), or some now with Bluetooth pairing [6]. The type of transmission can affect the distance of transmittance, and each microphone's sending unit must be paired with a receiving unit that will still have a wired output plug for use with any attached equipment. The biggest limitations of wireless equipment are transmitting distance and need for batteries or recharging.

When it comes to high-fidelity audio, you often get what you pay for, whether it be a microphone, mixer, preamplifier, powered speaker, or processor. The better the quality of audio gear, the better the sound quality of the final audio. This does not mean that the highest priced equipment must always be used. Short of full professional gear, adequate quality audio reproduction for the needs of simulation and education can still be obtained, even though it may not be suitable for concert performances at Carnegie Hall. Testing equipment in the space and working with a sound engineer to understand your needs will allow cost-effective infrastructure design choices.

Walkie-Talkies

Walkie-talkies with a connected earpiece can be used for communication to a standardized patient or embedded participant so that information can be released to or held from the learners at the appropriate time in the scenario (Fig. 11.3). Perhaps a learner would like to run a blood test. The embedded participant could be told by faculty that the blood test is pending and to withhold pertinent information until other interventions are explored first. Updates about upcoming physiologic changes in the patient are easily communicated with walkie-talkies as well. This technology has also improved drastically from the children's toys of the early 1980s. Now an open field range measured in miles and hundreds of unique channels are common features. Still, call clarity is far from the professional audio equivalent and the risk of crosstalk even with multiple channels is high due to the increased range.

Professional intercom systems can be wired or wireless and are designed to communicate from control room to stage in live theater productions. These systems can have multiple channels with long ranges and clear signal with very low risk of cross talk but are often cost prohibitive for all but the largest of simulation budgets. They are also unlikely to be inconspicuously worn by an embedded participant due to the size of the headset and/or belt-pack that are required for function.

Fig. 11.3 A clinical actor (also known as an embedded participant) is about to administer a drug while awaiting cues and information from faculty and simulation staff in the control room. Her walkie-talkie is locked to a specific channel, and the audio output line runs up and around to her ear

Speakerphone

During a well-designed scenario, there are points in time when learners may feel the need to reach out to someone not in the simulation room either to gain assistance from consultation with a care specialist or to give report and the expected transition of care to a receiving medical team. This role can be played by an attending physician, educator, or healthcare simulation technology specialist (HSTS). Having a speakerphone available allows for the introduction of advice, feedback, or confirmation about the medical situation in which the learners are involved. By using speakerphones installed in the simulation room and the control room, a prepared faculty member or HSTS is able to answer the call as another doctor, blood bank administrator, or whomever the learner needs. Learners may have ordered chest x-rays and are calling for results, or there could be questions about the patient's history or a request for data from the lab. A direct cell phone to cell phone call can also work, if the speakerphone function is on. The use of speakerphone allows all participants to hear both sides of the exchange. The location of the phone can often impact the need and location of microphones within the room, as this is a common time when medical decision making and critical thinking by the participant is shared and can be used to help guide training.

Public Address Systems (PA)

An overhead public address system, commonly known as a PA, might be needed during a scenario for announcing something pertinent to all participants. This separate microphone, amplifier, and speaker system in its simplest form consists of a tabletop condenser microphone connected by a cable to a powered speaker/amplifier combination that resides in the ceiling. The overhead speaker can distribute key information, like when the scenario concludes or to let participants know that something important or potentially dangerous is about to happen without their awareness. For instance, learners might be confused about the use of the defibrillator and are about to shock the simulated patient, but have not yet "cleared" the team members who are still physically contacting the simulator. The PA can be used to immediately announce, "Everyone step away from the patient! You are using a real defibrillator!" The overhead PA (sometimes referred to as the *Voice of God*) can come in handy as a quick communication link between control room and simulated spaces. For example by providing announcements such as: "Learners are outside the room," "Please move to your next station," or "Room is safe," indicating that the live simulation is no longer being broadcast to the observation/debriefing room and preparations can begin for the next scenario. Some educators like to avoid the overhead paging system, citing that it takes away from the realism, while others use it to help redirect learners and believe that it will actually help them engage in the scenario with short verbal redirects so they can focus on the medical tasks and not the artificial environment with which they are trying to interact. This is a simulation center-specific culture, and understanding how this piece of equipment is used will be important at each individual site.

Speaker systems for paging are often different from those of home audio systems. A standard speaker is essentially a resistor. A speaker resists the flow of electricity, and converts the oscillating electric signal from the attached wire into an oscillating magnetic field as it flows through a coil of wire near a fixed magnet on the speaker's cone. Representative oscillation is observed in the speaker from the attraction or repulsion of this induced magnetic field, relative to the fixed magnet. The oscillation of the magnetic field is transmitted to the cone of the speaker and produces a physical movement that transmits a pressure wave to our ear that is perceived as sound [7].

If multiple standard speakers are connected together, the resistance changes depending on how they are connected. Connected in series (end-to-end), the resistance increases because the electricity has to flow through two resistors. Connected in parallel (shared positive and shared negative terminals), the resistance is less because the signal can flow across either resistor. The resistance changes the relative volume of each speaker. A speaker with lower resistance will appear louder than one with higher resistance in the same circuit because

more current will flow through it. If more than two speakers are connected together, the math is much harder to figure out and requires calculations depending on if the resistors are in series or parallel. The power drop across the resistors can be calculated using both Ohm's law (voltage (V) = current (I) × resistance (R)) and the power calculation (power (watts(W)) = current (I) × voltage (V)). The power output and therefore volume could be calculated, but this technique is not recommended [8]:

$$R(\text{total}) = R1 + R2 \ldots (\text{series})$$

$$\frac{1}{R(\text{total})} = \frac{1}{R1} + \frac{1}{R2} \ldots (\text{parallel})$$

$$V = \text{IR}$$

$$P = \text{IV or } P = \text{I2R or } P = \text{V2 / R}$$

Often PA systems will allow a message to be sent to multiple rooms and/or hallways at a time. Because of this, PA systems operate on a fixed voltage system where any number of speakers can be connected together without the need for resistance calculations. The most common systems are 70 V and 25 V. Both the speakers and the amplifier must be of the same type to be compatible, and neither will work with a standard home audio speaker or amplifier. Using a constant voltage system, any number of speakers can be connected together as long as the total power (wattage) of the speaker connection does not exceed the power output of the amplifier. The signal from the amplifier is connected to the speaker using a "tap" (see Fig. 11.4).

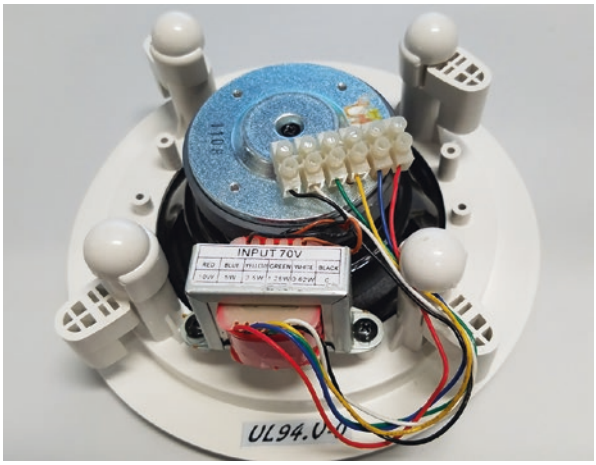


Fig. 11.4 The back of a speaker for use with a 70 V PA system is shown. The speaker has a 70 V transformer with a "tap" (6 wire connection terminal) to adjust the power output (volume) based on the location where the input wires are connected

The connection of the speaker to the corresponding power tap (denoted in watts) will determine the volume of the speaker relative to others in the same system. A speaker tapped at 2.5 watts may be loud enough in a debrief room to hear the page that the session has ended, while the noisy environment in front of the elevator may require the speaker to be tapped at 5 watts to be noticed in the same way by those in the area.

Audio Mixer

The audio signal collected by a microphone or microphones is usually connected to a device to modify or modulate the signal in some way before it is rebroadcast or recorded. Two primary systems for accomplishing this are commonly available in simulation centers. One is a user-accessible mixer or "mixing board;" the other is a large-scale analog or digital audio signal processing unit that, although configurable, is not designed for frequent user-accessible adjustment and will be located in a server or equipment closet.

The microphones in any simulation center will have to be connected by cabling and terminated to some types of audio preamplifier or mixer. The most common type of cable for this in professional audio is the XLR cable. This cable has three wires and metallic shielding to prevent radio-frequency "noise" from altering the signal as it travels along the wire. The XLR cable can be terminated into an XLR plug (Fig. 11.5) or a Phoenix plug (Fig. 11.6), depending on the type of equipment used. Tabletop mixers like in Fig. 11.7 use an XLR plug, while whole center signal

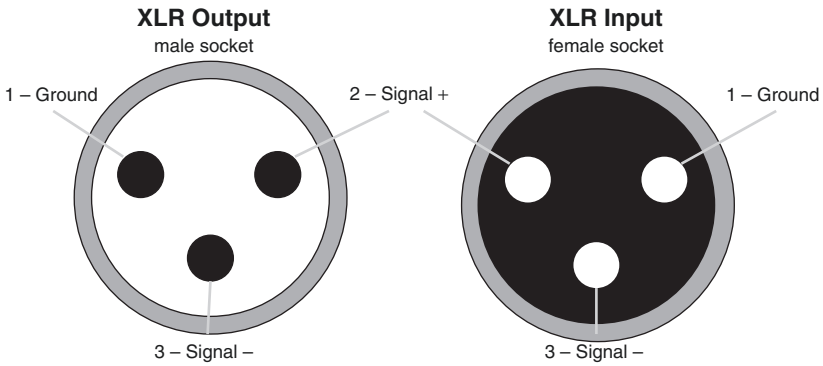


Fig. 11.5 The pin output connection pattern for male and female style XLR connectors is shown. This round style plug is used to connect to microphones or mixers. See Fig. 11.24 for connector photos

processing units will use Phoenix connectors because they have a smaller size and can connect more cables in a smaller space on the system (Fig. 11.6). The XLR cable terminal is stronger and designed to be plugged and unplugged many times, while the Phoenix connector has a greater risk of a wire getting disconnected or broken if moved frequently.

Fig. 11.6 An array of 3-Pin Phoenix plug connections is shown going into the back of a digital sound processor (DSP) from multiple simulation rooms

Fig. 11.7 The audio mixer is broken up into channels (M1-ST2) where inputs accept audio connections from XLR, Tip Ring Sleeve (TRS), and RCA-type connectors. The volume and tone of each channel can be sculpted and mixed with other audio channels. The final mono or stereo mix is sent to amplified speakers for the live main volume in the control room and simultaneously outputs another playback mix that is distributed by cabling to a recording medium like an audio encoder, digital video recorder (DVR), hard disk recording system, or digital audio server

The audio mixer or "mixing board" is where the sound from multiple mics or other audio inputs is enhanced, combined together, and output. The output will go either to an amplifier with speakers for the immediate "live" control room mix or to the video encoder to add the audio signal to the video signal from a room for recording or broadcast.

Once the audio cables from the microphones are connected to separate input channels on the mixer, each channel can be adjusted independently. Below each channel (in a column), the dials will adjust specific aspects of that channel. Common control options by channel are to boost or attenuate the signal with the gain dial, change the tone by adjusting the relative volume of high or low frequencies with equalization, pan the signal to the left or right audio output in the stereo field, and adjust the volume of each channel independently. Once each channel is adjusted, the overall level for all channels together can be adjusted once again with the master level.

Most condenser microphones require phantom power to operate. Phantom power is a low amperage 48V power supplied over the usual XLR cable and is what allows this type of microphone to detect soft or subtle sounds. The mixer delivers this to the microphone when it is connected. If the phantom power is turned off, a microphone that requires it will appear not to work. Good-quality XLR microphones that do not require phantom power will operate normally, and without risk of damage, even if phantom power is turned on. A well-equipped audio mixer should be able to direct some signals to specific outputs either together or independently. Even small mixers can accomplish this through the use of pan. Assignable outputs can allow a mix that is suitable for live listening in the control room and one that is heard by learners who are viewing remotely.

> **Special Note:** Pan can allow a single mixing board to direct signals to separate left or right channels. This feature can be used to have two separate rooms adjustable by a single mixer if detailed sound localization (from stereo inputs) is not required within each room. One control room can receive audio from the left channel; the other can receive audio from the right channel.

For instance, two separate mixes from two different outputs on the mixer can be sent simultaneously from the playback and main mix: one to the control room and one to the recording-streaming-playback system. These final audio mixes can be synchronized with the video by the A/V network system or by sending the live video and audio together directly to a monitoring source.

Large-scale digital signal processing (DSP) devices exist with the ability to mix and direct signals to multiple outputs and are highly configurable. The BiAmp Tesira and Toa M-9002 m are examples of fully integrated DSPs [9, 10]. In these devices, separately purchased control cards allow for adjustment of the number and type of audio inputs and outputs. Once installed, adjustments can be made through a graphical user interface (GUI) on an attached computer system. Setup, installation, and adjustments of these systems should be reserved for AV installers, but fortunately, many of these adjustments can be done remotely via a computer network connection (Fig. 11.8).

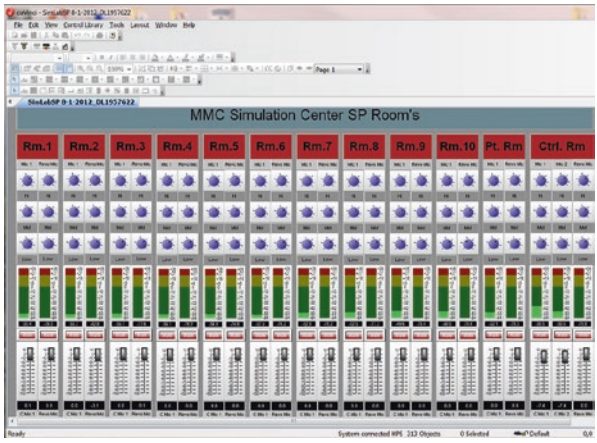


Fig. 11.8 Example of master digital audio mixing console running on proprietary software that can be accessed from any computer in the simulation center. This mixer is the SP lab configuration where 25 microphone feeds can be equalized and balanced

Decisions about which type of system to use will come down to an understanding of the size of the center, the number of expected microphones or other audio inputs, the technical knowledge of the staff within your center, and their ability to support and troubleshoot each system, as well as the financial consideration of each.

Listening

A pair of professional headphones is recommended for use in control rooms that might need isolation from other actions taking place. For example, some simulation lab control rooms are set up to view and listen to multiple simulation theaters at once. Headphones are required so that each HSTS running the simulator and associated media can hear only the room they are controlling without being distracted by those around them. Over-the-ear headphones are most common for simulation room listening and come in two primary types: open back and closed back. An open-back headphone allows outside noise to enter the ear cup easily, so talking can still occur between adjacent wearers. A closed-back design provides a physical blockage for outside noise, which is great if working around significant cross talk or noise, but can inhibit communication with a wearer [11].

Noise cancellation may seem like a good option to remove outside noise, but it requires power and frequent battery changes. Noise cancellation was designed to remove a persistent hum or constant background sounds (like what may be encountered on a train or airplane) by reproducing an inverted sound wave to the wearer to "cancel" the outside noise. This does not work well for removing variable noise, talking, or clatter, because the inverted signal is both low in volume and not fast enough to minimize all outside sounds. Noise isolation from earbuds or closed-back headphones is best for this concern.

Video

Analog Video

A simulation session is often recorded for post-simulation review and sometimes saved for the learner's record. This can assist with debriefing, evaluation, grading, and technical skill review and improvement. Will the recorded event(s) be recorded to VHS tape or DVD? In this day and age probably neither, but it is worthwhile to understand how the final audiovisual signal is output from the recording system, whether the signal is analog or digital, and in what format the file is finalized.

If the primary A/V system is analog, meaning it uses analog closed-circuit television (CCTV)-type video cameras connected by coaxial, composite, S-video, or component video cabling, then that final mixed video signal is an analog video signal. Normally, an analog multi-camera system will have a termination point called a multiplexer, or matrix, which will feature several connecting points for camera inputs. It will also have one or more outputs to send a signal(s) to a video monitor. A rack-mounted or tabletop multiplexer organizes the cameras by allowing a user to program them with a camera controller, which also plugs into the multiplexer. With the camera controller in sync, one of the multiple cameras can be selected and then panned, tilted, zoomed, or focused onto a subject using a joystick-style control. In general, the final analog video signal coming from the multiplexer might vary in display resolution, aspect ratio, and refresh rate depending on brands and types of analog systems sending video. However, the color video signal in all analog television images contains luminance, brightness, and chrominance and may be displayed in either standard definition or high-definition video quality. For video, there are two frame rate standards: NTSC at about 30 frames per second (in the United States) and PAL/SECAM at 25 frames per second (in most of Europe, Asia, and Australia) [12]. That means the video system is producing 25–30 pictures a second and projecting that sequence through a monitor to the human eye. The final analog video signal can also be digitized with a media encoder and sent to a stand-alone recording device like a computer with a large hard drive, digital video recorder (DVR), or digital video server.

Digital Video

Today, most newly built simulation centers are outfitted with digital video cameras connected through video mixers or multiplexers and output through an encoding service to cat5 (category 5) or cat6 (category 6) ethernet cables to a digital video recording server. Digital video is similar to motion picture film in that it uses encoded digital data (pictures) displayed in rapid succession to achieve the effect of motion. Digital video (DV) has been available commercially since the 1980s and has slowly but surely taken over, replacing analog video to become the medium used throughout the world [12].

The advantages of DV are numerous. DV can be copied and easily edited with no degradation in its quality. It can be played and edited on computers, phones, and tablets. It can also be stored on hard disks or streamed over the internet to end users who watch content on a computer screen, smart TV, or portable web-connected device. With many reputable vendors producing hundreds of mountable digital video cameras, the choices are innumerable. Most new ceiling and wall-mounted video cameras used in simulation can now be networked into a Local Area Network (LAN) structure and are termed Internet Protocol (IP) cameras. These same cameras may offer combined outputs of analog and DV from the same device. Often produced for the security and surveillance industry, IP cameras have allowed versatility and flexibility of remote operation and control from a computer interface. Some can pan, tilt, and zoom (PTZ) or be programmed to scan or move back and forth at a certain pace. Depending on the design, IP digital video cameras can be controlled by software, or by hardware-based camera control systems, which mimic analog controllers by utilizing a joystick or number pad interface.

There are many different digital video file formats. A DV file is usually made up of two parts: the *container* and the *co*mpressor/*dec*ompressor (*CODEC*). The container denotes what the file type is, for example, .AVI, .MOV, or .MPG. Inside the container there is a CODEC that has the instructional code and settings for how the video and audio are to be decoded and played [13]. Some of the most commonly encountered CODECs in IP camera transmission are currently M-JPEG, H.264, and MPEG-4, among hundreds of others. Commercial video software is usually preloaded with the most popular and most used CODEC and container decoders so that playback of these files is possible. Therefore, when any digital video camera outputs its video, also included is a "wrapped" container format, which most often can be unwrapped or decoded to play back through a software program, or a media device that has the right CODEC. VLC media player and SPlayer are two open-source video players capable of displaying most video files.

The primary disadvantage to most IP-based digital videos is a small but often detectable delay between picture capture, encoding, and later decoding and reproduction. Unlike full analog systems, this delay can make real-time communication with a room being observed difficult. It can also present problems for use if the equipment is not correctly designed and understood. Delays of 300 ms or more are common with many systems and are an argument for the combination of IP digital video for recording and analog video for direct viewing, especially if real-time audio communication is being used.

Analog or Digital?

Different analog signals have specific distances that they can travel down a cable before their signal degrades and needs amplification to keep the signal sharp and discernible. Audio cables carrying a signal over 100 feet should be re-amplified before reaching their destination at a distribution amplifier or mixer. An analog video signal also degrades over cabling, so reamplification should take place every

150–300 feet for composite and S-video signal, respectively, while VGA (video graphics array) and component video transmission can only travel 30 or 100 feet, respectively, before signal degradation may occur [14]. IP network cabling has a limit of 328 feet (100 m) between devices [15].

The advantage of analog point-to-point cabling is that the cables plug directly from source camera/mic to video monitor/mixer. Few errors can occur unless the cable gets cut, but expandability and remote viewing are nearly impossible. In a large simulation center, the initial expense of the cabling will have to be considered. Analog is likely more expensive and requires careful planning to ensure control or viewing locations are not likely to move. It is also becoming increasingly difficult to find and implement professional standard definition analog video equipment, as audiovisual vendors are continuously replacing older formats like S-video, component, and composite video with their high-definition and digital counterparts: high-definition serial digital interface (HD-SDI), digital video interface (DVI), high-definition multimedia interface (HDMI), cat5/cat6, etc.

Analog does not always mean low definition. Analog high-definition (AHD) cameras have been produced that will still send high-definition signals using an analog signal, but with the higher resolution that we have come to expect from computer and television monitors [16]. The primary type of cable used for these connections is Bayonet Neill–Concelman (BNC) terminated coaxial cable (RG-59 or RG-6). AHD cameras were produced to allow resolution upgrades without having to change wiring for older analog security systems. This same cabling can support HD-SDI and high-definition transport video interface (HD-TVI). These are newer broadcast-quality connections that will send high-definition signals without the encoding and decoding delay experienced by IP video signals [16, 17]. Despite these advances, the ease of wiring and ability to add onto an existing system still makes IP-based cameras the best choice for price, function, and ease of use for most simulation centers.

IP cameras have begun to overcome proprietary control system limitations from the many manufactures now present in the industry with the use of ONVIF (Open Network Video Interface Forum) [18]. This functionality allows multiple brands of cameras to be connected to a single video recording and control system with near-seamless functionality across all devices.

Management Systems

A large simulation center might have the following setup: a standardized patient laboratory consisting of ten exam rooms, one hybrid/high-fidelity simulation room, one learner orientation room, one standardized patient-meeting room, one large SP control room, and a hallway between all the exam rooms. If every room has 2 active mics, 1 extra microphone input, and 2 video cameras, that means there are 30 video and 25

audio input connections required to terminate at an A/V matrix/multiplexer system. The individual signals from each room will be transmitted through the system to multiple separated observation stations where any listener, SP, trainer, or faculty member can select any of the ten exam rooms to see and hear via individual video screens and headphones. The cameras and microphones in the SP orientation and learner rooms are for the SP coordinator and HSTS to be able to keep track of what's going on before, during, and after an event. Cameras in the hallway and SP control room are for flow control (of learners) and oversight of the whole learning activity. If an analog video-based system is desired, then the video cameras, coaxial cable, and multiplexer(s) will all have analog connection points – as in a coaxial, S-video, component, or composite video connection from camera-to-cables-to-appliance (multiplexer). This type of technology connects directly to live video monitors. An A/V matrix can send video and audio synchronously to the multiple sources or to just the sources that are selected. Each observation station is connected to the matrix by its own connected analog A/V cable. In some SP centers, running left and right audio cables and separate video cables from every room throughout the center is not uncommon. With a few simple button selections, exam room 1's A/V can be sent to observation stations 4, 6, 9, or any combination of rooms. Figure 11.9 shows an example schematic for connections and equipment in a well-equipped simulation room.

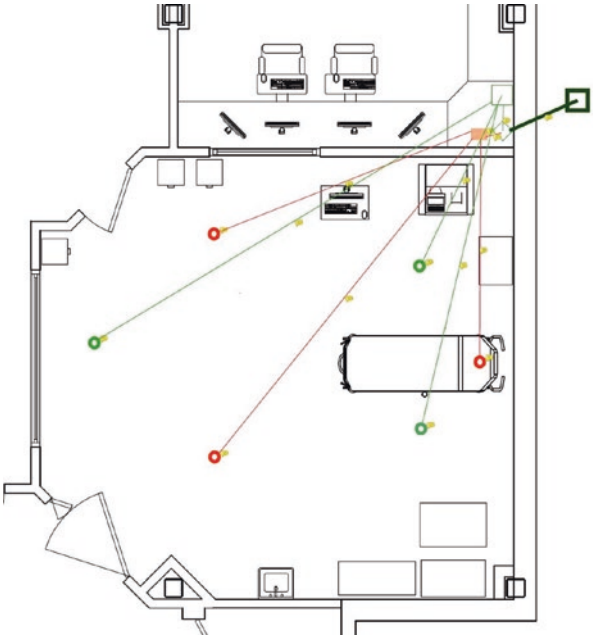


Fig. 11.9 An example of ceiling-mounted video camera placement and ceiling-mounted microphones with signal flow demonstrated by color. Video is represented in red; audio is represented in green. Video signal terminates in a multiplexer or video mixer (orange rectangle). Audio signal from microphones connects to an audio mixer (large green square). Both A/V mixers send the signal to an encoding system (small green square) and then out to the A/V servers (large black square)

A server-based A/V data management system is arguably the most powerful and efficient video delivery and retention system for the modern healthcare simulation center. Many companies produce or design these types of A/V systems (enterprise solutions) or will work to integrate existing pieces of A/V equipment (A/V integrators). There are robust simulation management systems designed for audio and video capture with additional features often offered for grading, scenario cataloging, and inventory and room management components. The specific features may vary from company to company, but functionality is similar for most systems. Institution-wide solutions exist with features that include the ability to record all cameras at once, provide near-instantaneous retrieval of A/V for playback, streaming of live A/V to multiple endpoints (classrooms, debriefing spaces), add annotations that will be embedded into the recorded timeline, and track and evaluate collected learner data. This computer- and server-based network operates similarly to the analog A/V systems described above except that all listening stations are connected by cat5 or cat6 cables instead of being hardwired with analog cabling. IP video cameras are connected to a network switch and then to the A/V servers that feed live-streamed or recorded audio and video out to computer observation stations. For some users, however, it may make sense to combine the use of analog and digital equipment, picking and choosing for individual equipment advantages.

For a variety of reasons, often financial, programs, especially when beginning or working in temporary spaces, have evaluated and implemented modified home security systems with functional results [19]. This may be an adequate solution for many programs, and it has been shown that video-assisted debriefing may not be routinely required to provide feedback and enhance learning [20].

Auxiliary Equipment

Ultrasound equipment, video laryngoscopes, computerized medication dispensing systems, and a variety of other clinical and simulation-specific training tools may have video output capabilities. Some centers have the ability to connect these extra devices into a video system for recording or real-time display to review technique and assist with skills training. One specific example of this is real-time CPR (cardio-pulmonary resuscitation) monitoring. Some simulator control systems can collect data directly from the manikin and can display the learner's CPR performance in real time (Fig. 11.10). Research has been shown that when this data is displayed and used for instruction during resuscitation in simulation, the quality of CPR provided by the learner improved [21]. Making information like this available for training or for retrospective review may be important to some centers. The chest compression and ventilation measurements can be sent from the VGA, HDMI, DVI, or display-port output on the simulator controller (aka instructor) laptop. A scan converter can digitize the output signal of a computer and convert it to an IP or analog video signal. This signal can then be encoded and sent as another viewing "window" into the A/V system.

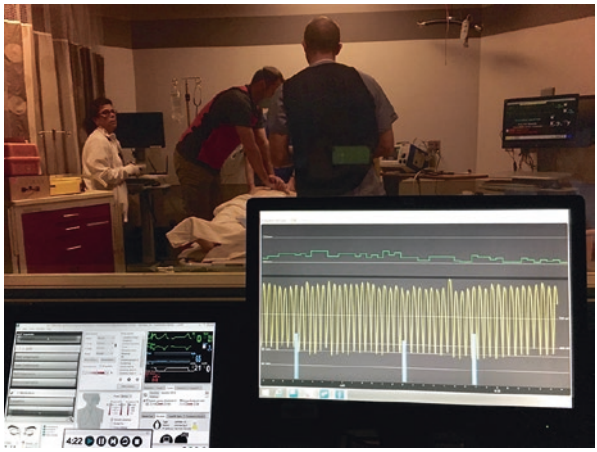


Fig. 11.10 Interdisciplinary team performing CPR on a patient simulator, while the instructor laptop's secondary video output sends the CPR performance data to the control room and debriefing room monitors. Depth, rate, and release of chest compressions (green and yellow lines) and ventilation efficacy (blue lines) are displayed in real time and recorded for postevent review

Physiologic Monitor

Being able to see the patient's vital signs monitor in the debriefing room is important to a medical care team while watching or reviewing performance, so converting the output of this monitor to a video signal is an important feature of a robust A/V system. A connection from the simulation monitoring system can be made via VGA, DVI, or HDMI output into a scan converter that converts the computer's video signal to analog video and sends it both to a control room monitor and to an encoder. The encoder converts the analog video back into a digital video signal (essentially a file) that can then be sent into the system as a separate view or for recording. Decisions about how the physiology of the simulator might change during the case and what will be communicated to the clinical actor will have to happen efficiently so that the simulation appears real to the learners in the room and the observers in the classroom. For instance, if a learner in the simulation performs a clinical action like reconnecting the oxygen delivery mask to the patient simulator, the HSTS can zoom a camera onto the oxygen regulator to view what the current settings are and adjust the simulator's physiological response. The patient monitor will then change accordingly so that all observers can see the latest vital sign trends.

A/V for Specific Simulation Spaces

The A/V requirements of a simulation center can differ greatly, depending on what type of educational event is taking place and for which group of learners the event is designed. The following three examples illustrate the differing A/V needs of the mature simulation center.

Example 1: High-Fidelity Simulation Lab
Let's suppose that an emergency medicine simulation event is taking place, and the scenarios call for the simulation space to resemble an emergency room. Aside from the room requiring multiple medical provisions and familiar clinical gear, it will also need to be outfitted with audiovisual technology that captures the happenings inside the room. The learners will communicate with each other in the controlled environment of the simulated emergency room, while the sights and sounds of the simulation are presented in both the control and debriefing rooms. A portion of this scenario example is shown in Fig. 11.11.

In order to simultaneously send multiple high-quality moving images and sounds to connected displays in classrooms, lecture halls, or a control room, an ideal high-fidelity A/V system should include a collection of PTZ cameras, a camera control system, microphones, a sound mixer, sound amplification, speakers, A/V encoders, walkie-talkies, headsets or handheld microphones, wireless microphones, scan converters, audio processors, video multiplexers, video monitors, and multiple computers and screens. The observers will need to see what all the participants are doing and hear what they are saying while also seeing the patient's clinical monitor displaying vital signs. In the control room, the simulation team should have a view of the action from multiple angles. Digital or analog video camera systems can be used to capture the busy visual environment. Oftentimes the action and communication of the learners will influence real-time programming of the simulator, so cameras affixed to walls and/or ceilings should provide adaptable viewing options, allowing the HSTS to anticipate upcoming actions while also transmitting the A/V signal to the

Fig. 11.11 Emergency medicine faculty and the HSTS producing the simulation from the control room. The embedded participant (acting as a family member) is engaging with emergency medicine residents and the patient simulator. Three unique camera views and a separate monitor for viewing the simulated patient's vitals are to the extreme left-hand side of the picture

Fig. 11.12 Learners in a debriefing space are watching the live-streamed simulation and ready to join their compatriots when "code blue" is called. Multiple views of the simulation theater are visible and faculty can re-watch the recorded event when the participating learners return to debrief with the whole group

observers in the debriefing room. While orchestrating the scenario from the control room, the HSTS and faculty should also be able to see the entire simulated space through a two-way mirror.

Ideally, one to three camera views from different angles can shape the visual story for the learners in the observation/debriefing room. But more than three views of the same scene can be visually taxing for observers, distracting them from scenario objectives. Conveniently, up to three camera views and one vital signs monitor stream can be displayed in a grid easily for viewing using a multiplexer or software display system (Fig. 11.12).

The lead faculty may also request that the simulated patient present with an unattached non-rebreather mask, a real clinical monitor connected to display the patient's vital signs, and an ultrasound machine to be placed at the bedside. From behind the two-way mirror, the healthcare simulation technology specialist or faculty member can also speak as the patient through a microphone system designed to transmit sound as the voice of the manikin. This can be accomplished with hardware included in many manikins, or connected separately with a speaker mounted under the patient's bed. Voice modulators have been used to increase the vocal fidelity of the manikin operator and mimic the tone and quality of male, female, pediatric, or geriatric patients [22].

Example 2: Standardized Patient Lab

A standardized patient simulation lab has similar A/V needs and some of the same monitoring equipment used in the high-fidelity simulation labs, but operators of these spaces usually function in more of an observational capacity than an interactive one compared to the observer/control room interaction of their high-fidelity simulation room counterparts. Speakerphones in an exam room can be used for simulated calls to other exam rooms or to the coordinator's phone in the control room if interaction is needed without a complex microphone system. Some

Fig. 11.13 Emergency medicine residents attending to their patient. A unidirectional wireless cardioid microphone (not visible) is temporarily mounted to the exam light for enhanced audio during this intimate interaction. A prepared faculty or HSTS is speaking as the patient through a walkie-talkie tucked into the pillow

encounters between learners and standardized patients are intimate, emotional scenarios and tend to produce quieter conversations. For those scenarios, a wireless lavalier microphone can be employed to capture the sensitive speech as well or better than a ceiling-mounted condenser microphone (Fig. 11.13). An extra XLR input on the wall of the room can make connection of the wireless microphone's transceiver easier. Having an extra plug in every standardized patient exam room for potential use would require foresight during the design of the center. These optional audio inputs will connect to the main A/V matrix and can remain connected even if no microphone is physically present. This example of specialized design can allow expandability and enhanced functionality.

For smaller, one- or two-room standardized patient spaces, all that may be required is a two-way mirror for viewing, a sensitive microphone, a simple audio mixer, and a pair of headphones. If all pertinent action and information can be observed and noted from this simple perspective, it may be all that is needed for faculty to observe and provide feedback to learners partaking in the encounter without adding video cameras. There are many smaller medical schools and training centers that employ this basic configuration and enjoy longstanding success. However, a larger standardized patient center that services multiple learners at a time in individual exam rooms and requires several faculty members to be present will require many more A/V elements to conduct the event. Because most of what happens in an SP center is conversation-based, the ability to hear discreet spoken details is vital. Occasionally, there may be more than two or three people speaking at a time in an exam room, but usually, SP cases are one-to-one encounters involving a trained standardized patient and a learner. If the created cases call for a procedure, these are not usually technically oriented and therefore don't require close-up observation of meticulous medical procedures. So, in most recently built SP labs, the A/V in the exam rooms consists of one or two PTZ or stationary cameras, one or

Fig. 11.14 Each instructor is observing and listening to separate encounters in separate rooms on separate computers in the same control room. The use of headset microphones allows for inter-room communication and intercom capabilities

two well-placed microphones, and a camera control system that runs from a nearby control room. Sometimes, these systems may not have a direct line of sight from a two-way mirror or control room, and so the reliance on the AV equipment becomes even greater (Fig. 11.14).

Example 3: Skills Lab

The A/V needs of a skills-based laboratory are unique to the particular simulation center with which they are established. Since the flexibility of any skills lab is an important requirement, an adequate number of AC power receptacles should be available for the specialized clinical equipment that will come and go from the space. Ultrasound machines, simulators, ventilators, and cauterizing guns might all share space in a busy simulation center's general skills lab, sometimes at the same time. Ceiling and wall-mounted cameras can be implemented so that an HSTS can watch over a busy skills lab event (Fig. 11.15).

Depending on the size of the skills lab or labs, two to four cameras and microphones might be needed to cover all the smaller interactions going on in each part of the room. For example, if in one corner of the room, an instructor is demonstrating how to put a central line into an ultrasound manikin, it would behoove the simulation staff to keep watch of when a learner may be attempting such a procedure just to make sure the equipment is treated correctly. Sometimes, a lecturer would like to demonstrate a procedure to the entire 20–30 learners in the room. A well-equipped computer with powered speakers and a projection screen should be outfitted so that there are video inputs (VGA and HDMI) to the projector. This way, when the

Fig. 11.15 Faculty demonstrating the dissection of a swine heart for students. The document camera (not visible) is hung over the heart and is plugged into a computer that is connected to the projector

lecturer shows up with his special presentation or his or her own computer, it can be plugged into an input directly connected to the projector. Sometimes, a session may need to be recorded for later viewing, archiving, or direct live viewing. The skills lab should be set up like any other simulation room to capture and record whatever happens in these spaces.

Conclusion

In conclusion, we are on the edge of a changeover in the clinical simulation A/V arena. As the switch from analog-to-digital media continues in earnest, it is still necessary for healthcare simulation technology specialists to know how to use and adapt between the two systems. The availability of high-fidelity audio/visual equipment that delivers excellent image and sound is now ubiquitous. But as any experienced HSTS who works in the field of simulation knows, the best gear is often not the most important factor in running successful simulations. In actuality, it is the knowledge of the interactions of these media elements that matters most. Knowing the signal path of your system's cabling, the IP addresses of your cameras, or the cardioid pattern of the microphones is key when troubleshooting issues or when planning upgrades or work-arounds to a system. Understanding what the

equipment's strengths and weaknesses are cannot be overstated. Having a clear grasp of where and why everything is connected the way it is can help clarify any misconceptions about what is going on behind the walls, on the server, and in the ceilings. The prepared HSTS should stay up to date on A/V terminology within the field of simulation as it continues to grow and encompass many electrical, information technology, and theatrical elements. An A/V system that is designed for efficient ease of use and versatility can free up the creativity and improvisational skills necessary for the simulation team to run at the highest standards of execution. A well-designed simulation is a communicative art form, similar to directing a theatrical production. The healthcare simulation technology specialist must be the catalyst for those channels of communication, whether it is fine-tuning the microphone settings, converting the video quality to maintain system performance, or making sure the instructions from faculty to clinical actor are clear. Knowing the details of the A/V system is a must in today's growing field of medical simulation education.

Acknowledgments Images courtesy of the Hannaford Center for Safety, Innovation and Simulation, Maine Medical Center, and Texas Tech University Health Sciences Center El Paso's Training and Educational Center for Healthcare Simulation (TECHS).

Appendix: Cables and Connectors

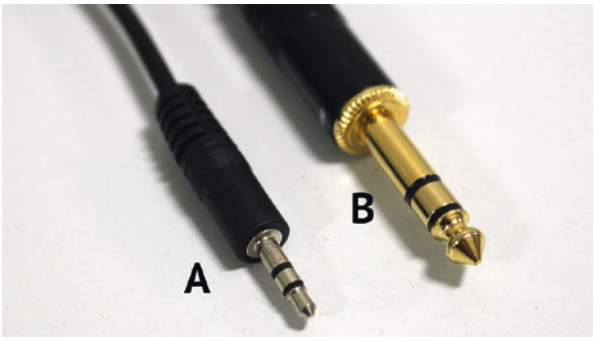


Fig. 11.16 **A** 3.5 mm (1/8″) Male Tip-Ring-Sleeve (TRS) audio connector; **B** 6.5 mm (1/4″) Male TRS audio connector

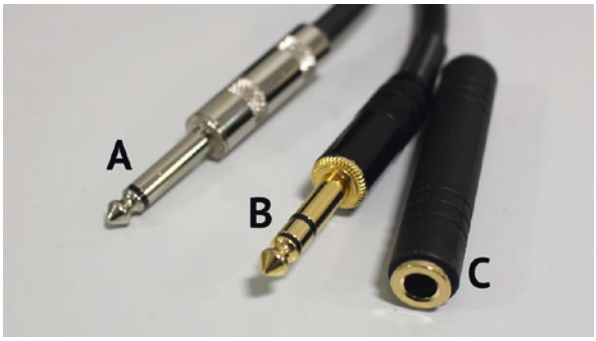


Fig. 11.17 **A** 6.5 mm (1/4″) Male Tip-Sleeve (TS) audio connector; **B** 6.5 mm (1/4″) Male TRS audio connector; **C** 6.5 mm (1/4″) female audio connector

Fig. 11.18 **A** BNC female connector; **B** BNC male connector

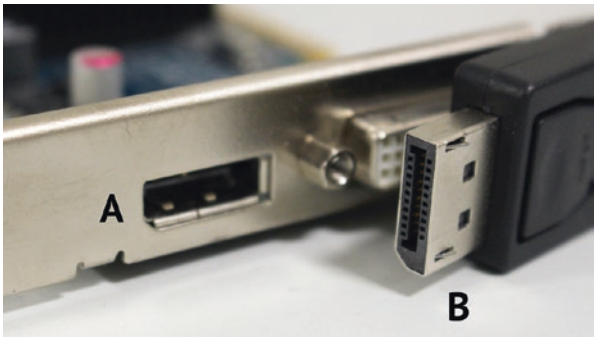


Fig. 11.19 **A** Display port – female port; **B** Display port – male connector

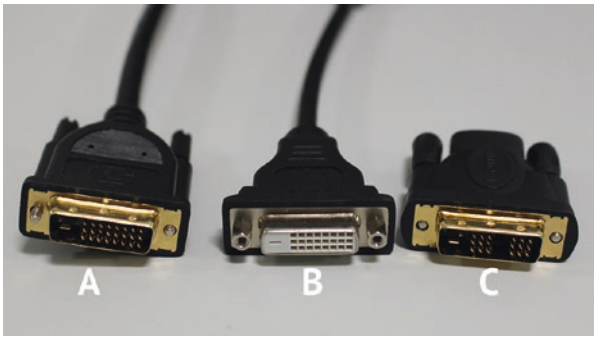


Fig. 11.20 **A** DVI-D (dual link) male cable; **B** DVI-D (dual link) female cable; **C** DVI-D (single link) male connector

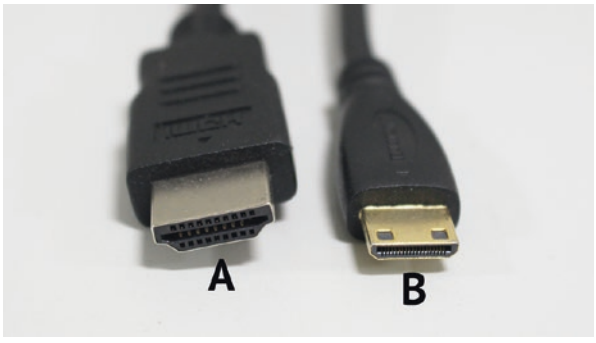


Fig. 11.21 **A** HDMI male cable; **B** HDMI mini male cable

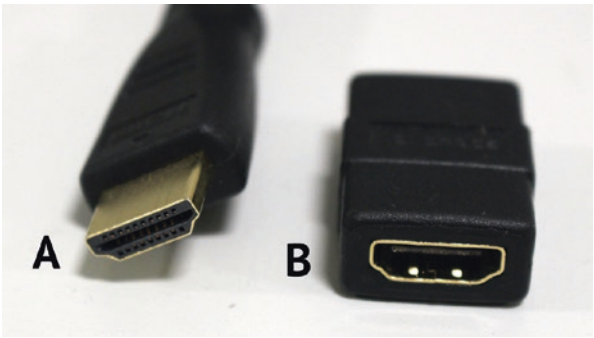


Fig. 11.22 **A** HDMI male cable; **B** HDMI female connector

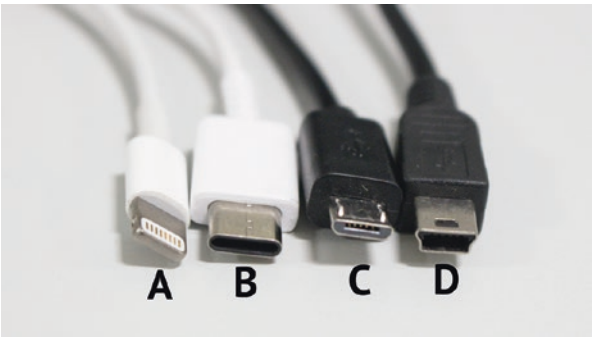


Fig. 11.23 **A** USB lightning cable (male); **B** USB-C cable (male); **C** USB-micro cable (male); **D** USB-mini cable (male)

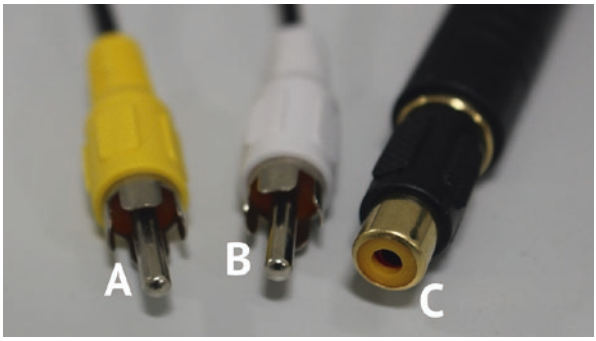


Fig. 11.24 **A** RCA male connector (composite video); **B** RCA male connector (left-channel (white) audio); **C** RCA female connector. Red RCA male (right-channel audio) not visible

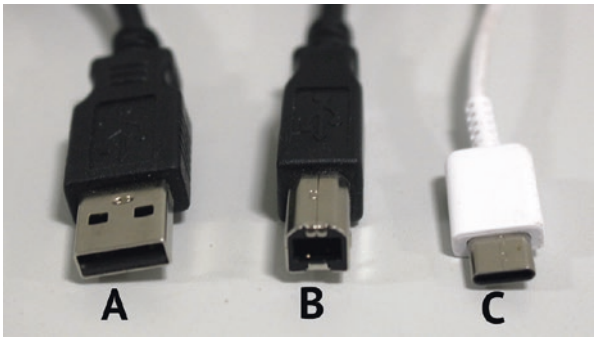


Fig. 11.25 **A** USB-A male cable; **B** USB-B male cable; **C** USB-C male cable

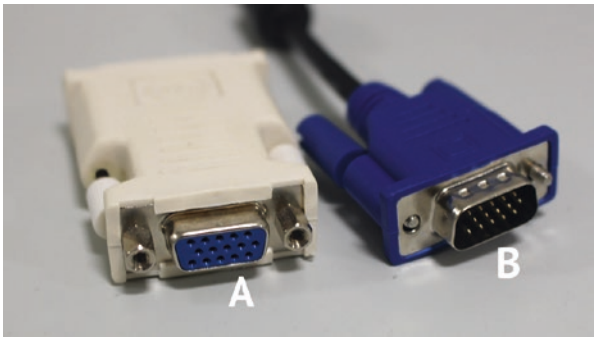


Fig. 11.26 **A** VGA female port (analog); **B** VGA male port (analog)

Fig. 11.27 **A** XLR female (audio) cable; **B** XLR male (audio) cable

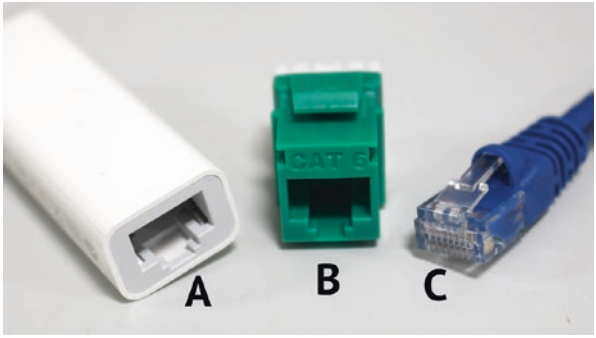


Fig. 11.28 **A** Category (CAT) 5/6 female port (network dongle); **B** CAT 6 keystone female port; **C** CAT 5/6 twisted pair (RJ-45) male cable

References

1. Alinier G. Simulation audio/video requirements and working with audio/video installation professionals. In: Kyle RR, Murray WB, editors. Clinical simulation: operations, engineering and management. London: Academic Press; 2008.
2. Sherwood L. Human physiology: from cells to systems. Boston: Cengage Learning; 2015.
3. Ballou G, Ciaudelli J, Schmitt V. Microphones. In: Ballou G, editor. Handbook for sound engineers. 4th ed. Burlington: Focal Press; 2013. p. 489–594.

4. Adorama. What are the different types of microphones? 2018. Available from: https://www.adorama.com/alc/what-are-the-different-types-of-microphones
5. Rio J. Getting the best out of lavaliers [Online]. https://l2pnet.com/getting-best-out-lavaliers-03302014/2014. Available from: https://l2pnet.com/getting-best-out-lavaliers-03302014/
6. Audio-Technica. UHF versus VHF [Online]. https://www.audio-technica.com/cms/site/af9d127e26abf498/. Available from: https://www.audio-technica.com/cms/site/af9d127e26abf498/
7. Harris T. How speakers work 2001 June 29, 2018.
8. FHSST. Electricity. 2005. In: The Free High School Science Texts: A Textbook for High School Students Studying Physics [Internet]. [Online]. http://www.nongnu.org/fhsst/fhsstphy.pdf: Free High School Science Texts. p. 258–64. Available from: http://www.nongnu.org/fhsst/fhsstphy.pdf
9. Toa. M-9000M2 Digital Matrix Mixer [Online]. http://www.toaelectronics.com/products/Amplifiers/9000m2-digital-matrix-mixer/m-9000m2-digital. Available from: http://www.toaelectronics.com/products/Amplifiers/9000m2-digital-matrix-mixer/m-9000m2-digital
10. Biamp. TesiraForte June 29, 2018. Available from: http://cdn.biamp.com/software/docs/default-source/downloads/biamp_brochure_catalog_tesiraforte_feb17.pdf
11. Thomas C. Open back vs closed back headphones: which are right for you? [Online]. https://www.soundguys.com/open-back-vs-closed-back-headphones-12179/: soundguys.com; 2017. Available from: https://www.soundguys.com/open-back-vs-closed-back-headphones-12179/
12. Wu Y, Hirakawa S, Reimers UH, Whitaker J. Overview of digital television development worldwide. Proc IEEE. 2006;94(1):8–21.
13. Ho AT, Li S. Handbook of digital forensics of multimedia data and devices. Hoboken: Wiley; 2015.
14. Rhodes T. Some clarity concerning analog and digital video signals 2013. Available from: http://www.generaldigital.com/blog/some-clarity-concerning-analog-and-digital-video-signals/
15. Panko RR. Physical layer concepts. Business data communications and networking. 3rd ed. Hoboken: Prentice Hall; 2001. p. 75–96.
16. Poynton C. Digital video and HD: algorithms and interfaces. Amsterdam: Elsevier; 2012.
17. Revo. Revo 2015 Catalog 2015 June 29, 2018. Available from: http://revomena.com/wp-content/uploads/2015/01/REVO-2015-Catalog.pdf
18. ONVIF. Our mission [Online]. https://www.onvif.org/about/mission/. Available from: https://www.onvif.org/about/mission/
19. Edler AA, Chen M, Honkanen A, Hackel A, Golianu B. Affordable simulation for small-scale training and assessment. Simul Healthc. 2010;5(2):112–5.
20. Cheng A, Eppich W, Grant V, Sherbino J, Zendejas B, Cook DA. Debriefing for technology-enhanced simulation: a systematic review and meta-analysis. Med Educ. 2014;48(7):657–66.
21. Dine CJ, Gersh RE, Leary M, Riegel BJ, Bellini LM, Abella BS. Improving cardiopulmonary resuscitation quality and resuscitation training by combining audiovisual feedback and debriefing. Crit Care Med. 2008;36(10):2817–22.
22. Crawford S, Monks S, Greer V, editors. Hardware voice modulator for reality enhancement. Simulation in healthcare. San Diego: Lippincott Williams and Wilkins; 2015.

The Healthcare Simulation Technology Specialist and Educational Constructs in Simulation

12

Kirrian Steer

Introduction

Healthcare simulation course design is a complex process and requires the input of a diverse team and a variety of resources to produce high-quality learning experiences. While it is the responsibility of the simulation educator to design and develop simulation course content in a simulation program, the healthcare simulation technology specialist (HSTS) plays a crucial role in the planning and implementation of this curriculum and will need to work closely with the educator in preparing and executing the simulation activities. The healthcare simulation technology specialist's role during the course planning phase is to assist and advise the educator on technological issues. This allows the educator and HSTS to match the educational objectives to the capabilities of the simulation center equipment and staff.

Instructional Design

The term instructional design has been used to name a process, a profession, and a field of study. To reduce confusion, the process of instructional design is often referred to as instructional systems design, or abbreviated to ISD [1]. ISD is an approach to course design that focuses on learning and optimizing learning outcomes [2]. Just as the role of an HSTS has domains, there are domains within the field of instructional design [3]. These are:

- Learners and learning processes
- Learning and performance contexts

K. Steer (✉)
Department of Rural Health, University of Melbourne, Wangaratta, VIC, Australia
e-mail: kirrian@simghosts.org

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_12

- Content structure and sequence
- Instructional and noninstructional strategies
- Media and delivery systems
- Designers and design processes

There are many theories of ISD that are used to guide the process of education and/or training from planning through evaluation; however, none have been developed specifically for healthcare simulation instructional design [2]. The most commonly known model of ISD is ADDIE, which is an acronym for "Analysis, Design, Development, Implementation, and Evaluation." The ADDIE model was used as part of the conceptual basis for medical education curriculum development with Kern's six-step approach [4]. The US Navy developed a modification of ADDIE, known as PADDIE+M that is well suited to simulation-based education as it incorporates two extra steps that are invaluable additions to a simulation program: planning and maintenance (see Fig. 12.1) [5].

In 2016, the International Nursing Association for Clinical Skills and Learning (INACSL) published an updated Standard of Best Practice for Simulation Design, which is summarized in Fig. 12.2 [6]. The items detailed in this standard describe the elements to be included in each phase of the PADDIE+M process. Some of these items are detailed in Chap. 7 of this book, namely, needs assessments, measurable objectives, and scenario development.

This chapter will explore the application of the PADDIE+M process to best practice simulation course design. A benefit of using PADDIE+M is that it is broadly applicable to a range of healthcare simulation programs and settings. The focus of this chapter is on the role of the healthcare simulation technology specialist and their role in simulation operational processes.

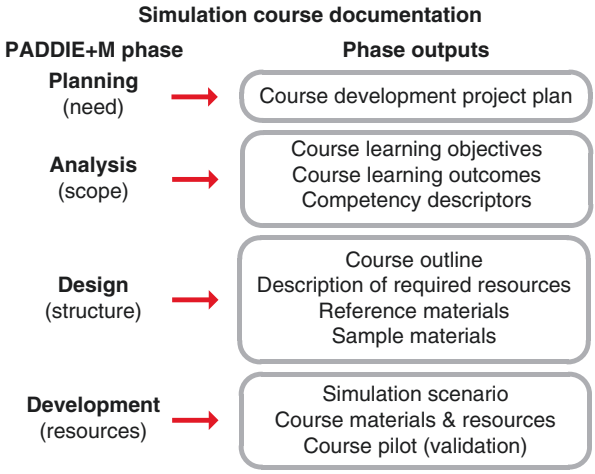


Fig. 12.1 Simulation course documentation produced during each of the first four phases of the PADDIE+M instructional design process

Elements of the INACSL Standard of Best Practice for Simulation Design:

1. Needs assessment
2. Measurable objectives
3. Format of simulation determined by purpose, theory and modality
4. Use of scenario or clinical case to provide context
5. Use of fidelity to provide realism
6. Participant-centered facilitation approach
7. Begin with a pre-briefing
8. Follow simulation with a debriefing or feedback
9. Evaluate the participant(s), facilitator(s), the simulation experience, the facility and the support team
10. Provide preparatory materials and resources
11. Pilot test simulations before full implementation

Fig. 12.2 A summary of the INACSL Standard of Best Practice for Simulation Design

Best Practice Simulation Course Design Using the PADDIE+M Process

Planning

The starting point for any course design is to define the goal of the course by completing a needs assessment or similar process. It is important to identify not only the need for the course, but also how it integrates with the overall curriculum or organizational strategy. The need for a course may arise through situations such as curriculum or strategic plan redesign, a quality or safety issue, a performance issue, changes to accreditation, registration or licensure standards, changes to guidelines, policies or procedures, changes to equipment or environment, or changes to job roles.

The second step is to define the performance expectations of the learner(s) in order to satisfy the course goal. This should detail the knowledge, skills, behaviors, tools or equipment, and information resources (such as guides, handbooks, instructions, reports, regulations, forms, and publications) related to the course topic.

The third step is to review the existing resources available and using this to recommend the delivery method (simulation modality and supporting course materials). Additionally, the existing resources assist with determining the instructional methodology to design, develop, and deliver a learning experience that will meet the course need. In the interest of efficiency, existing training resources, whether internal or from other organizations, should be used or revised wherever possible. This includes equipment, courses, scenarios, and E-learning content.

The third step also requires the learner evaluation to be considered. The proposed course or individual simulations within the course are to be categorized as a formative (teaching) or summative (assessment) experience. The learner evaluation type (formative or summative) and method must be determined prior to development of the simulation-based experience and should be based on the objective(s), outcome(s), and/or intent of the simulation [7]. The final components in this step are a review and projection of the development and delivery staffing requirements, and scheduling a course development and delivery timeline.

The information gained during the first three steps informs the development of the business case for the course. This should identify the course funding source(s), detail the budget for course development and delivery, and estimate the course lifecycle maintenance costs.

The final step of the planning phase is to plan the evaluation of the course. This is not only the evaluation of the learners as described above but evaluation of the course, facilitators, facility, and support staff. If there is a possibility that evaluation may be used for research publications, it may also be necessary to submit a research proposal to an ethics review board or institutional review board. The time involved in this process needs to be considered in the course development timeline.

Risk needs to be considered during the planning phase but will need to be reviewed in each of the PADDIE+M phases. It will be possible to eliminate or manage some risks through the design and development of the course, but new risks may be identified as the course details emerge.

An important consideration in the planning phase is the suitability of the course for an interprofessional learner cohort. The World Health Organization defines interprofessional learning as occurring "when students from two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes" [8]. Simulation-enhanced interprofessional education (Sim-IPE) provides a mechanism for learners to learn together just as they would work together in a real-world environment, and as such, Sim-IPE is particularly relevant for courses with a focus on team performance [9].

At the conclusion of the planning phase, the information gained from each of the steps outlined above should be documented in a course project plan. This will provide all stakeholders involved in the course with the information required to fulfill their contribution to the course development and delivery process.

The HSTS contributes to the planning phase mostly through determination of existing resources and helping to plan the course delivery method, which includes space, equipment, recording systems, consumables, and moulage materials, among others. This involves assisting the educator to select the most appropriate simulation modality to meet the course objectives while staying within the technical, financial, and scheduling capabilities of the simulation facility and team. The HSTS may also contribute to the project budget planning as they identify and select course resources and review cost estimates with the simulation coordinator. The HSTS should be included in the evaluation planning considerations, as they are likely to be responsible for reporting simulation

activity and resource utilization within the facility. They are also encouraged to identify the simulation facility and support team evaluation criteria that are most relevant to the simulation facility.

At the end of the planning phase, the following should be documented in a course development project plan:

- Needs assessment and course goal(s)
- Performance expectations of learners
- Instructional methodology, evaluation type, simulation modality, and supporting delivery equipment, tools, and supplies required
- Funding source(s)
- Budget for development, delivery, and maintenance of the course
- How course, facility, facilitators, and support staff are to be evaluated
- Requirement for research proposal
- Timeline for course development and delivery

Analysis

The primary focus of the analysis phase is to comprehensively define the expected learner performance in order to complete the course goal(s). The analysis phase extends to the development of learning objectives and outcomes once the learner characteristics have been analyzed. The analysis phase is mostly performed by those in educator roles, but healthcare simulation technology specialists may be required to assist with compiling documents and resources to be analyzed.

An in-depth analysis of the resources and documents collected during the planning phase is conducted, along with systems analysis, review of quality improvement programs and patient safety goals, and the survey of stakeholders, learners, clinicians, and/or educators. The next step is to conduct an analysis of the learner characteristics. Learner characteristics include the learner discipline or job role, their level of study or employment, and the typical experience level(s) of the learners.

Using this information, the educator is able to guide the development of learning objectives and desired outcomes. Learning objectives are structured statements describing measurable skills or knowledge to be attained [10]. Learning outcomes are specific subsets of learning objectives and describe the measurable aspects of job performance to be demonstrated by the learner. Along with learning objectives and learning outcomes, instructional designers and educators need to determine outcome measures. These are an indicator of the success of the course and may include measurements such as change in learner knowledge, performance or behavior, learner satisfaction, return on investment, or patient outcomes [11].

It is important to note that the PADDIE+M process is iterative rather than linear process. It therefore might be necessary to make revisions to the planning phase if findings in the analysis phase contradict earlier assumptions.

At the end of the analysis phase, the following should be documented:

- Descriptions of expected duties, tasks, and behaviors to be demonstrated in the workplace in order to successfully satisfy the course goal
- Review of the current performance of learners as related to the expected duties, tasks, and behaviors to be demonstrated in the workplace in order to successfully complete the course goal
- The course learning objectives and outcomes, which will guide decisions made in the design phase

Design

The first step in the design phase is to organize the course objectives and outcomes into groups and sequences that provide the most efficient use of training resources. This is where the subject matter expert is able to work with the instructional designer(s) and educator(s) to identify the most effective combinations of objectives and outcomes. These can then be sequenced in increasing difficulty or complexity so that the learners are continually challenged as they progress through the course. On occasion, it is not appropriate to reveal the learning outcomes to the learner prior to participation in the simulation activity as it may reveal important detail about the scenario and compromise the quality of the learning. In this case, it is appropriate to provide learners with a broad learning objective that provides them with a general understanding of what is expected of them in the simulation without compromising their learning opportunity. If this situation applies to the course being designed, a description of the actual learning outcomes and the information to be provided to learners should be clearly stated in the course design plan. The course design plan should also identify opportunities for formative and summative evaluation of learners and specify the evaluation tools and methods that will be used [7].

From the course design plan, a course outline can be developed. The parent organization or simulation program is likely to have a template to record the course outline. This outline should describe the modules or lessons to be completed by the learners and include the time allocated to each module or lesson. The course's instructional methodology and delivery method that was drafted during the planning phase is now refined using a theoretical or conceptual framework appropriate to the learning objectives and intended learners. Examples of the most common frameworks used in simulation are adult learning theory and experiential learning theory.

The technical term for adult learning is "andragogy." This term first emerged in Europe in the mid-1960s but was made popular by Malcolm Knowles who defined it as "the art and science of helping adults learn" [12]. Knowles explains that children approach learning as a process of gaining building blocks to build upon as they progress to the next step of their life. What they learn in each phase of schooling prepares them for the following phase, which then prepares them for trade school, college, or university, with the ultimate aim of supporting a fulfilling and

productive adult life. This can also be called a subject-led approach to learning. Contrastingly, most adults approach learning as a strategy for managing a current or emerging life situation. This is because the variety of challenges and changes experienced in life as an adult make learning much more complex and unpredictable. Adults are capable of analyzing, evaluating, or diagnosing their own learning needs and will often take a self-directed approach to learning. This means that they have a problem-centered or performance-led approach to learning. This combined approach is demonstrated in the training and education of health professionals as novice practitioners gain the underpinning knowledge and skills required to practice their profession (subject-led), the application of professional knowledge and skills to gain experience and develop expertise (performance-led), and then recognize gaps in learning that are required to address current or potential life circumstances (problem-centered).

Kolb's Experiential Learning Theory describes a cyclical learner process (Fig. 12.3) of having a learning experience, reflecting on the experience, forming conclusions or hypotheses, and then applying the new learning. The theory states that not only are all four steps required for learning, but the learners must also have an awareness of, and engagement in, all four steps in order for experiential learning to occur [3]. Simulation is an example of Kolb's experiential learning cycle in that learners complete or observe an experience and then participate in a debrief in which they undergo a process of reflection and learning which can then be applied in the clinical setting [13].

Once the theory underpinning the course design has been selected, instructional methods or strategies are then placed within the framework. The instructional design elements of most benefit to simulation are range of difficulty, repetitive practice, distributed practice, cognitive interactivity, multiple learning

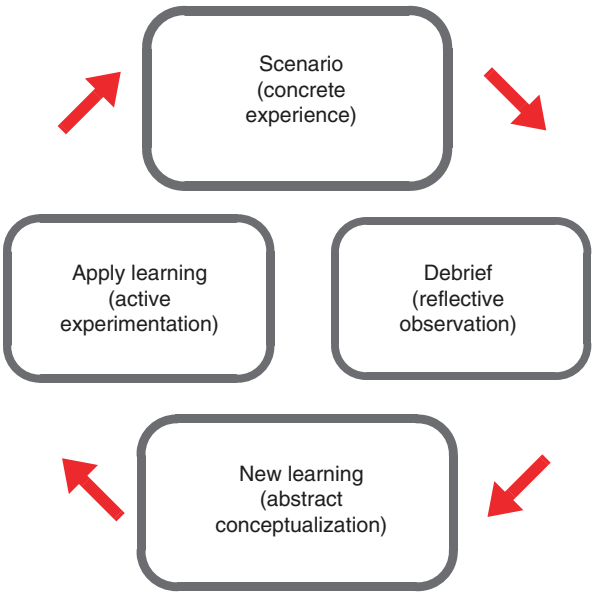


Fig. 12.3 The healthcare simulation learner's journey through an experiential learning cycle. Learning starts with the scenario experience and then develops through the debrief and construction of new learning and concludes with application of the learning in the clinical setting

strategies, individualized learning, mastery learning, feedback, longer time, and clinical variation [14]. Other instructional design elements of simulation that have been found to contribute to effective learning are curriculum integration, controlled environment, defined outcomes, and simulator validity [15]. There is limited evidence supporting individual instructional design elements for specific learners or specific circumstances. This is to be decided by the educator and/or instructional designer based on the expertise and knowledge of the learner groups.

The final step in the design phase is to document the method for content delivery required. The primary delivery method will be the simulation modality, with supplementary media in the form of preparatory materials such as readings, audio or video recordings, animations, and e-learning resources. As with all elements of course design, the selection of a delivery method should have a theoretical basis. A theory proposed by a group of researchers working with the Canadian Network for Simulation in Healthcare recommends delivery media and instructional methodology based on a decision tree featuring learner objectives and taxonomies targeting patient-centered simulations [2].

The advantages of one simulator over another vary according to the learning objectives and context. It is therefore more beneficial to consider the instructional design concepts demonstrated to be effective for simulation-based education than the equipment itself [12]. An HSTS who has an understanding of instructional design principles and a comprehensive knowledge of the features and functions of the simulation center and available equipment is well positioned to contribute to the design of quality learning activities at their center.

When planning the delivery method for a simulation course, one of the most important considerations is realism. Fidelity is the term commonly used to describe realism in a simulation setting; however, there is a growing movement within the healthcare simulation community to replace fidelity with terms that describe physical resemblance and functional task alignment [16]. The HSTS will need to work with the rest of the course design team to negotiate the level of realism required for the scenario. The educators and instructional designers will be able to advise on the aspects of realism that are most critical for learning, which are usually those related to the functional task(s) of the learners. The level of realism required is not necessarily equivalent to accurately reproducing a real-world experience, but minimum characteristics of the real-world experience are necessary to provide a quality learning experience [2]. The HSTS and educator work together to balance the realism required with the capabilities of the simulation center staff and equipment so that the learners are best able to achieve the learning objectives. This may also require negotiating cost and benefit to achieve an acceptable plan.

Most simulation learning experiences include a scenario. The simulation scenario is a framework that positions the learner(s) in a relevant context in which they can apply their skills, knowledge, and experience. The scenario macro-narrative is the overarching story or construction of events that provides context, establishes realism, and increases immersion for the learners. A micro-narrative is developed by each individual learner as they cognitively interpret and explain the scenario

events. While it is not possible to control the micro-narrative that the learner develops from the simulation activity, it is possible to guide the micro-narrative that is formed through the design of scenario events and skillful facilitation during the debrief. The educator(s) and instructional designer(s) will lead the design of the scenario macro-narrative and intended micro-narratives.

At the end of the design phase, the following should be documented:

- The theoretical or conceptual framework(s) underpinning the course design
- The course outline
- The delivery method and tools required for all aspects of the course
- Reference materials to aid in achieving realism in the simulation – ideally, photographs or videos of the scenes to be reproduced in the scenario
- A storyboard or outline of the scenario macro-narrative and intended micro-narratives
- Sample materials (if appropriate)

Development

The goal of the development phase is to produce all of the resources required for the course. This phase primarily involves the HSTS, the educator, and the subject matter expert. The educator is responsible for development of the assessment and evaluation resources, the subject matter expert is responsible for development of the learning resources, and the HSTS is responsible for organizing and developing resources to achieve realism. The HSTS may also be required to assist with the development of audiovisual resources, such as demonstration videos, and upload of materials to the simulation program learning management system (LMS). If involved in the upload of materials to the LMS, the HSTS may be required to assist with SCORM (Shareable Content Object Reference Model) compliance and WCAG2 (Web Content Accessibility Guidelines) conformance of online learning content. The instructional designer is responsible for development of course implementation resources, such as lesson plans and facilitation guides [17, 18].

One of the end products of the development phase is the simulation scenario. This is a framework that positions the learner in a relevant context and is the blueprint for others to follow in order to reproduce the complete learning experience. In simpler terms, it is a recipe for combining instructional design and theatrical production. Simulation scenario design is covered in detail in Chap. 17 of this text; the aspects of scenario design discussed in this chapter will be limited to documentation of scenarios.

Most simulation programs have at least one template to use for documentation of the simulation scenario. A single best-practice simulation scenario template does not exist, as the template needs to be flexible enough to meet the individual requirements of each simulation center. Many simulation websites publish sample simulation scenario templates, and one may find they need to combine elements of several templates to design one that will meet the needs of their program.

Common elements of simulation scenario templates are:

- Overview
- Logistics
- Scenario
- Learner brief
- Debrief
- Appendix

The overview typically contains the scenario title, learning objectives and outcomes, the discipline and experience level of the intended learners, and a summary of the scenario.

The logistics section describes the personnel required to run the scenario. This will include the subject matter expert, facilitator, technical support, embedded or non-learner participants (confederates), and the requirements of the patient or voice of the patient. The technical logistics will detail the technical requirements of the scenario such as simulation equipment, audiovisual recording or display, electronic medical record devices/software, other devices and software, and networking/connectivity. The equipment and consumable logistics section lists the clinical and nonclinical equipment required and specifies which of the clinical and consumable items are real and which are simulated.

The staging section describes how the technical equipment, and consumable items need to be arranged in the simulation environment to achieve the level of realism required. This section may also include descriptions of patient dress, moulage, operation settings for equipment, and room layout. Risk management is often addressed in this section although it may instead be covered in the overview or learner brief. Photographs and diagrams may be included in this section or provided as an appendix.

The scenario section contains the macro-narrative which describes the patient(s) and key events such as expected learner actions and transition points in the scenario. The patient description includes details about the patient's profile, medical history, and their script. If the scenario was designed for a standardized patient, it will include descriptions of patient responses or behaviors during the scenario. Photographs or videos are helpful for patients to understand postures, behaviors, gait patterns, and other physical representations that may be required for the scenario.

The key events should include a clearly identified start point and end point to the scenario as well as the clinical presentation required for each phase of the scenario. The scenario events may have a branched or looped structure where the course of events is determined by the learner actions in the scenario. As learners progress through the scenario, they follow branches in the scenario structure that will lead to different end points depending on the decisions made and actions they have taken. The clinical presentation contains objective and subjective data designed to provide learner cues. This information is used by an HSTS to program a scenario for use on a manikin or make manual adjustments to a manikin during a scenario.

The best practice elements of a learner brief include contextual information, identification of learner expectations, activities to promote an environment of psychological safety, establishment of ground rules, limitations and fiction contract, orientation to the simulation environment and learning objectives, and safety information [6]. It is recommended that a written or recorded briefing plan be used for each scenario, especially for those involving high-stakes assessment. This will help a learner feel more confident about what they are expected to do or demonstrate in a given situation.

The debrief section of the scenario documentation should recommend the debriefing model to be used and also provide an overview of key debriefing points or questions to be asked.

The appendix may contain any of the following as necessary:

- Course materials including lesson plan, facilitator guide/instructions, learner guide/instructions, evaluation tools, and administrative materials
- Reference and support materials such as technical manuals, publications, clinical guidelines, policies, and procedures
- Patient medical records

The final step in the development phase is to validate the scenario by conducting a course pilot. All of the scenario documentation and materials should be provided to a third party to trial the scenario. The purpose of this is to establish that the scenario meets the intended purpose and provides a quality learning experience. The participants should be representative of the intended learners if possible, and all involved in the pilot should provide feedback regarding any confusing, insufficient, or omitted elements of the course. The feedback can then be used to improve the course design and materials before full course implementation [6].

At the end of the development phase, the following should be documented:

- Simulation scenario
- Course materials and resources
- Facilitator guide
- Assessment tools/rubrics
- Course validation

Implementation

Implementation of a simulation course should only occur after the development and revision of course materials following the course validation process. The role of the HSTS in the implementation phase may include scheduling of rooms, equipment and personnel, preparing the simulation environment, orienting learners to the simulation environment, assisting with simulation delivery, contributing to the debrief, and restoring the simulation environment. The primary responsibility of the facilitator is to select and apply facilitation methods to support and guide learners to

achieve their learning goals [19]. This requires them to oversee effective group dynamics as well as respond to the individual needs of each learner. The facilitator also leads the simulation team through the implementation of the course. The professional expectations of the entire simulation team in the implementation phase are described in the INACSL Standards of Best Practice: Simulation℠ Professional Integrity [20]. They include conducting oneself with professional integrity at all times; following the standards, guidelines, principles, and ethics of one's profession; providing a safe learning environment; and requiring confidentiality of simulation scenarios and performances.

Implementation of simulation courses should include preparatory learning activities, a learner pre-brief, the simulation experience, and debrief. Preparatory activities may include reading, viewing multimedia content, practicing psychomotor skills, or other learning activities. The pre-brief is used to address psychological and physical safety issues, describe the expectations of learners in the simulation, establish the simulation context, and explain the approach to learning in a simulation environment. Psychological safety is the learner belief that their performance in the simulation and debrief will not negatively impact their self-image, social standing, or career trajectory [21]. This empowers the learner(s) to be able to challenge themselves, exposing themselves to the risk of making mistakes or errors without fear of ridicule or rejection. The learner(s) can then examine and learn from their performance in order to improve future outcomes. Psychological safety is an essential component of healthcare simulation. The orientation to the learning environment is often conducted as part of the pre-brief and should address safety issues, instructions on operating simulation and clinical equipment, clarification of which elements of the simulation are real and which are simulated, and what to do during the simulation if they need assistance with any equipment.

The simulation scenario is initiated and concluded by the facilitator. The facilitator will issue instructions to the simulation team that will guide the sequence of scenario events and ensure the quality of the learning experience. The HSTS will oversee the operation of the simulation manikin and other simulation equipment with the aim of delivering cues to learners that will assist them to interpret and respond to scenario events. The HSTS may also be required to communicate with non-learner participants and/or learners during the scenario, including at times as the voice of the patient.

A simulation debrief may occur during the scenario or immediately following the scenario. The simulation debrief is a discussion to explore and reflect on the events and experience of the simulation with the aim of identifying means to improve future performance. The debrief is widely accepted as the aspect of simulation providing the greatest contribution to learner development [21, 22]. Most commonly, the simulation debrief is conducted after the scenario and is led by a facilitator or educator. The facilitator leads the debrief by establishing and maintaining a supportive culture and structuring the debrief using a recognized theoretical framework to focus learning on the intended objectives and outcomes of the simulation.

Some of the more commonly used debriefing methods are [22]:

- GAS (Gather, Analyze, Summarize)
- Debriefing with Good Judgment
- Promoting Learning and Reflective Learning in Simulation (PEARLS)
- Debriefing for Meaningful Learning (DML)
- Plus-Delta
- 3D Model of Debriefing [23]
- OPT Model of Clinical Reasoning [24]

Just as there is no ideal manikin for healthcare simulation, there is no ideal debriefing framework for healthcare simulation. The simulation educator will select the debriefing method based on the context of the simulation and the learner group, as well as their own skills and preferences [22].

The HSTS may be required to provide audiovisual replay of parts of the simulation, or may be required to provide feedback to learners from the perspective of the patient if this is a role they represented during the simulation. The use of audiovisual review in the debrief is common in healthcare simulation; however, original research and a meta-analysis of the use of video-enhanced debriefing have found that it has minimal impact on the educational outcomes achieved. Audiovisual review may enhance the simulation debrief but is not considered an essential component [22].

If providing feedback to learners from the perspective of the manikin or standardized patient, the HSTS should provide clear descriptions of scenario events and relate this to their perspective of the patient experience. A statement such as "When you introduced yourself, you maintained eye contact with me and as the patient, this made me think that I could trust you," demonstrates the description of a scenario event and the patient perception. The HSTS should refrain from commenting on procedural competency or clinical knowledge and limit comments to only those relating to their experience as a patient.

Evaluation

The goal of the evaluation phase is to assess the value and effectiveness of the course for the purposes of quality control, academic integrity, research, and cost-effectiveness. Evaluation takes place throughout the instructional design process as the course designers are considering how the effectiveness of the training can be improved, how the learning materials can be enhanced, how the course design corresponds to the learning need, and how to best demonstrate the value of the course. The course pilot or validation provides valuable information to aid in evaluation of the course design and materials. All of the members of the course design team are expected to contribute to the course evaluation as each has a different role in course design and development and can offer feedback from their unique perspective and expertise. The course design and simulation

teams should also evaluate their own performance to identify opportunities for improvement.

There are two models of evaluation that are often used in healthcare simulation. These are Kirkpatrick's Training Evaluation Model and Translational Science Research [25].

The Kirkpatrick Model has four levels:

- Reaction – How did the learners react to the experience?
- Learning – What knowledge was gained?
- Behaviors – What can learners now do?
- Results – Do learners provide better care to patients?

Translational Science Research has three phases of course evaluation. Phase one evaluates learning, phase two evaluates transfer of learning into the clinical environment, and phase three evaluates improvement in patient outcomes.

Application of learning in the clinical environment and the impact on patient outcomes are the most prized evaluation products; however, they are difficult to evaluate and are sometimes omitted from course evaluation. One of the reasons for this is that there may be multiple learning events that contribute to the behaviors observed in the clinical environment and the patient outcomes achieved. Another reason is the time interval between the learning experience and the learning being applied in the clinical setting, which may be weeks, months, or even years.

Evaluation tools that have been validated for use in healthcare simulation include [25]:

- Sweeny-Clark Simulation Performance Evaluation Tool
- Clinical Simulation Evaluation Tool
- Lasater Clinical Judgment Rubric
- Creighton Simulation Evaluation Instrument

The tools are validated for evaluation of learner performance in certain circumstances, and it cannot be assumed that the tool is effective in evaluating learner performance in all types of simulation. The educator and instructional designer will select an appropriate evaluation tool for the content and learner involved in the course.

A tool for evaluating faculty is the DASH (Debriefing Assessment for Simulation in Healthcare) tool, which is used to evaluate debriefing performance [26]. The DASH tool was developed to be applicable to a wide range of simulation settings and debriefing models.

Maintenance

The final phase of the PADDIE+M process is lifecycle maintenance of the course. For a simulation course, this involves regular review (surveillance) for clinical

accuracy and to identify areas for improvement based on evaluation results, changes in technology, and facility capabilities. Surveillance situations that would indicate a need for course review are change in curriculum, change in operating procedures or policy, change in clinical guidelines, change in job duties, updated standards, or change of equipment, technology, or environment. In the absence of any of the above events, a course should be reviewed after 2–3 years as a quality improvement initiative.

The entire course development team should be involved in the maintenance of the course as they each have areas of expertise and responsibility applicable to the surveillance situations outlined above.

Conclusion: Applying the PADDIE+M Process to Your Simulation Program

This chapter has provided a detailed process for simulation course design using the PADDIE+M instructional design system. The chapter provided an operational overview and example of best practice simulation course design and highlights the roles and responsibilities of the various simulation program personnel. It is unlikely that the process as described will be a perfect fit for any simulation program as there will be existing organizational processes that must also be followed.

The HSTS does not require an expert knowledge of education theory to contribute to the development, implementation, and evaluation of the courses in the simulation program. The strongest contributions can be made through an understanding of the capabilities and features of the simulation center resources and identifying the suitability of those resources in assisting the learners to achieve the desired learning outcomes for both current courses and future programs.

References

1. Richey RC, Klein JD, Tracey MW. The instructional design knowledge base: theory, research, and practice. London: Routledge; 2010.
2. Battles J. Improving patient safety by instructional systems design. BMJ Qual Saf. 2006;15(suppl 1):i25–9.
3. Chiniara G, Cole G, Brisbin K, Huffman D, Cragg B, Lamacchia M, et al. Simulation in healthcare: a taxonomy and a conceptual framework for instructional design and media selection. Med Teach. 2013;35(8):e1380–95.
4. Kern D, Thomas P, Howard D, Bass E. Curriculum development for medical education: a six-step process. Baltimore: Johns Hopkins University Press; 1998.
5. United States Navy. Naval education and training command integrated learning environment course development and life-cycle maintenance [Online]. http://www.netc.navy.mil/ile/_Documents/NAVEDTRA136/NAVEDTRA_136.pdf2010. Available from: http://www.netc.navy.mil/ile/_Documents/NAVEDTRA136/NAVEDTRA_136.pdf
6. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Simulation design. Clin Simul Nurs. 2016;12(Supplement):s5–12.
7. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Participant evaluation. Clin Simul Nurs. 2016;12(Supplement):s26–9.

8. Health Professions Network Nursing and Midwifery Office. Framework for action on interprofessional education & collaborative practice. Geneva: WHO; 2010.
9. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Simulation enhanced interprofessional education (Sim-IPE). Clin Simul Nurs. 2016; 12(Supplement):s34–8.
10. Carnegie Mellon University. Design & teach a course: articulate your learning objectives [Online]. https://www.cmu.edu/teaching/designteach/design/learningobjectives.html. Available from: https://www.cmu.edu/teaching/designteach/design/learningobjectives.html
11. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Outcomes and objectives. Clin Simul Nurs. 2016;12(Supplement):S13–5.
12. Knowles M. The modern practice of adult education, vol. 41. New York: New York Association Press; 1970.
13. Kolb D. Experiential learning: experience as the source of learning and development. Englewood Cliffs: Prentice-Hall; 1984.
14. Cook DA, Hamstra SJ, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Comparative effectiveness of instructional design features in simulation-based education: systematic review and meta-analysis. Med Teach. 2013;35(1):e867–98.
15. Issenberg BS, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach. 2005;27(1):10–28.
16. Hamstra SJ, Brydges R, Hatala R, Zendejas B, Cook DA. Reconsidering fidelity in simulation-based training. Acad Med. 2014;89(3):387–92.
17. Rusticic software. SCORM explained [Online]. https://scorm.com/scorm-explained/. Available from: https://scorm.com/scorm-explained/
18. Web Accessibility Initiative. Web Content Accessibility Guidelines (WCAG) overview [Online]. https://www.w3.org/WAI/standards-guidelines/wcag/. Available from: https://www.w3.org/WAI/standards-guidelines/wcag/
19. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Facilitation. Clin Simul Nurs. 2016;12(Supplement):s16–20.
20. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Professional integrity. Clin Simul Nurs. 2016;12(Supplement):s30–3.
21. INACSL Standards Committee. INACSL Standards of best practice: Simulation℠ Debriefing. Clin Simul Nurs. 2016;12(Supplement):S21–5.
22. Sawyer T, Eppich W, Brett-Fleegler M, Grant V, Cheng A. More than one way to debrief: a critical review of healthcare simulation debriefing methods. Simul Healthc. 2016;11(3):209–17.
23. Zigmont JJ, Kappus LJ, Sudikoff SN, editors. The 3D model of debriefing: defusing, discovering, and deepening. Semin. Perinatol. 2011;35:52; Elsevier.
24. Kuiper R, Heinrich C, Matthias A, Graham MJ, Bell-Kotwall L. Debriefing with the OPT model of clinical reasoning during high fidelity patient simulation. Int J Nurs Educ Scholarsh. 2008;5(1):1–14.
25. Adamson KA, Kardong-Edgren S, Willhaus J. An updated review of published simulation evaluation instruments. Clin Simul Nurs. 2013;9(9):e393–400.
26. Brett-Fleegler M, Rudolph J, Eppich W, Monuteaux M, Fleegler E, Cheng A, et al. Debriefing assessment for simulation in healthcare: development and psychometric properties. Simul Healthc. 2012;7(5):288–94.

The Healthcare Simulation Technology Specialist and Healthcare

13

Nikita Joshi, Crystal Miles-Threatt,
and Teresa Roman-Micek

Introduction

To err is human is a commonly used phrase in healthcare. The actual full phrase is "to err is human; to forgive, divine," a quote attributed to Alexander Pope [1]. Many will also recall that this quote is in the title of a well-known document by the Institute of Medicine from November 1999 called "To Err is Human: Building a Safer Healthcare System" [2]. This groundbreaking publication highlighted the enormity of patient safety concerns within the healthcare system through preventable medical errors. The report discussed the cost of errors, not only financial, but also through societal losses to patients. Although healthcare education was not a focus of this paper, it has become clear to healthcare educators that understanding and preventing medical errors can and should originate throughout the training process. The issue becomes, however, how to teach the health sciences without compromising patient safety knowing that medical errors can and will happen during the training process.

The answer can be found in simulation! Healthcare simulation has come to be regarded as an integral component of healthcare training that allows educators to provide high-quality education while preserving the sanctity of patient safety. Through the use of manikins, task trainers, and standardized patients,

N. Joshi (✉)
Department of Emergency Medicine, Alameda Health System, Oakland, CA, USA

C. Miles-Threatt
Emergency Department, Stanford Healthcare, Stanford, CA, USA
e-mail: cmthreatt@stanfordhealthcare.org

T. Roman-Micek
Center for Immersive and Simulation-Based Learning, Stanford University School of Medicine, Stanford, CA, USA
e-mail: tromicek@stanford.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_13

health sciences can be taught to learners of all levels. These technologies allow the educator to create medical scenarios framed around learning objectives that challenge learners, without compromising patient safety. Scenarios that are particularly useful for simulation include high-stakes events that occur only rarely but are associated with great morbidity or mortality. An example of this includes mass casualty disasters such as bomb explosions in areas of large gatherings which would create an influx of patients. While this scenario rarely occurs, if and when it does, it seriously stresses the healthcare system and providers. Understanding how to manage these scenarios is invaluable, even though it is a rarely occurring event, and simulation allows this to happen. Another example where simulation is highly applicable is in ethical scenarios. Imagine an operation where a foreign body such as a surgical instrument is left behind in the patient. While a rare event, it does happen. Teaching learners how to follow procedures to prevent and manage these delicate situations is critical.

The Role that Simulation Plays in Medical Training

A basic understanding of medical and nursing training is important for background to understand how and why different components of simulation training are incorporated across disciplines and training levels.

Medical school is generally 4 years in length and begins after undergraduate training. Medical school is broken into preclinical and clinical years. Curricula in the preclinical years are generally lecture and small-group learning activities with an emphasis on learning foundational scientific principles of medicine from molecular and biochemical function of cells and pharmacology to macroscopic interactions of organ systems. Most medical schools will incorporate various levels of clinical exposure during this time through standardized patients, shadowing experiences, or student-run free clinics. An overarching goal is to understand how to obtain a history of presenting illness and perform a complete physical examination of a patients. The last two years of medical school is focused on clinical training in specialties such as internal medicine, emergency medicine, general surgery, obstetrics and gynecology, neurology, and pediatrics. The focus of these last two years is on experiential learning through patient encounters in the setting of clinics and within the hospital with minimal lecture. After medical school, students are awarded the degree of doctor (either MD, doctor of medicine, or DO, doctor of osteopathic medicine) and will apply for residency training in a specialty for an additional 3–7 years depending on the specialty. Those with a DO degree receive additional specific training in osteopathic manipulation and holistic medical care. Simulation is used in most residency training programs. There is emphasis now placed on integrating interprofessional training to focus on communication and continuity of care across the medical system and between subspecialty care areas. Even after formalized education, junior and senior practicing physicians will often have exposure to

simulation in continuing medical education (CME) courses throughout the duration of their career.

Nursing school is dynamic. There are associate, bachelor's, accelerated bachelor's (intensive 12-month programs designed for students who already have a bachelor's degree in a non-nursing field), master's, and doctoral nursing degree programs. Prerequisite requirements differ depending on the higher level of educational program that is selected. However, generally, the nursing curricula are the same. The nursing curriculum consists of lectures relevant to nursing professional practice, skills labs, and clinical courses in both hospital and community settings. Simulation may be used throughout the nursing training curriculum.

Allied healthcare is a term to describe a diverse set of ancillary training disciplines that support and provide specialty care and services to patients both in the inpatient (inside the hospital) and outpatient (in clinics and home) care environments. Examples of these roles might be physical therapy, speech and occupational therapy services, respiratory therapists, nutritionists, social workers, phlebotomists, paramedics, and many others.

Pharmacists have not been traditionally thought of to be present in the clinical environment, but this is not the case. Pharmacists are often critical members of inpatient teams such as critical care units and within the emergency department. They have become increasingly involved in healthcare simulation training to provide guidance on safe use of medications, drug-drug interactions, and appropriate weight-based dosing. Pharmacists also provide counselling and information about medication use and interactions in the outpatient setting.

Healthcare education curriculum takes advantage of all types of simulation in its various types; Chap. 2 describes some of these uses in greater detail. Immersive simulation scenarios allow training in high-risk scenarios such as code team training. Task trainer education is effective for teaching procedures and curriculum that has very focused learning objectives. Ultrasound-enabled task trainers are popular to teach bedside ultrasound skills for procedural teaching and visualization of pathology. Standardized patient training is utilized in preclinical years across disciplines to teach students how to obtain a history and physical examination without compromising patient care. Advanced surgical and virtual reality training devices are also being designed to improve surgical and interventional skills.

Through all these forms of simulation, students ultimately develop skills in history taking and performing physical exams and procedures and acquire the competence of a healthcare professional through experiential learning. The most useful aspect of simulation is that it allows the student to leave the lecture hall and go to the bedside – to learn how to become a healthcare professional through the act of "doing." Simulation is an essential alternative and middle ground to passive learning in a lecture hall or active learning in a clinic setting which could compromise patient safety.

Basic Principles of Curriculum Design

A strong working relationship between healthcare educators and healthcare simulation technology specialists (HSTSs) is important to conduct successful simulation-based education. The educators are responsible for creating the curriculum design, learning objectives, and working with the HSTS on implementation of the curriculum. The healthcare simulation technology specialist (HSTS) is tasked with helping to make these educational plans come to life. An understanding of curriculum design is helpful and Kern's six-step model for curriculum design is a great foundation [3].

Kern's six-step model:

1. Problem Identification and General Needs Assessment
2. Needs Assessment for Targeted Learners
3. Goals and Objectives
4. Educational Strategy
5. Implementation
6. Assessment or Evaluation

To visualize this process, imagine the following hypothetical scenario where an educator wishes to create a simulation-based educational program:

The educator wishes to teach learners about the management of shoulder dystocia. Shoulder dystocia is a dangerous obstetric emergency and is the process where a baby's shoulder is stuck under the mother's pelvic bone during delivery. This essentially prevents labor from continuing which results in a stuck baby. The baby may die from hypoxia, and the mother may die through hemorrhage.

Obstetric doctors would benefit from training to rapidly identify and perform the necessary maneuvers to alleviate shoulder dystocia. Targeting learners who are practicing obstetricians in a community hospital is important because in the nearby towns, there is currently no postgraduate refresher course to review shoulder dystocia. The goals of the educational program would be for learners to identify shoulder dystocia as it is occurring and to practice maneuvers to alleviate it. For this, an educational strategy using high-fidelity simulation will be used in monthly required seminars. Learners will be assessed by pre- and post-knowledge tests and evaluated by collecting rates of maternal morbidity and mortality related to shoulder dystocia pre- and post-intervention implementation.

In this scenario, using Kern's model, here is the breakdown of the curriculum design:

1. Problem Identification and General Needs Assessment: Women who develop shoulder dystocia are at a higher risk of death for themselves and their babies and need healthcare providers who can identify and treat the condition.

2. Needs Assessment for Targeted Learners: Obstetric doctors need refresher training on identification and management of shoulder dystocia. Nothing currently exists in nearby towns.
3. Goals and Objectives: Identify shoulder dystocia and practice maneuvers to alleviate it.
4. Educational Strategy: High-fidelity simulation.
5. Implementation: Monthly required seminars.
6. Assessment or Evaluation: Knowledge-based pre- and post-testing and morbidity and mortality data pre- and post-intervention.

While it may seem tedious for an HSTS to have to understand this process of applying Kern's six-step model, it is actually vital to ensure that simulation is effectively used and is the appropriate strategy for the curricular design. Perhaps full-body simulator is not necessarily the only or optimal educational choice. Perhaps a less complex task trainer would better serve the learners (Fig. 13.1). Or perhaps dismissing simulation and using a small-group workshop may meet the educational learning objectives more effectively. But by understanding how curriculum is formulated, the HSTS can have productive discussions with educators to ensure simulation is used wisely and effectively.

Familiarity with step 3 of Kern's model: educational objectives and goals are also critical. Educational objectives and goals are what the educator seeks to accomplish with their simulation. Understanding it will help drive technical support such as understanding room and equipment setup.

Setup can be highly detailed and costly in terms of time and personnel. It is not always possible to entirely recreate a healthcare environment; more importantly, it is not always necessary. However, knowing the goals and objectives can provide guidance for the necessary setup. For example, if the goal of an educational session

Fig. 13.1 A lumbar puncture (LP) task trainer is shown. This device can allow training of a specific procedure with good task representation and does not utilize a full-body simulator

is to teach nurses how to manage arterial lines that have been placed by doctors, a full-body manikin may not be required (Fig. 13.2). It may be sufficient to only use a task trainer arm. And, if the goal of a simulation scenario is to teach ventilator management to anesthesia trainees, it may not be important for the room to be set up exactly like an operating room. Perhaps having only the ventilator present will provide the realistic function and physiologic response to reach the educational objectives.

Knowing the level of the learner and their training is also important. A first-year medical student has very basic healthcare knowledge compared to a graduating medical student. A graduating medical student has very limited knowledge compared to a practicing physician. The training needs of a student in medical school versus the learner in nursing school will also be very different. Each group's educational needs will vary. As an example, the degree of realism necessary in a scenario can and should vary based on the degree of training and experience [4, 5]. A great example is going back to teaching ventilator management. A medical student will be overwhelmed if learning ventilator management in an

Fig. 13.2 An arterial line transducer is shown connected to an IV pole. The location of the transducer on the pole can affect the accuracy of the blood pressure measurements it provides

Fig. 13.3 An intubation head is shown. This is a task trainer to allows care providers to practice using a laryngoscope (A) to place an endotracheal tube (ETT) (B) using the malleable stylet (C). A laryngeal mask airway (LMA) (D), an oral airway (E), or nasal airway (F) can also be used to assist with airway control. A "Macintosh" blade (curved) (G) is connected to the laryngoscope handle, while the "Miller" blade (straight) (H) is shown next to it

immersive scenario with a manikin that is undergoing surgery and with the presence of a confederate surgeon giving orders at them. In this case, their level of training is minimal, and all the realism will be overwhelming. The educational goals and objectives may be better met with a manikin intubation head only (Fig. 13.3) next to a ventilator.

Healthcare Principles Taught in Simulation

In this section, we will review what is taught using healthcare simulation. Table 13.1 lists a few examples of specialties and the cases/diseases commonly encountered in healthcare simulation. This list is by no means fully inclusive.

Other areas of simulation application across all specialties include ethical issues and communication skills. This is taught in interprofessional healthcare educational curriculum. Examples of ethical issues that are particularly well taught through simulation are the intoxicated or impaired medical provider, concern for child or elder abuse, and special circumstances such as refusal of potentially life-saving interventions that are not compatible with a patient's religious beliefs. Communication issues that are particularly well taught through simulation include informing a patient's family of an unexpected death or unexpected outcome, disclosing a medical error, or optimizing communication with dysfunctional interprofessional team dynamics.

Table 13.1 Commonly encountered specialties and cases/diseases

Specialty	Pathology/topics
Allied healthcare	Child abuse Evaluation of a patient under intensive medical care Medication interactions Prehospital emergency management
Anesthesia	Airway emergencies Adjuncts to intubation Ventilation management
Emergency medicine	Cardiac arrest Toxicology emergencies Mass casualty disasters Traumatic injuries
Internal medicine	Geriatric emergencies Procedure training – arterial line placement, bronchoscopy, central line placement, endoscopy, pericardiocentesis Sepsis management
Neurology	Procedure training – lumbar puncture Seizure management Stroke management
Nursing	Code team management Medical resuscitation Procedure and equipment skills training Patient assessment
Obstetrics/ gynecology	Complications from cesarean sections Postpartum hemorrhage Shoulder dystocia
Pediatrics	Ingestions and poisoning Neonatal resuscitation Pediatric resuscitation Procedure training – lumbar puncture, umbilical line placement
Surgery	Complications from common surgeries – appendectomy, cholecystectomy, etc. Laparoscopic equipment management

Basic Knowledge of Scenario Clinical Information Needs

Immersive simulation and standardized patients are great tools to teach how to obtain a history and perform a physical exam. Manikins are essentially blank slates whereby an HSTS can skillfully create pathology through manipulation of the equipment.

Understanding vital signs and the general status of a patient is very important. These two components present critical information for every learner from the beginning of the scenario. The primary vital signs and their trend during a case are targeted at demonstrating the clinical status of a patient and are usually shown on a cardiorespiratory patient monitor (Fig. 13.4).

The primary vital signs are pulse (P) measured by palpating the arterial pulsation from the heart, heart rate (HR) measured by the electrical activity of the heart (these should be considered synonymous, but it is possible to have an electrically detected contraction of the heart that does not produce a palpable pulse), blood

Fig. 13.4 On this monitor, the pulse is 57, the oxygen saturation is 98%, the blood pressure is 100/58, and the respiratory rate is 10

pressure (BP) measured either by a noninvasive blood pressure cuff (NIBP) also called a sphygmomanometer, respiratory rate (RR) measured by watching the rise and fall of the patient's chest, oxygen saturation (O_2 Sat) measured by a pulse oximeter on the finger of the patient, and temperature (T) obtained either continuously via a probe placed inside of the patient or intermittently recorded using a thermometer. In patients who are diabetic or exhibit altered mentation, the blood glucose level (BGL) may be requested and can be obtained in a few seconds at the bedside using a glucometer. Even though the blood glucose level is not typically thought of as a vital sign, it is often requested alongside initial vital signs. Some more detailed scenarios might allow measurement of end-tidal carbon dioxide ($EtCO_2$), the amount of CO_2 being exhaled by the patient. This can be measured when the patient is intubated or when wearing special monitoring equipment. In some specific intensive care settings, a continuous blood pressure reading from a pressure transducer, placed in the artery of the patient, (Arterial Line) might be available. Continuous blood pressure readings like this, however, would not be expected in most clinical encounters.

After evaluating the patient's physiologic status by checking vital signs, many learners will progress through the scenario to obtain a patient's history. This is where the learner talks to the patient and/or their surrogates to learn what is ailing them. A commonly taught method of obtaining a patient history is OPQRST: onset, provoking/palliating factors, quality, radiation, severity, and timing [6]. A scenario, particularly one that involves a patient with pain, should be able to address each of these points.

Example:

- *Learner – "What brings you to the medical office today?"*
- *Patient – "The chest pain started two hours ago after I went up a flight of stairs and got better after I sat down and took a nitroglycerine tablet. The pain felt like a pressure/squeezing sensation that radiated to my left arm and jaw. The pain was a 9/10 when it started and lasted for 30 minutes before going down to a 5/10. The pain has happened like this for the past month, but worsened this morning."*

In addition to information about the patient's current presenting symptoms, the patient's past medical history may be asked and should include the following information:

- Past medical history (PMH)
- Past surgical history (PSH)
- Family history (FH)
- Allergies
- Social history (SH) (usually encompasses use of tobacco, alcohol, and illicit substances)

A review of systems (ROS) is asked to help make sure that subtle or seemingly inconsequential symptoms that the patient may be experiencing are not omitted from the patient's presentation that could help lead to a diagnosis or identify a problem that may have gone unrecognized. The PMH often addresses current or recent medication use or treatments, but this information may be collected separately.

Familiarity with the range of adult normal vital signs is also important and is listed in Table 13.2. Pediatric patients have vital signs that range significantly based upon their age.

Table 13.2 Range of normal adult vital signs

Vital sign	Adult vitals normal range
Heart rate	60–100 beats per minute
Respiratory rate	12–20 breaths per minute
Temperature	35.8–37.9 °C
Blood pressure	Systolic 100–140 mmHg Diastolic 60–90 mmHg
Oxygen saturation	>95%

Medications

There is an innumerable amount of medication types available to treat or alleviate symptoms of disease. While it would be impossible to prepare every single potential medication that could be used in a simulation scenario, there are particular medications that are more commonly used. Some common medications and drug classes are listed in the following table. Medications commonly have two names, a generic name and a brand or trade name; think of this as the difference between facial tissue and Kleenex®. For simplicity, only the generic medication names are listed in Table 13.3.

Table 13.3 This is a list of common medications listed by generic name with a description of the class, or type, of medication that they are and common diseases or reasons for their use. This list could be used as a quick reference when reviewing a simulation scenario, but any detailed information on dosing or actual use should be reviewed with the content expert or case designer

Medication	Class of medication	General use
Albuterol	Beta-agonist	Asthma treatment
Insulin	Insulin	Lowers blood sugar
Furosemide	Diuretic	Congestive heart failure, liver failure
Aspirin	Nonsteroidal anti-inflammatory drug (NSAID)	Antiplatelet effect, ischemic stroke; myocardial infarction
Naloxone	Opioid antagonist	Reverses opiate effects, heroin overdose treatment
Lidocaine	Local anesthetic, antiarrhythmic	Procedural pain control, antiarrhythmic in cardiac arrest
Analgesics (pain relievers)		
Acetaminophen	Analgesic	Fever or pain control
Ibuprofen	Nonsteroidal anti-inflammatory drug (NSAID)	Fever or pain control
Morphine	Opiate	Pain control
Fentanyl	Opiate	Pain control
Gastrointestinal		
Ondansetron	Antiemetic	Decrease nausea
Metoclopramide	Prokinetic	Decrease nausea
Loperamide	Opiate	Treats diarrhea
Cardiac		
Metoprolol	Beta-blocker	Lowers BP and HR
Labetalol	Beta-blocker	Lowers BP and HR
Diltiazem	Calcium channel blocker	Lowers BP and HR
Nifedipine	Calcium channel blocker	Lowers BP and HR
Adenosine	ACLS – antiarrhythmic	Slows cardiac conduction
Nitroglycerin	Nitrate	Chest pain
Vasoactive medications (pressors)		
Epinephrine	ACLS – inotrope	Cardiac arrest, anaphylaxis
Norepinephrine	ACLS – inotrope	Hypotension
Dopamine	ACLS – inotrope	Hypotension
Anesthesia		
Etomidate	Anesthetic	Sedation, intubation
Ketamine	Anesthetic	Sedation, intubation

(continued)

Table 13.3 (continued)

Medication	Class of medication	General use
Propofol	Anesthetic	Sedation, intubation
Lorazepam	Benzodiazepine	Sedation, stop seizure, decrease agitation
Diazepam	Benzodiazepine	Sedation, stop seizure, decrease agitation
Succinylcholine	Paralytic	Intubation
Rocuronium	Paralytic	Intubation
Antiepileptics		
Levetiracetam		Prevent seizures
Phenytoin		Prevent seizures
Obstetrics/gynecology		
Oxytocin		Induces labor
Terbutaline	Tocolytic	Stops labor; asthma treatment
Carboprost tromethamine		Stops postpartum hemorrhage
Electrolytes		
Calcium		Stabilizes hyperkalemia, treats hypocalcemia
Potassium		Prevents arrhythmias in hypokalemia
Magnesium		Treatment in eclampsia and cardiac dysrhythmias
Sodium bicarbonate		Treats acidosis and hyperkalemia
Antibiotics		
Piperacillin/tazobactam	Extended spectrum penicillin	Infections
Penicillin	Penicillin	Infections
Ceftriaxone	Cephalosporin	Infections
Azithromycin	Macrolide	Infections
Vancomycin	Glycopeptide	Infections
Metronidazole	Other	Infections
Levofloxacin	Fluoroquinolone	Infections
Trimethoprim/sulfamethoxazole	Sulfonamide	Infections
Nitrofurantoin	Other	Infections

Medications are administered through many routes. There is an innumerable amount of medication types available to treat or alleviate symptoms of disease (Fig. 13.5). The most commonly used routes of medication administration include intravenous (IV), intramuscular (IM), intraosseous (IO), oral (PO), subcutaneous (SC or SQ), intravaginal, and per rectum (PR). The IV route is further divided into peripheral and central. A central line is a long IV catheter that is placed into a larger vein in the neck or groin. Another specialized IV access type is the umbilical line [7]. This line is only available within the first week of life and could be applied in neonatal resuscitation cases. Which route is most useful depends upon the patient type and clinical scenario.

Fig. 13.5 Because simulation equipment and tools are either real or have been made to look the same as real equipment, it is important for equipment and medications used in simulation to be labeled carefully with a warning label indicating that the device or material is "simulated" or not for use on a real patient. This is of particular importance for simulation spaces that are in situ (in a real healthcare environment)

Table 13.4 Common types of crystalloid fluids

Fluids	Use
Normal saline (0.9% NaCl)	Treats hypotension, dehydration
Lactated Ringers	Treats hypotension, dehydration
Dextrose	Treats hypoglycemia

In addition to medications, IV fluids are also commonly given through IV or IO routes. Some common types of these fluids are listed in Table 13.4. There are many different types of fluids that can be administered. The dose of these fluids can range from measurements of a few milliliters (mL) through a syringe to as much as 1–2 liters (L) at a time rapidly pushed into the body using gravity or pressurized delivery systems (Fig. 13.6).

There are other commonly used treatments in critical care settings aside from medications. Blood products are an important treatment option that is commonly used in scenarios where the patient has trauma or is bleeding, such as from surgery or during childbirth. These blood products include red blood cells, platelets, and fresh frozen plasma (Table 13.5). Doses for these products are generally given in the form of "units" and are packaged in a small plastic package and connected to an IV line for administration (Fig. 13.7).

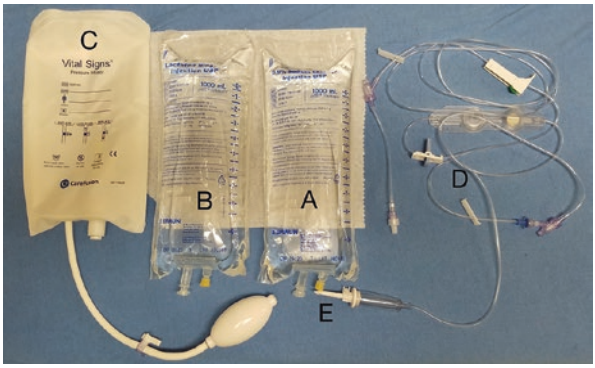


Fig. 13.6 Intravenous (IV) fluids are given for dehydration, bleeding, and severe infections and to support blood pressure. The two most common fluids are normal saline (NS) (A) and lactated Ringers (LR) (B). Fluids can be delivered into a vein faster with the use of a pressure bag (C). In order to access the fluids, an IV tubing (primary) line must be connected or "spiked." The sharp white end of the IV tubing is used for this purpose

Table 13.5 These are the three most common types of blood products used to correct coagulation abnormalities or replace blood loss. In the real clinical setting, they are extracted and processed from human donors

Blood products	Use
Packed red blood cells (PRBCS)	Treats anemia, hemorrhagic shock (bleeding)
Platelets	Improves clotting and prevents hemorrhage
Fresh frozen plasma (FFP)	Improves clotting and prevents hemorrhage

Room Setup

The HSTS must be aware of the general layout of commonly encountered areas within the medical setting. This includes the typical setup for an operating room, an emergency department room, a clinic room, and a variety of other settings (Figs. 13.8 and 13.9).

Working with the educator to understand the ideal room setup is critical before the simulation begins; this will ensure that setup meets the educational needs. Knowing what cues a clinician sees, hears, feels, and smells as they enter the treatment setting will help to create a more realistic and engaging scenario. It is also helpful to have an understanding of universal precautions and ensuring that the room is well stocked with gowns, gloves, and masks or other specialized equipment that would be expected for the case. Proper setup will help the learner feel more like the learning environment is an actual clinical setting and will help with experiential learning (Fig. 13.10).

Fig. 13.7 Simulated blood products are shown here with the expected blood type labeling, A, B, AB, or O. The presence or absence of Rh factor protein from the donor is also denoted as positive or negative. These labels are of great clinical importance and should be matched to the recipient prior to administration

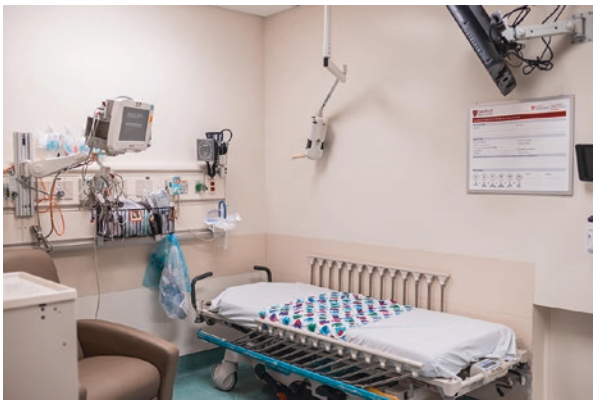


Fig. 13.8 This image shows a typical emergency department examination room with hospital gurney (bed) and examination, resuscitation, and monitoring equipment on the headwall above the bed

Fig. 13.9 This image shows a typical clinical examination room setting with otoscope, ophthalmoscope, and sphygmomanometer (from left to right) present on the wall above the examination bed. An otoscope allows inspection of the ear and ear canal, an ophthalmoscope allows visualization of the retina, and a sphygmomanometer allows measurement of blood pressure

Fig. 13.10 This is a typical simulation manikin setup using a combination of real and simulated medical equipment to help demonstrate appropriate physiologic realism

Anatomy Review

Having a basic understanding of anatomy in the human body will also be helpful to the healthcare simulation technology specialist. Figure 13.11 goes through the most important external landmarks of the body.

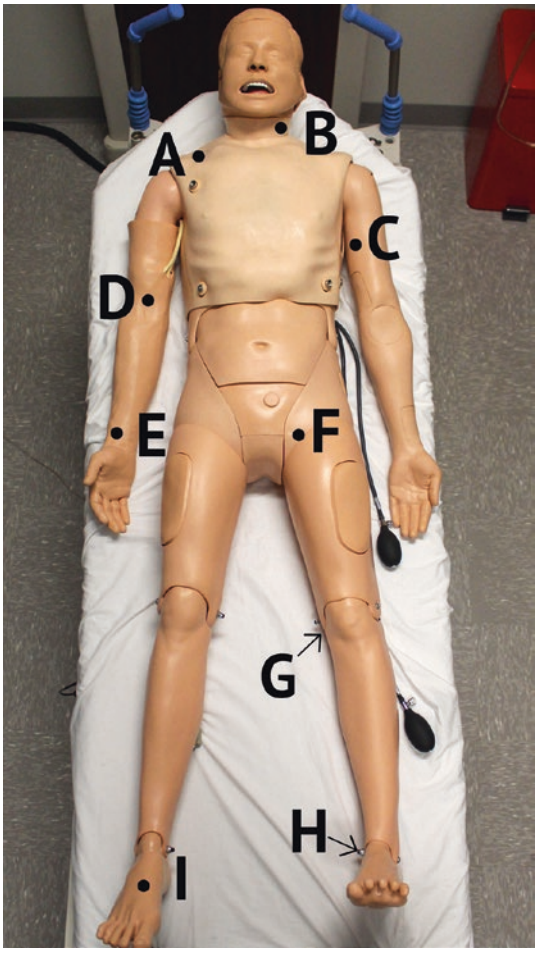


Fig. 13.11 The labeled points on this manikin photo show common locations to either check a pulse of obtain vascular access with the use of an IV catheter. (A) Subclavian (under the clavicle) is a location for placement of a central venous catheter. (B) Marks both the site of the carotid artery to check a pulse and the location of the internal jugular vein, an additional site for placement of a central venous catheter for IV access. (C) The area on the inner portion of the upper arm is the site of the brachial artery; this is a preferred point to check the pulse of children and neonates. (D) The antecubital fossa refers to the area on the flexor side of the elbow and is one of the most common sites to establish IV access. (E) The radial artery runs along the arm and is palpable and accessible at this point. Pulse checks are commonly performed here, and arterial lines to check continuous blood pressure readings can also be established at this site. (F) The femoral area is a site for palpation of a pulse during CPR or in a patient with very low blood pressure. This is also a site to access the femoral vein to place a central venous catheter or the femoral artery to place an arterial line. (G) The area behind the knee is called the popliteal area. Although a large artery, nerve, and vein are present in this area, it is not generally used for pulse checks or vascular access. (H) On the medial (toward the middle of the body) side of the ankle, the posterior tibial pulse is palpable just behind the medial malleolus (bony prominence of the ankle). (I) The top of the foot has another pulse point called the dorsalis pedis and is palpable on many manikins

Medical Tools Review

The following images in Fig. 13.12 show the different types of equipment used both in clinical practice and simulation followed by a basic description for the use of each tool.

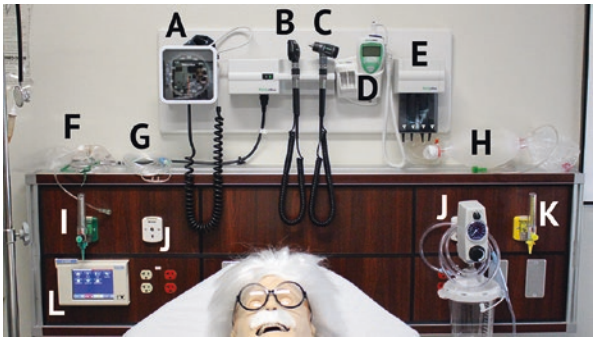


Fig. 13.12 A simulated headwall system with real equipment and gas connections is shown. (A) A blood pressure cuff (sphygmomanometer) with a pressure dial; as the pressure in the cuff is increased, it will occlude the arterial flow. The highest pressure where some of the blood flow resumes during contraction of the heart is called the systolic blood pressure. The lowest pressure where flow is still blocked, during relaxation of the heart, is called the diastolic pressure. (B) An ophthalmoscope; this device can allow a clinician to look at the retina of a patient by focusing light through the pupil. (C) An otoscope; this device can allow examination of the eardrum (tympanic membrane) and ear canal, but it can also be used to look at the size of a patient's pupils, into their nose, or in the back of their throat. When this device is used to look into the ear or nose, a disposable plastic "speculum" (labeled E) should be used to prevent contamination of the device. Item D is a digital thermometer. In the clinical environment, it can be used to check the temperature of the patient either in the mouth (oral), armpit (axilla), or rectum. Use of a thermometer for any of these sites should be done with the use of a plastic cover to prevent contamination. If a patient is having trouble breathing or feeling short of breath (SOB) with low oxygen saturation, supplemental oxygen can be supplied from the wall oxygen port (labeled I). Oxygen can be supplied either with a nasal cannula (NC) (labeled G) or a non-rebreather (NRB) mask (labeled F). The nasal cannula should generally be used for low oxygen requirements 4 L/min or less, while the non-rebreather can be used at flow rates up to 15 L/min or more. If a patient is having even more trouble breathing or has stopped breathing, a bag valve mask (BVM) (labeled H) can be used to provide assisted breathing. Oxygen ports will be green in color (labeled I) and look similar to ports for medical air that will be yellow in color (labeled K). The other common port for connection of gases is a vacuum or suction port that will be white or gray in color (labeled J). The vacuum port on the left side of the picture does not have a valve connector, while the one on the right side of the picture has a valve with an adjustable gauge to control the amount of suction. This valve can also control whether the suction is continuous or intermittent (cycling on and off). Suction setups will also require a suction canister and tubing. Labeled L is a bed alarm and "code blue" call system. A code blue alarm is used in the clinical settings to allow signaling of a medical emergency, such as cardiac arrest. This alert is sent to an entire team of people in the hospital to come and assist.

Fig. 13.13 An example of a cardiac defibrillator

A cardiac defibrillator (Fig. 13.13) is connected to a patient with adhesive pads and can be used to either defibrillate (provide a single large dose of electricity to reset the electric activity of the heart) or pace (provide small and recurrent electrical stimulation to the heart to stimulate natural contraction). These devices, even in the simulated environment, are real and can be dangerous if not used and connected properly.

Common Medical Abbreviations, Terms, Prefixes, and Suffixes

Often medical and nursing professionals use medical terminology, acronyms, and shorthand in teachings and communications regarding their curriculum. Familiarity with medical and nursing terminology is helpful to navigate these discussions with educators and learners. Also, it will facilitate equipment setup and allow for smooth execution of simulations. For example, understanding how to position a pediatric manikin to teach lumbar puncture procedures is important as both the *decubitus* position (lying down on a side) and the sitting upright position are used in very particular medical settings, and often for different reasons. Another example is that patients are often placed in *Trendelenburg* (feet up, head down, flat) position if they are *hypotensive* (having low blood pressure). Table 13.6 will review common anatomic positions and body location descriptions. Table 13.7 outlines common prefixes or suffixes that are used to describe body parts and organ systems or medical specialties.

Common Abbreviations

Tables 13.8 lists abbreviations and terms used for descriptions of diseases and common medical terms.

Equipment

Table 13.9 reviews abbreviations of medical tools and diagnostic equipment.

Table 13.6 Descriptions of anatomic positions and body location descriptions

Patient orientation	
Cephalic	Head
Anterior	Front
Posterior	Back
Superior	Above
Inferior	Below
Proximal	Closer to
Distal	Further away from
Prone	Face down, flat
Supine	Face up, flat
Trendelenburg	Feet up, head down, flat
Semi-Fowler's position	Reclined, head of bed 30–45°
Fowler's position	Sitting up, head of bed 45–60°

Table 13.7 Common terms, prefixes, and suffixes for anatomical parts

Terminology related to organ systems	
Cardio-	Heart
Chol-	Gallbladder
Col-	Large bowel
-enter	Small bowel
Gastro-	Stomach
Heme-	Blood system
Hepato-	Liver
Mandible	Jaw
Nasal	Nose
Nephro-	Kidney (renal)
Neuro-	Brain
Orbit	Eye
Pharyngeal	Related to the upper airway/throat
Pulm-	Lung
Thora-	Chest cavity

Table 13.8 Common medical abbreviations

ACS	Acute coronary syndrome	Chest pain conditions that do not meet criteria for myocardial infarction
DM	Diabetes mellitus	Elevated blood glucose
DKA	Diabetic ketoacidosis	Dangerously elevated blood glucose
Dx	Diagnosis	
CHF	Congestive heart failure	Inadequate pumping function of the heart
CVA	Cerebral vascular accident	Stroke, either from bleeding or blockage of blood flow
FB	Foreign body	Objects that are not typically found within the body, that are now in the body
HTN	Hypertension	Elevated blood pressure
Hx	History	
MI	Myocardial infarction	Heart attack; blockage of blood flow to the heart muscle
PEA	Pulseless electrical activity	Abnormal rhythm seen in cardiac arrest
PNA	Pneumonia	Lung infection

Table 13.8 (continued)

PTX	Pneumothorax	Deflated lung
PUD	Peptic ulcer disease	Ulcers within the gastro system
PID	Pelvic inflammatory disease	Inflammation of pelvic organs such as cervix, fallopian tubes, and/or ovaries
Rx	Prescription	
SOB	Shortness of breath	The feeling of being short of breath
SVT	Supraventricular tachycardia	Abnormal fast heart rhythm
Sx	Symptoms	
Tx	Treatment	
VF	Ventricular fibrillation	Abnormal rhythm seen in cardiac arrest
VT	Ventricular tachycardia	Abnormal rhythm seen in cardiac arrest

Table 13.9 Common abbreviations for medical equipment

NG	Nasogastric tube	A tube placed through the nose which extends into the stomach
ETT	Endotracheal tube	A tube placed into the trachea to allow assisted ventilation with ventilator
IO	Intraosseous	Usually referring to gaining access to the intraosseous space which is within the bone marrow
OG	Oral gastric tube	A tube placed through the mouth which extends into the stomach
US	Ultrasound machine	Used to aid in physical exam diagnosis
MRI	Magnetic resonance imagery	Medical imaging technique that detects the magnetic spin of atomic particles and is used to view 3-dimensional representations of a patient
CT	Computed tomography	X-rays taken from a circular view that are processed together to give a three-dimensional representation of a patient's anatomy

Terminology Related to Vitals and Physical Exam Findings

Table 13.10 Prefixes used to describe relative values for vitals and laboratory or examination findings

Hyper-	Above
Hypo-	Below
Hypoxia	Low oxygen saturation
Tachy-	Fast
Brady-	Slow

Abnormal Vital Signs

Table 13.11 A representative sample of terms to demonstrate the application of the common prefixes from Table 13.10

Hypothermia	Low temperature
Hyperthermia	High temperature
Bradycardia	Low heart rate
Tachycardia	Fast heart rate
Apnea	Slow breathing rate
Tachypnea	Fast breathing rate
Hemorrhage	Losing a significant amount of blood very quickly
Hypoxia	Low oxygen saturation
Hypotension	Low blood pressure
Hypertension	High blood pressure

General Symptoms and Physical Exam Findings

Table 13.12 General symptoms and physical exam findings

Altered mental status	Confusion, change in behavior
Anuria	Not making urine
Anxiety	Nervous, agitated
Ascites	Fluid in the abdominal cavity
Ataxia	Loss of control of body movements; example is a stumbling walk
Avulsion	Description of tearing; for example, an avulsion on the skin is a wound on the body where the skin is torn or scraped, an avulsion of the tooth is when the tooth is almost or completely removed from the gum
Congenital	From birth
Constipation	Difficulty with having bowel movements
Cyanosis	Low oxygen state, which can be observed with pale or bluish tint to lips and palms
Dehydration	State of having low body fluid volume
Diaphoresis	Excessive sweating, can be form cardiac disease, drug withdrawal and endocrine diseases
Dysmenorrhea	Painful menstruation
Dysphagia	Pain while swallowing
Dysuria	Pain while urinating
Ecchymosis	Discoloration of the skin, usually related to bruising
Edema	Swelling
Emesis	Vomit
Epistaxis	Nose bleed
-ectomy	Removal of
Failure to thrive	Not growing or living well
Fistula	Abnormal or surgically made pathway between two organs, or one organ and the body surface
Fussiness	Usually a description of difficult behavior in a neonatal or pediatric patient
Gait	Walk
Hematemesis	Blood in vomit
Hematoma	Clotted blood pooled under the skin or body part
Hematuria	Blood in the urine
Hemoptysis	Blood in cough
Jaundice	Yellowing of the skin
Laceration	Cut to the body, usually the skin
Lethargy	Fatigue, very difficult to wake up, sluggish
Lymphadenopathy	Swelling of lymph nodes in the groin, in the armpit area, or in the neck area
Malaise	Feeling tired
Obstruction	Blockage
-ostomy	Surgical opening to the body surface
Palpitations	Fast or irregular heartbeat
Paresthesia	Abnormal sensation, pins and needles sensation in the body
Pruritus	Itchiness
Rhinorrhea	Runny nose
Scleral icterus	Yellowing of the eyes (another form of jaundice)
Shock	A disease state of low blood pressure that is not improving with medical treatment such as medications or blood transfusion
Shortness of breath	Fast and/or difficult breathing
Stridor	Harsh sound, usually referring to noises made while breathing
Syncope	Passing out, losing consciousness, and/or falling/slumping over
Tinnitus	Ringing sound in the ears
Tremor	Shakiness to a part of the body that is involuntary
Urinary incontinence	Unable to maintain control of bladder, leakage of urine
Urinary retention	Unable to urinate
Vertigo	Dizziness
Wheezing	High pitched sound heard while breathing, usually related to asthma disease state

ABEM curriculum – https://www.abem.org/public/docs/default-source/publication-documents/2013-em-model.pdf?sfvrsn=10

Common Diagnostic Tests and Orders

Table 13.13 Common diagnostic tests and orders

ABG	Arterial blood gas
EKG/ECG	Electrocardiogram
CT/CAT scan	Computed tomography scan
CXR	Chest X-ray
LP	Lumbar puncture
MRI	Magnetic resonance imaging
US	Ultrasound
VBG	Venous blood gas
XR	X-ray

An electrocardiogram (EKG or ECG) detects the electrical activity generated by the heart as it stimulates muscular contraction. It is displayed most often in the form of a 3-lead or 12-lead strip, determined by the number of detection points used. Most manikins allow for a 3-lead detection and display system, with attachment at the right and left second intercostal spaces (upper chest) and lower chest or abdomen on the left and right. A mnemonic of white on right, snow on the tree, and smoke above fire will allow correct placement of the four colored leads (white, green, red, black) used in a 3-lead reading. The brown lead, if present, will go in the center of the chest. Figure 13.14 shows an example of a 3-lead EKG connection on a manikin. Most high-fidelity manikins will actually generate small electrical signals to display correctly on real cardiac monitoring equipment.

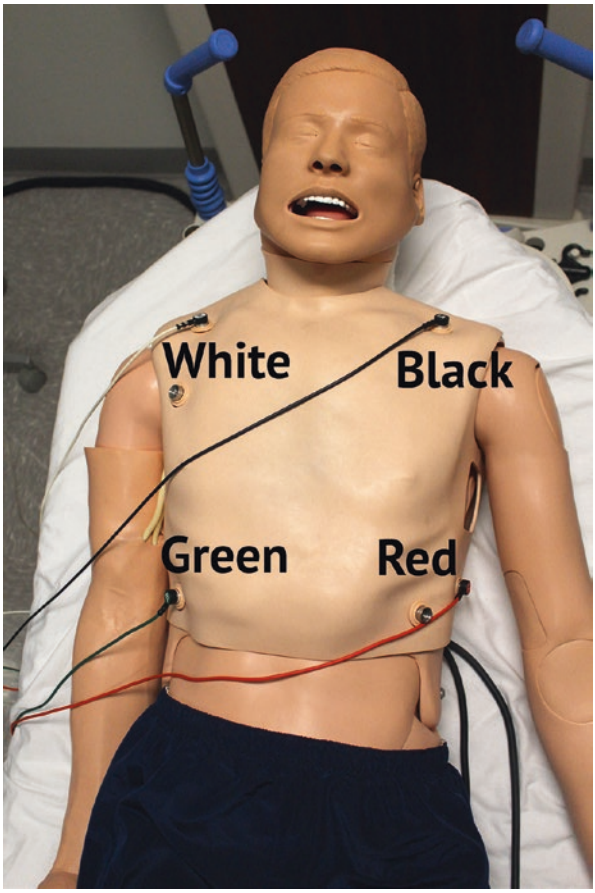


Fig. 13.14 This manikin torso is labeled with the color and location of a four-connection system to generate a "3-lead" EKG. The unlabeled ports on the manikin's upper right chest and lower left chest are connection points for use with a defibrillator like that shown in Fig. 13.13

Conclusion

Ultimately a healthcare simulation technology specialist is not expected to have the same level of healthcare knowledge as a medical educator. However having a basic understanding is helpful for the role in supporting the educational curriculum – from supporting the educator, supporting the learner, and of course bringing the educational curriculum and vision to life. Of course, having a positive and inquisitive attitude will always be beneficial. Ask questions of the educators, be open to learning something new, and remember most of all that the HSTS plays a vital role in the learner experience. Increasing healthcare knowledge will be beneficial in making each simulation as successful as possible.

References

1. Pope A. Essay on criticism. JM Dent; 1903.
2. Kohn LT, Corrigan JM, Donaldson MS. To err is human – building a safer heatlhcare system. Washington, DC: National Academy Press; 1999.
3. Kern D, Thomas P, Howard D, Bass E. Curriculum development for medical education: a six-step process. Baltimore: Johns Hopkins University Press; 1998.
4. Grober ED, Hamstra SJ, Wanzel KR, Reznick RK, Matsumoto ED, Sidhu RS, et al. The educational impact of bench model fidelity on the acquisition of technical skill: the use of clinically relevant outcome measures. Ann Surg. 2004;240(2):374.
5. Beaubien JM, Baker DP. The use of simulation for training teamwork skills in health care: how low can you go? BMJ Qual Saf. 2004;13(suppl 1):i51–6.
6. Swartz MH. Textbook of physical diagnosis E-book: history and examination. Philadelphia: Elsevier Health Sciences; 2014.
7. Roberts JR, Hedges JR. Roberts and Hedges' clinical procedures in emergency medicine E-book. Philadelphia: Elsevier Health Sciences; 2013.

The Healthcare Simulation Technology Specialist and Information Technology

14

Eduardo R. Luevano and William Morton

There is no one correct path to troubleshoot or design Information Technology (IT) systems. This chapter will provide an overview of IT terminology, infrastructure, and its application to the healthcare simulation environment. Many simulation centers are part of larger institutional systems and therefore connection and integration for these centers will be guided and governed by existing IT personnel and policies. Smaller centers may have much less robust infrastructure and function more closely to that of a small business or home network infrastructure. Regardless of the type of network structure or availability of onsite support, simulation hardware and software will need to communicate and function in order to provide simulation-based education at any center. Understanding the basics of IT terminology and systems will empower a healthcare simulation technology specialist (HSTS) to troubleshoot and work with vendors or institutional IT personnel to set up, grow, and troubleshoot computer and technology-related systems.

When working with an IT professional, it is very helpful and somewhat satisfying to speak in their own terminology. Although it can feel like a single IT person knows everything computer related, IT is broken down into several subspecialties. When the physician/doctor says, there is an issue with your heart based on the lab work, you commonly ask them, "So what is it?" They graciously respond, "Let me get you a specialist, a cardiologist." IT operates in much the same manner. The help desk may identify a network issue, but then escalate the issue to the network team

E. R. Luevano (✉)
Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA
e-mail: Eduardo.luevano@ttuhsc.edu

W. Morton
Department of Information Technology Services, Des Moines University, Des Moines, IA, USA
e-mail: Bill.Morton@dmu.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_14

to find the root cause and fix the issue. There are many specialties in an IT infrastructure, which this chapter will help define.

Information Technology Terminology

As the HSTS strives to establish a genuine relationship with the IT department, it is important to understand and know networking fundamentals. The first question to be addressed is – What is a network? A network is defined as two or more computing devices (nodes) that exchange information with each other using connections between the nodes [1]. Although this definition may be self-explanatory, there are different types of communications networks that need to be defined.

A network administrator may ask the simulation center, "What kind of network is needed?" Several types of networks exist and serve distinctly different functions.

- Local area network (LAN): Computers that are geographically close together (i.e., in the same building). For example, operating a simulation manikin in the same room as the control computer or a location in proximity.
- Campus area networks (CAN): Multiple interconnected LANs within a limited geographical region. For example, operating a computer/manikin at one campus location from a distant campus location (e.g., between buildings a few blocks apart).
- Wide area networks (WAN): The computers are farther apart and are operated by different organizations, typically connected by a third-party internet service provider (ISP). For example, an internet connection is a WAN connection.

There are other types of networks as well, but these are the three that are most frequently used when designing or managing a simulation facility. In designing a simulation facility, it is important to determine whether the facility will operate on the same floor or multiple floors in the building. Typically, a single floor is considered to be a LAN; however, if you plan to operate a simulation from one building to the next building, a CAN would be required. If access is needed from off campus, across the internet, a WAN connection would be needed. This lingo will help the IT department understand the intentions of the design and how simulation tools are being used by the faculty of a center and its learners.

Tip
The MAC (media access control) address is a set of hexadecimal numbers that provide a set physical identifier for a piece of networking hardware, they will appear in the format MM:MM:MM:SS:SS:SS. The MM portion is unique to the manufacture of the device, and the SS is equivalent to a serial number provided by the manufacturer. This number can be used to identify a piece of equipment (e.g. camera, manikin, computer) on the network. [2]

IT security and/or a server administrator will frequently be present when evaluating or expanding any design involving the network IT department. Network security is a very important consideration that is much easier to implement at the same time a new network is established.

Every device connected to a network whether a manikin or a computer will have one or more network interface cards (NICs) (Fig. 14.1). Each NIC has a unique hardware address built into it called a Media Access Control (MAC) address. A NIC may utilize either a physical connection to an ethernet cable or a wireless connection to an access point. Each type of connection has inherent properties related to the speed of transmission. In addition to the theoretical speed limitation of each connection type, the actual transmission speed available is related to the amount of data being sent across the network and the bandwidth allocated to each device or user.

Beyond the geographic region or size of a network, understanding how each computer connects to the system is also of fundamental importance. This connection is either through a physical network cable or through a wireless network connection. This connection type is possible in any type of network configuration (LAN, CAN, or WAN).

Wireless local area network (WLAN) is similar to the LAN description above in which computers are located geographically close together but can be described separately when all nodes communicate with each other wirelessly. A WLAN can be built with any wireless network protocol, but most commonly Wi-Fi or Bluetooth is used. In order to make a connection in this manner, two categories of devices exist. The first is an access point. An access point is a wireless connection device that usually serves as a physical connection point into a wired network. The second is a client. A client is a device such as a computer, phone, or manikin that connects to a larger network through an access point or router. An independent network can be formed using a wireless connection without an access point but usually will not then also have connection to the internet and is termed a

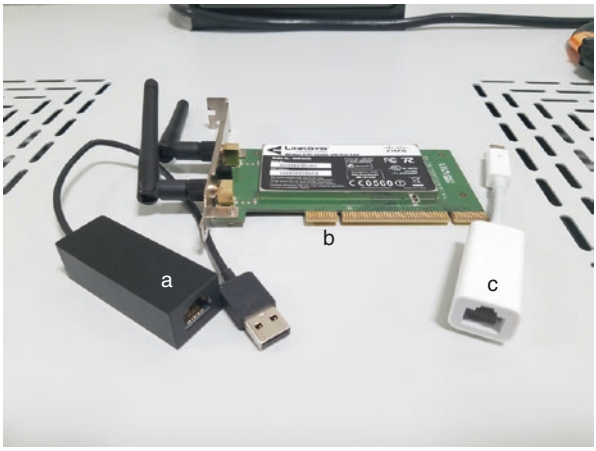


Fig. 14.1 Shows several types of network adapters, traditionally called network interface cards (NICs). The device (**a**) shows a USB to Ethernet adapter, (**b**) is a wireless card that would be installed into a desktop computer, and (**c**) shows a similar adapter to (**a**) but with a Thunderbolt connection. The bandwidth of the possible connection is a property of each adapter

peer-to-peer, or ad hoc network [3]. Manikin and control devices or PCs deployed in situ are often configured in an ad hoc configuration to eliminate the need to have a physical connection if they are used out in the field or in a room of a live healthcare environment.

Bandwidth Speeds

In order to communicate across a WAN, an internet service provider (ISP) is required to provide access to the internet. ISPs build out their own communications network to customers and are limited to certain geographic areas. Typically, there will be two or three ISPs located in most metropolitan areas, while rural areas may have only a single option for reliable connection. Other than a connection, the primary variable feature of this connection is bandwidth. Bandwidth is a measurement of the connection speed to a private or public internet service provider. Bandwidth is commonly defined by data upload speeds (amount of data sent out across the network in a period of time) and/or download speeds (amount of data received in a period of time) (see Fig. 14.2). Upload speeds are sometimes slower in comparison to download speeds for most consumer based ISPs. Upload speed is important if you have many external users on the internet that need to access information stored on your network. Download speeds are important if you are accessing data external to your network, on the internet.

Bandwidth is typically measured in Megabits (1 million bits per second (Mbps)), some connection speeds are much faster and operate in the range of Gigabits (1 billion bits per second (Gbps)). Although bandwidth speeds may vary, in general, the higher the bandwidth the higher the cost of service will be. Most ISPs will lock you in on an annual contract with early termination fees, so properly sizing your bandwidth is important. With the contract, a Service Level Agreement (SLA) is offered, which provides a guarantee of bandwidth.

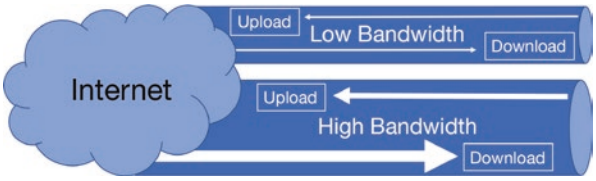


Fig. 14.2 Shows a graphical representation of bandwidth. Bandwidth is often thought of as water flowing through a pipe. High bandwidth would be a large pipe where more water (data) can fit or flow in a period of time. Data is usually measured in Megabits (1 million bits)/second (Mbps) or Gigabits (1 billion bits)/second (Gbps). The amount of data or rate of flow is often different depending on whether it is flowing out (Upload) or in (Download) to a network device. In the graphic above, the download speed is shown to have a higher bandwidth (bigger arrow) than the upload (smaller arrow) even in the high bandwidth connection

Connection Types

Cables

Several types of physical connection exist for connection to an ISP. Home and small business connections are usually through either a coaxial cable (RG-6) or a digital subscriber line (DSL) through an RJ-11 (Cat 3) telephone style connection. Both of these connection types require a modem to convert the signal to a more traditional connection for use by network components. Larger institutions may have different options for connection to an ISP, such as fiber optic cable. Fiber optic cable is a thin strand of glass that transfers data using a light source. Fiber optic cable can transfer data extremely long distances at a very high bandwidth. While this solution may be expensive, the advantage is that there is significant room for growth, and bandwidth speeds are in the 1Gbps to 100 + Gbps range and transmission distances can go upward of two kilometers between devices [4, 5].

Category 5E (Cat 5E), Category 6 (Cat 6), or Category 7 (Cat 7) data cable connections are all very similar in external appearance and vary in price and bandwidth support based on the gauge (size) of the wires and the type of shielding in the cable. All of these cables have a construction made up of eight smaller wires twisted around each other in four pairs, frequently called "twisted-pair" cables for this reason. The end of each of these 8-conductor cables is terminated in a small plastic rectangular clip called an RJ-45 terminal (Fig. 14.3).

Cat 5E and Cat 6 cables support all current Ethernet technologies, Cat 7 is expected to provide future ethernet technologies while being backward compatible with older equipment. New installation infrastructure might benefit from thinking to the future with Cat 6 or Cat 7 cables in walls or ceilings, but most simulation equipment does not fully utilize the bandwidth offered by these connections.

These 8-conductor twisted-pair cables can span distances of 100 meters (328 feet) before re-amplification of the signal is needed [5]. Another feature of the physical cable and housing is whether it is plenum or non-plenum. A plenum rating is often required by code when there is no conduit available and the cable is run through air spaces (above dropped ceilings). It is required for compliance with National Fire Protection Association standards [6, 7]. As such, this option is required in most hospitals and schools.

Non-plenum (riser cable) is usually less expensive but is not intended to run through air conditioning and ventilation spaces. Plenum cable can replace riser cable but riser cable cannot replace plenum cable. Non-plenum wires are typically run in network closets and between wall jacks and devices often called patch cables. More information about cable types and specifications can be found under the International Standard ISO/IEC 11801. These are global standards designed for various data communications [8].

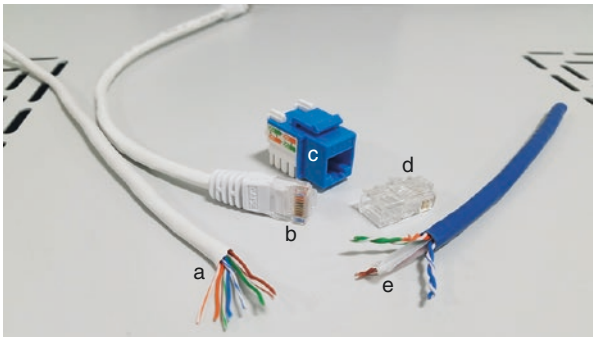


Fig. 14.3 The white bare cable is a Cat 5E cable (**a**) with the eight conductors separated out in preparation for placement into the RJ-45 clip (**d**). Once crimped into place it will look like the assembled cable and connector (**b**). The blue cable (**e**) shows a Cat 6 cable with the wire pairs still twisted together, it appears almost identical to the Cat 5E cable (**a**). The difference between these types of cables relates mostly to the thickness (or gauge) of the wires, how each wire is twisted around the other wires in the larger cable, and the amount or type of shielding present in the cable housing. The final connector type shown is the receptacle (**c**). This type of square clip connection is referred to as a keystone connector. Although the receptacle shown says Cat 6 on it, it is compatible with all RJ-45 plug connections when the wires are appropriately "punched down" into the slots on the back of the receptacle

In-depth

Domain Name System (DNS) resolution is a process external to a local network where the IP address for a website is matched to a standard text name. For example, when writing https://www.google.com/ into a web address bar, a query is sent to A DNS server looking for the address of this site. The DNS server will then return the IP address of 24.244.4.44 that will allow the computer will use to connect to the website. A DNS server takes the text entry of an internet address bar and matches it to the IP address of in the DNS server database. Because of the number of possible websites available, the search for the correct IP address may be relayed to multiple DNS servers before the information is found. [9]

Router

A router is a device that forwards traffic between computer networks. These computer networks could be two different networks across the CAN or between the LAN and WAN networks. When data arrives at a router, it acts like a navigation system, and directs the traffic down the best path toward the intended destination. Routers often include additional security features such as firewalls. Firewalls prevent traffic from an untrusted WAN connection from reaching the LAN devices. Routers can also allow Virtual Private Network (VPN) connections for trusted users to access internal devices from the WAN. Additionally, in smaller networks, routers provide Dynamic Host Configuration Protocol (DHCP) and Domain Name System (DNS), which allow devices to automatically configure themselves with network

addresses and talk to each other. Internet protocol (IP) addresses and DHCP are discussed in the next section.

In-depth

Dynamic IP address - An IP address which is automatically assigned to a device by the network router usually through DHCP. This method allows a device to be connected easily, but the address may change each time it is connected, so connecting to or finding the device is more difficult.

Static IP address - An IP address that is fixed and never changes. This requires configuration within the device or the router to which it is connected, but can make finding and managing a network device such as a camera or manikin easier in the future. The IP address is usually tied to the device in this manner by assigning it to the MAC address of the connected device. Web browser shortcuts can be established with the static IP addresses to connect quickly and directly to a specific device (for example a simulation room's camera).

Network Switches

In order to make a connection within a network (LAN or CAN) or between networks (WAN), a switch and/or router is needed to handle the data traffic. Switches provide the physical termination point of a cable, and are the devices and the location for multiple pieces of connected equipment to communicate on a network segment. Some of the more common features of switches are described below.

Unmanaged Switches are less expensive than their managed counterparts and are best used for small business or portable solutions. They can be used as an out-of-the-box solution with little to no setup required other than plugging in the cables. Unmanaged switches do not offer security, routing, or remote management options. All connected devices will therefore be on the same network/subnet (discussed later). Most home routers have a simple switch built into them to allow the connection of multiple (usually four) wired devices.

Managed switches may be more expensive but provide many features required for larger institutional infrastructure and security needs. A managed switch is a more advanced solution, providing the capability to manage data going across the LAN or direct it within a CAN. The most important features are some increased security functions and the ability to prioritize data, voice, and video to optimize bandwidth needs [5]. This network traffic prioritization is called quality of service (QoS). Managed switches are called such because of the ability to manage not only these bandwidth settings but also controlling remote accessibility and setting up virtual local area networks (VLANs) and dividing a network into subnetworks (subnets). They can also be used to connect both Cat5/6/7 cables and fiber optic cables in the same device. The ability to separate a network is an important consideration for simulation centers because it can provide more security and improved network speed based on the type of data or network traffic anticipated for each portion of the segmented network.

In-depth

Quality of Service (QoS) is a protocol used to notify the switch to prioritize data that is being transmitted inbound and outbound. This designation will depend on the type of data that is routed. [5] Data, video, and voice are three of the most common types of network traffic. If video or voice data transmission has even a small delay, this signal is noticeably degraded. Having the ability to delay data, in favor of a video or voice is an important feature across high utilization networks.

Subnets and IP Addresses

A subnet, short for subnetwork, is a method used for partitioning a network into smaller networks. An example of a partitioned network is shown in Fig. 14.4. Partitioning allows a simulation center to create a set of smaller segmented networks, within a larger network.

An example of a partitioned/segmented network could be the following:

- Desktops/laptops – that are hardwired
- Tablets/mobile devices – that are traditionally wireless
- Printers
- Video and microphone (in a digital video recorder (DVR))
- Simulators (manikins)
- Auxiliary simulated applications
  - Virtual reality system simulators
  - Nursing call units

For the intermediate and advanced network designer, subnetting is much more than segmenting devices onto different networks. It is important to understand that

Fig. 14.4 Shows a network switch that also supports power over Ethernet (PoE). Connected devices do not use the PoE power unless they are designed to do so and therefore will not harm other connected equipment

a router will allocate IP addresses within a defined range for any designated network via DHCP. When a device is connected to a network, regardless of whether it is hardwired or wireless, it is given an IP address (like a mailing address) to identify and communicate on the network. Nearly all computers and simulation equipment use Internet Protocol version 4 (IPv4) addresses. IPv4 addresses are in the form xxx.xxx.xxx.xxx, where each set of three Xs (called an octet) forms a number between 0 and 255 allowing for 256 (2^8) unique numbers per octet. There are some special IP addresses such as 255.255.255.255 that are reserved for the "broadcast address" and the first IP address in a subnet called the "network address." The number of usable addresses for a subnet will always be two less than the total theoretical number of addresses to account for these reserved IPs. The most common subnet that will be used in a network environment is a "class C" address. A class C address uses the first three octets to define the network, and the last octet to assign network addresses to each device. For example, the network address 192.168.10.0 would allow for 254 devices (256 minus 2) ranging from 192.168.10.1 to 192.168.10.254. The subnet mask for a class C network is 255.255.255.0. Unless you have specific reasons to use a subnet that allows more than 254 devices, using class C networks will allow for future growth and be more universally understood by non-network professionals. If more than 254 devices will be present on a network section then understanding subnetting as described further in the Appendix to this chapter will be required. While this section may seem confusing, for class C networks, the takeaway should be this: First, if the first three octets (example 192.168.0.xxx) between two devices do not match, they are not on the same network and therefore will not be able to connect to one another. Second, if there are more than 254 devices (tablets, smartphones, manikins, laptops, printers, cameras, simulation control computers, or office workstations) on your network, a specialized system or additional subnet may be required to meet your simulation center's needs.

If reading this chapter creates an increased interest in networks, acquiring a Cisco Certification will help to further understand the intricacies of network design. Consider looking into the additional certifications listed under the additional readings listed at the end of this chapter to discover how to allocate, prioritize, and manage data flow in a network.

Power over Ethernet

Power over Ethernet (PoE) is used to provide electrical power over a network cable to a remote device, such as an IP based camera or Voice over IP (VoIP) phone which may be located in an area that does not have any power outlets available or where additional wires are undesirable. Devices that support PoE may be labeled as 802.3af compliant. Switches that have PoE-enabled ports (Fig. 14.4) are more expensive than traditional switches but will also function with devices that do not use PoE. An alternative option is a power injector, which can supply a single device with PoE (Fig. 14.5). This option is more economical than buying a PoE-enabled switch if you only need to power a small number of devices. It is important to ensure

Fig. 14.5 Shows the connections of a single device power injector. The network data connection is plugged into the port labeled (A) and the output from the port labeled (B) will send the now mixed data and power from the connected wall plug on the other end of the device (not shown) on to the connected device

the PoE injector or PoE switch has enough power for the device to which it will be connected. This power is rated in watts per port. Most PoE power is transmitted at 44 V (volts) of direct current (DC) at up to 350 mA (milliamps), for a total of 15.4 W (watts). This power output is based on the original specification termed 802.3af. The upcoming 802.3at standard is expected to provide up to 25.5 W to allow more robust equipment support [5, 10].

Servers: Physical/Virtual/SaaS/Cloud

Some simulation software may require a high-performance server dedicated to running a specific application and no other tasks. Servers are high-end computers designed to be highly reliable and powerful to run resource intensive software applications. Traditionally, servers were individual physical machines; however, in the past decade there has been a strong shift toward virtualization and cloud hosting. If your simulation environment is part of a larger organization, there is a good chance a virtual server environment or cloud environment is already available, and IT can help provision a new server in short order. Virtual servers operate on the premise that multiple software-based servers are able to share the same physical hardware. Cloud hosted servers run in a remote datacenter, such as Microsoft Azure or Amazon EC2, and require an internet connectivity to access. Cloud hosting is a pay-per-use model; instead of having to pay for all the equipment upfront, you only pay for the server resources as you use them.

Alternatively, another popular trend in the industry is Software as a Service (SaaS). Under a SaaS model, the vendor hosts the application and is responsible for software patching, security, and hardware maintenance. The customer then pays a monthly/yearly contract to have access to the application over the internet.

Databases

Many applications that are hosted on site, or cloud hosted, require a database server to operate. If your simulation center is part of a larger environment, IT may already have database hosting solutions available, and knowing what options are available before selecting a software vendor is important. Microsoft SQL, MySQL, and to a lesser extent Oracle comprise the majority of SQL installations [11, 12]. Although all three of these applications are database solutions, they are not directly compatible, and software vendors will likely only support one option. Work with local IT resources and software vendors to determine which database solutions are supported and best fit your environment.

Data Storage: SAN/NAS/RAID/Cloud

Once data, video, and other information is collected or created in a healthcare simulation environment, it needs to be stored somewhere. The security and accessibility of this data is of utmost importance. Care needs to be taken to make the storage as resilient as possible and ensure a strong backup solution is present to protect against human error and site level disasters such as fire/flood/hurricane/tornado.

When multiple computers and devices need a location to store and access data, a centralized storage appliance is useful to allow a single location that can store and share data between many different devices simultaneously. Many remote or cloud-based solutions exist, such as Microsoft OneDrive or Dropbox. The file or data in active use is typically stored on the local device to satisfy the performance requirements of applications before it is uploaded for access by another device or user. These systems have easy access and the ability to share between users, but many large organizations and healthcare groups do not like these solutions due to security and privacy concerns. Box is another similar system that has additional security controls that allow use even when healthcare data may be present.

Two popular options for centralized on-site data storage are a storage area network (SAN) or network attached storage (NAS). The difference between SAN and NAS is often blurred as most new technologies support many different protocols; however, typically a SAN is connected to servers running applications/file shares and appears and functions like a connected hard drive for databases. A NAS on the other hand functions like a large file share that connects to end-user computers and devices allowing access to files such as documents and images [13]. A NAS includes a dedicated hardware device that connects to a local area network LAN using ethernet to connect. NAS has less complex architecture compared to SAN and is typically less expensive. On the downside, it is slower than SAN, since SAN uses Fiber

Channel to connect directly into a server which makes it faster. Most environments will use one technology to serve both server and client data; however, there may be situations where having both can be advantageous. NAS equipment is available to and configurable by most small business or home users, while SAN would require higher-level database knowledge and infrastructure to be functional.

At the core, a SAN/NAS device is a large collection of hard disks that are combined to form one large pool of storage that is made available to the network. The underlying technology that is responsible for this is RAID (Redundant Array of Inexpensive Disks). In short, a RAID system allows data to be spread across multiple disks mounted in the same device, either to allow a larger total storage capacity than the individual disks or to increase efficiency of access to the data by reading/writing to multiple disks at the same time. One common misconception is that RAID can replace backups. RAID is not a backup, it is about high availability. In a RAID system, one (or several) disk(s) can fail without losing data because the data is shared across multiple disks for redundancy, which makes RAID a high-availability tool. However, if a file is accidently deleted, or there is a site disaster, RAID offers no recovery options. There are several different "levels" or configuration options for RAID that have different advantages/drawbacks. The following are the most common configurations (Table 14.1).

RAID (except RAID 0) allows a SAN/NAS to recover from a drive failure and rebuild the data on a new drive. Being electrical/mechanical devices, hard drives have a finite lifetime and will eventually fail; making RAID an important consideration in a centralized storage solution. Equally important is a backup strategy that maintains a copy of your data off-site. Backup options vary depending on the

Table 14.1 Shows an overview of some common redundant array of inexpensive disks (RAID) configurations

RAID level	Advantages	Disadvantages	Capacity	Value
5	High read performance, allows for single drive failure	Moderate write overhead	N-1	Good value/redundancy
1	High read performance	Faster writes, less capacity	N/2	Maximum redundancy at highest cost
6	High read performance, allows for two drive failures	Moderate write overhead, requires more drives	N-2	Data protected if a second drive fails while the array is already rebuilding from a drive failure
0	Maximum read/write performance	No redundancy, a single drive failure will cause complete data loss	Nx2	Maximum capacity and performance, almost guaranteed to fail.

Overall RAID allows for some efficiency and redundancy in case of an isolated drive failure but should not be viewed as a backup. Under the capacity column N refers to the number of hard drives connected together (example for RAID 5 with four 1 Terabyte hard drives: N = 4, N–1 × 1 Terabyte = 3 Terabytes)

storage device, sometimes a second SAN/NAS will be purchased and replication between the two can be configured. Increasingly, backing up to a cloud storage provider is becoming a popular option to protect against both accidental data loss and site disaster with a lower upfront cost. Instead of purchasing duplicate hardware, you can pay for just the data you need to protect.

Security

In this digital era, malicious individuals are the biggest threat to a network. Imagine the night before a large simulation, several simulation rooms have been staged according to the needs of the faculty and educators for a final exam grade assessment. What would be the ramifications for repair costs, damage to educational expectations, and institution reputation if on the day of the simulation after powering on the digital devices, it was discovered that the network has been compromised by a security intruder/virus? The thought would be indescribable. Digital threats are mostly remote intrusions, where a culprit from the outside accesses a network via the internet. So how can security be provided to help prevent these intrusions?

There are several layers of security that need to be implemented, which may involve assistance from your IT security team, if available.

A firewall is a network device, which can be physical or software based, to scan incoming traffic and block traffic from unknown senders or from sources that are identified as malicious. There are two methods for this. The first option is called whitelisting. Whitelisting allows only specific traffic identified as safe, either from a specific IP address, subnet, or location, into a network and blocking everything else. A second method is with the use of a Virtual Private Network (VPN). Some firewalls allow for Virtual Private Network (VPN) connections to allow trusted users to remotely access the network from another location. A VPN, or virtual private network, is a secure tunnel that allows two or more devices to connect with each other securely over a public network connection such as the internet [14]. This is useful when there is concern about snooping, interference, and censorship.

Digital Security Measures

1. Passwords – you will need to ensure complex and unique passwords are used to access any digital device, such as servers, desktops, tablets, and any other wireless components.
2. Wireless Access – Strong wireless security authentication such as Wi-Fi Protected Access-II (WPA2) must be enabled to prevent unauthorized users/devices from connecting to your network. Beware of older simulation equipment, especially manikins, which may only support wired equivalent privacy (WEP)-based security. WEP is an older and less secure connection method which is being deprecated quickly in the IT industry.

3. End Point Security – Antivirus/Antimalware software should be installed on every local computer. It should also be configured to automatically update and scheduled to run periodic full scans of the system. Windows Defender is a free option available from Microsoft, although many paid alternatives offer additional security features such as Data Loss Prevention (DLP), which will scan for sensitive information trying to leave your network.
4. Virtual LAN (VLAN) – A VLAN, is a way to separate/segment different networks from each other. VLANs can be used to isolate sensitive devices from being accessed by other devices, or as an organizational tool to group devices by type or location. VLANs require a layer 3 device (router) to communicate between these networks [5]. While VLANs are a powerful tool, they will require coordination with your network administrator to configure. A dedicated VLAN within a simulation environment can allow the network savvy HSTS to manage internet protocol (IP) addresses with minimal involvement of the IT department and with less security risk.
5. Active Directory – Large campus institutions can manage and control specific user access and permissions across all network computers by defining and using an Active Directory (AD) Organizational Unit (OU). When windows computers are part of a larger Microsoft Active Directory Domain, a network administrator can create a specific OU, granting the HSTS the necessary administrative rights in order to install the applications necessary to support and control the healthcare simulation environment. Because of the security concerns already mentioned, always follow local IT policies regarding the installation of new software. Often times a quick meeting with the systems/security administrator will be necessary to review any new applications to be installed to verify they comply with and are installed according to local policy.

Authentication – Simulation applications may be able to use your existing Microsoft Windows Active Directory (AD) Domain for authentication and user account information. The advantage of using an existing AD domain is the management overhead of account maintenance is shifted to the IT department. Although the specific application may vary, configuring user access can be as simple as specifying a specific OU group that should have access, and adding/removing users from the OU as necessary. The user can use their existing Windows Domain credentials, and will not need to remember a second username/password for the simulation software.

There are several ways that third party applications can authenticate with a windows domain, some of which may or may not be supported in your local environment. When considering solutions, ask both vendors and your local IT department specifically about support for Lightweight Directory Access Protocol (LDAP), Active Directory, Security Assertion Markup Language (SAML), or Active Directory Federation Services (ADFS) support. Involving IT early on in

the vendor selection process can make your life much easier down the road, and the end-user experience will be better if your simulation solution supports domain-based authentication.

Remote Connection

Remote management allows for a connection to be made to computers or devices without having to physically be at the device, or even on the premises. This flexibility to "remote" into machines can be a powerful tool for supporting a simulation environment; however, care must be taken to be absolutely sure remote access tools do not introduce security vulnerabilities. This is one area that will require the involvement of the Network and Security administrator. The tradeoff of being able to diagnose and fix problems remotely greatly offsets the initial effort to configure these connections.

There are two primary types of remote connection technology, and most environments will end up using a combination of both types. At the network level, Virtual Private Networking (VPN) allows you to make a secure connection from anywhere in the world and access the simulation network as if your computer was directly plugged into the local network. Separately, remote access software, of which there are many options, allows for remote screen sharing of computers, including the ability to use a mouse and keyboard interface as though seated at the device. One method to make this type of connection is through virtual network computing (VNC).

Keep in mind that not all remote access software is created equal. While some VNC software is generally free, it also passes traffic in clear text that could be intercepted. One example of a hybrid approach would be using a VPN to remotely connect into the simulation network and then using VNC over the secure VPN tunnel that has been established. Be aware you can only manage devices that are turned on and accessible. Configuring the computer's power policy to prevent the device from going to sleep should be applied to computers that are expected to be available for remote management. While there are many free and paid version of software available to remote desktop to your computer, it is important to check with your institution/IT policy if you are allowed to use them (Table 14.2).

Although in no way an extensive guide for all the complexities that comprise a modern IT environment, the material presented here should provide a basic understanding of the components involved and enable a more educated conversation between the simulation center, IT departments, and vendor resources. At the very least, this material will help to define what questions to ask when implementing a new technology. The network diagram shown in Fig. 14.6 is of a mock simulation environment implementing many of the ideas and technologies discussed in this chapter.

Table 14.2 Lists several types of remote connection programs and advantages and disadvantages of each

Remote access software				
Remote desktop apps	Advantages	Disadvantages	Operating system	Fee
GoToMeeting	Screen share	Need someone on the other side of the PC to accept control	Windows/Mac	Variable cost
TeamViewer	Can access PCs/laptops via computer name, TeamViewer access code		Windows/Mac	Free (personal use), fee for enterprise level
LogMe In	Can access PCs/laptops via computer name/IP address	Need someone on the other side of the PC to accept control	Windows/Mac	Variable cost
Tight VNC	Can access PCs/laptops via computer name/IP address	Need VPN to secure remote connections	Windows/Linux	Free
Remote Desktop	Can access PCs/laptops via computer name/IP address Only available on professional/enterprise/educational versions of Windows	When you access a PC, it will take over a session, thus disabling the display screen at the local device Need to have permissions (provided by IT) in order to remote into desktop Best practice – use over VPN	Windows	Free
WebEx	Share screen	Need someone on the other side of the PC to accept control	Windows/Mac	Variable cost
Microsoft Lync	Share screen	Need someone on the other side of the PC to accept control	Windows	Free
UltraVNC	Can access PCs/laptops via computer name/IP	Need VPN to secure remote connections	Windows	Free
Chrome Remote Desktop	Shared screen, no VPN required for remote use	All computers must be signed into the same Google account	Any OS that supports Chrome web browser; Windows, Mac & Linux	Free

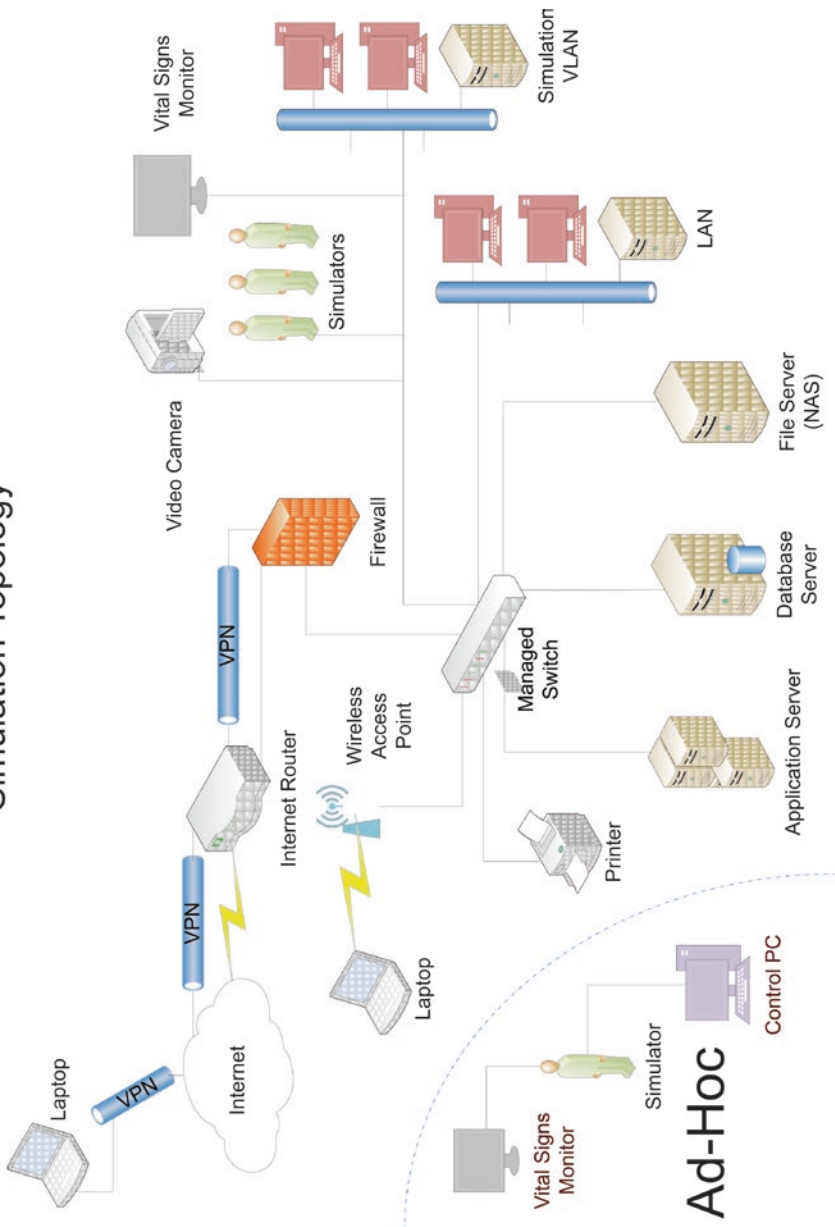


Fig. 14.6 Shows an example of a network connection layout (called a topography). Notice that the manikins and control computers are separated on the network using a VLAN. This segmentation allows the simulation specific equipment to be separated from the main LAN

Example Simulation Specific Applications

Major manikin manufacturers such as Gaumard and Laerdal use computer networks to connect the manikin control computer and vital signs computer. Additionally, Laerdal has a separate network connection to the manikin (which actually is running a lite version of a Windows operating system), while Gaumard uses a proprietary radiofrequency connection from the control computer to connect to the manikin. If these computers and manikins are not configured correctly on the network, they will not work correctly.

Laerdal

The original system design for SimMan 3G from Laerdal allows the manikin to function as a wireless access point for both the control computer and vital signs computer. This configuration allows the system to be installed and controlled without requiring internet access. This connection is accomplished by using a router inside of the manikin to create a network identified by the SSID for the Wi-Fi network created by the internal router to which each of the two computers (control PC and vital signs PC) will then connect.

The convenience and use of having a control computer on a larger campus network to access shared scenario files may prompt many centers to find a way to connect the manikin and control computer to a larger network. This can be performed by having the manikin connect to the same LAN as the control and vital signs computers by using the wired network port on the manikin's side for a faster and more reliable connection. While not officially supported by Laerdal, this procedure has been successfully performed by many centers. In order to make this change, the manikin will need to be opened up and a network switch (visible as a while square box), located on the router in the manikin's pelvis, configured (Fig. 14.7) [15].

After moving the selection switch on the device to "router" mode, the reset button can be held to return the login username and password to the default (User, admin; Password, admin). A connection can be made to the device by connecting a computer to the router's ethernet port. The router should assign an IP address in the form (192.168.x.100) to the connected computer, which can be determined by typing the command *ipconfig /all* into the command prompt of a windows PC. The router will be on the same subnet as the IP address returned from the ipconfig query and access should be possible by typing in the IP address of the router into a web browser (example: 192.168.x.1). Here the web browser should prompt for the username and password of admin/admin. Once logged into the graphical user interface of the router, the IP address of the router can be set to match the network scheme of the simulation center network where it will later be connected [16]. Now the switch on the side of the internal router can be moved to "client mode" (Fig. 14.8). A final short reset should allow the manikin

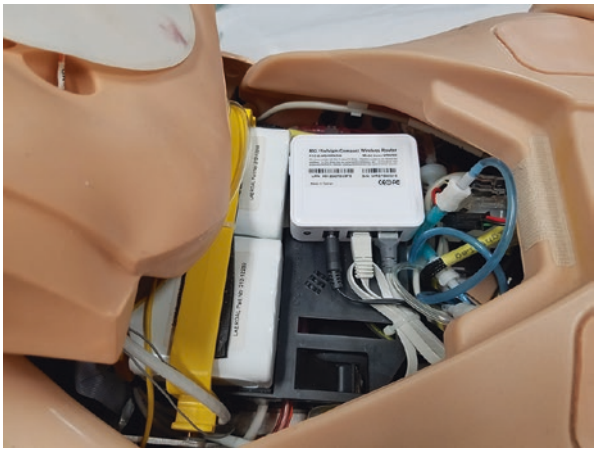


Fig. 14.7 Shows the wireless router location inside the 3G manikin

Fig. 14.8 Shows the selection switches on the router inside the SimMan3G Manikin. The switch options read Router, AP (Access Point), and Client. In Router mode, the box will create a network and assign IP addresses to any devices connected to the LAN port (right side of the box in the picture). In AP mode it will create an ad hoc wireless network with an SSID that can be searched for and used by the vital signs and control PCs. In Client mode, the router can be configured to allow connection to a larger network where IP addresses are assigned or reserved by a router outside of the manikin

to be connected and seen by the computers on the simulation center network. Laerdal does not include these directions in the manual for the system and will not likely support or troubleshoot this configuration if you encounter issues. Consider this modification at your own risk.

When configured in this manner, a control computer with the appropriate licensed software can control a manikin anywhere on the same network.

This SimMan 3G software application can have a single machine display vital signs and provide control of the manikin's physiology if a second monitor is connected. When a computer is configured in this manner and equipped with a VNC connection and a static IP address, a series of shortcuts can be created to allow remote login to each simulation room where the system is configured in this manner, and it can be controlled and run from any computer located within the simulation center's network.

Gaumard

While the connection from the Gaumard manikin to the control PC is not a standard IP network connection, it is for the connection between the vital signs computer and the control computer. When these devices are originally configured, the IP address for each must be identified and entered into a configuration menu within the Gaumard software. These systems can be configured in an ad hoc connection without requiring internet connectivity or through a switch and router as part of a larger network for the entire simulation center. In addition to verifying the two computer systems are on the same network/subnet by looking at the IP addresses, a port is required to be listed and must match between the control and vital signs PCs (Fig. 14.9). Most commonly the port is 8001, but can vary depending on the setup. It is possible to display vital signs to two separate vital sign computer displays, but will require two separate port entries, one for each display to be transmitted and received.

In-depth

In addition to the IP address, the port number can help to identify the type of network traffic being sent to or from a connection. The port is delineated with a colon (:) followed by the port number in the web address bar when typed in for access. A router or firewall can limit or restrict data transmission only to specified ports as a method of security on a network. For example, blocking access to port 80 would prevent connection to websites and the internet. Some IP camera systems will only allow video transmission or access on a specific port.

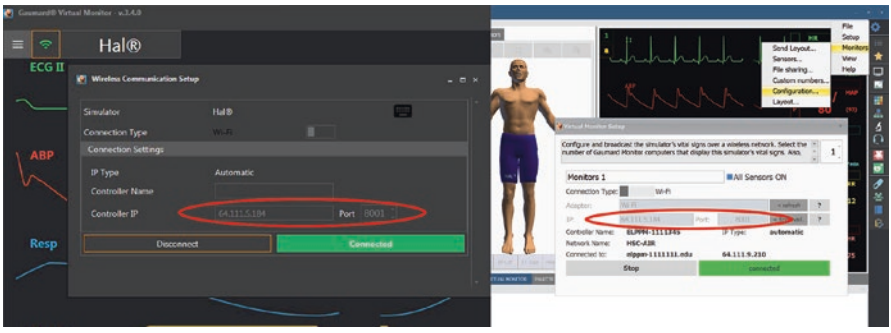


Fig. 14.9 Shows the screen of the Gaumard vital signs monitor (left) and Control PC with the UNI software (right). The circle is highlighting the Control PC's IP address and the port information that was required to connect the two devices. Courtesy of Gaumard Scientific

Conclusion

While this chapter is not designed as a replacement for a degree or certificate in information technology, understanding the terminology and functional considerations of networking and network components will help the HSTS to take a more active role in supporting simulation activities. Whether troubleshooting individual system connectivity, or taking on a larger role in suggesting design improvements to current or future simulation center IT infrastructure, the concepts discussed here play a vital role in defining the overall integration and functionality of simulation equipment. The connections between devices follow the same rules, whether it is for a single-room simulation facility or a multisite regional simulation institute. Appropriate planning and support of information technology is a must for a simulation center to provide quality education and learning outcomes.

Appendix: IP Addresses and Subnets

It is important to understand that a router will provide an allotment of IP addresses within a defined range for any designated network and across the Internet. Many understand that when a device is connected to a network, regardless of if it is hardwired or wireless, it is given an IP address (like a token) to connect to the network. Most IP addresses are in the form XXX.XXX.XXX.XXX, where each set of three Xs (called an octet) forms a number between 0 and 255 allowing for 256 (2^8) unique numbers per octet. This is called IPv4 notation. The 256 here is actually a decimal number system representation of the eight positions of a binary number in the range of 00000000–11111111 [17].

An IP address has three components much like the country, city, and zip code of a postal address. These parts are the network part, the subnet part, and the host part (see Fig. 14.10).

Dividing a network using a subnet can add several layers of difficulty if you are not familiar or comfortable with it. Whether you are novice, intermediate, or advanced in networking, understanding the concepts of segmenting small networks within a network is a desirable trait. Subnetting can make networks easier to manage and can improve security.

The subnet mask is intended for defining the type and number of IP addresses available for a given local network. Some default categories of subnet masks are as follows:

- Class A: 255.0.0.0
- Class B: 255.255.0.0
- Class C: 255.255.255.0

The subnetting process allows an administrator to divide a single Class A, Class B, or Class C network number into smaller portions.

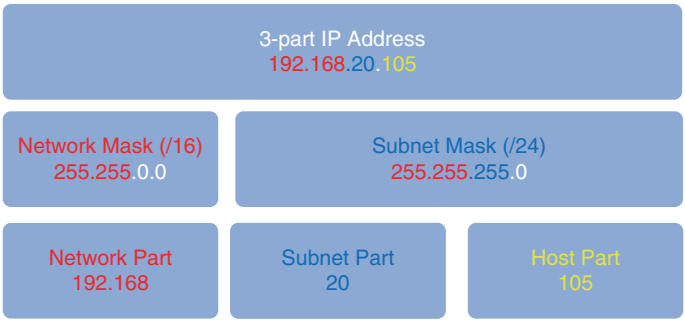


Fig. 14.10 In this figure the IP address 192.168.20.105 is shown and divided into its constituent pieces. The network part (in red) identifies the location potentially globally in the Internet where a piece of information is going to or coming from. The subnet part (in blue) marks a segment within a larger network. Finally the host (in yellow) identifies the specific computer or device. The "mask" that accompanies the IP address identifies how much of the IP address is allocated to the network or subnet portion. In the example above, the network mask is /16, identifying the first two octets (11111111.11 111111.00000000.00000000) or (255.255.0.0) as belonging to the network. The subnet mask is /24; this is the total of the first 16 bits from the network mask and the next 8 bits from the subnet mask totaling 24 (11111111.11111111.11111111.00000000) or (255.255.255.0). This configuration would allow only the final octet to be assigned to host devices within the subnetwork. Inside of an institution, when information is traveling across the Internet, the network mask is not used for routing, and instead the subnet mask is used to define hosts and routing of information within a network [18]

Example of subnets in action:

A college offering Internet connectivity may provide two SSIDs (service set identifier) to connect to its Wi-Fi network:

1. College Z – Student
2. College Z – Guest

This is an example of subnetting. The network administrator has configured the college's switch, which manages data flow, to route data traffic to one of two different subnetworks, to allow use by students and guests. This could be achieved by partitioning the college's network into two subnetworks by changing the subnet mask.

A subnet mask distinguishes an IP address, by separating it into "network address" (first) and "host address" (second) portions (<network>,<host>). A subnet divides the host portion further (<network>,<subnet>,<host>). A subnet mask is a 32-bit number that is used to define the number of assignable IP addresses within a network segment. The subnet mask makes all network bits "1s" and all host bits "0s" and therefore also indicates where the network and host address portions start and end [19]. For a standard home network, the subnet mask is a class C /24 network denoted as 255.255.255.0 (see Table 14.3).

The numbers 0 and 255 (00000000 and 11111111) in the host portion are reserved for the "network ID" and "broadcast ID," respectively, leaving only 254 possible numbers to be assigned to "hosts" (individual computers or devices on a network). The router, and the IP address assigned to it, is also called the default gateway and will occupy one additional IP address.

Table 14.3 Shows the subnet classifications, subnet mask, and the number of assignable IP addresses for different types of networks including Class A, B, and C and classless inter-domain routing (CDIR). Most home networks are Class C and allow for 254 connections, but multiple differentiations are possible as seen in the table. Online calculators are commonly used to assist with planning

Class	Address	# of hosts	Netmask (binary)	Netmask (decimal)
CIDR	/4	240,435,456	11110000 00000000 00000000 00000000	240.0.0.0
CIDR	/5	134,217,728	11111000 00000000 00000000 00000000	248.0.0.0
CIDR	/6	67,108,864	11111100 00000000 00000000 00000000	252.0.0.0
CIDR	/7	33,554,432	11111110 00000000 00000000 00000000	254.0.0.0
A	/8	16,777,216	11111111 00000000 00000000 00000000	255.0.0.0
CIDR	/9	8,388,608	11111111 10000000 00000000 00000000	255.128.0.0
CIDR	/10	4,194,304	11111111 11000000 00000000 00000000	255.192.0.0
CIDR	/11	2,097,152	11111111 11100000 00000000 00000000	255.224.0.0
CIDR	/12	1,048,576	11111111 11110000 00000000 00000000	255.240.0.0
CIDR	/13	524,288	11111111 11111000 00000000 00000000	255.248.0.0
CIDR	/14	262,144	11111111 11111100 00000000 00000000	255.252.0.0
CIDR	/15	131,072	11111111 11111110 00000000 00000000	255.254.0.0
B	/16	65,534	11111111 11111111 00000000 00000000	255.255.0.0
CIDR	/17	32,768	11111111 11111111 10000000 00000000	255.255.128.0
CIDR	/18	16,384	11111111 11111111 11000000 00000000	255.255.192.0
CIDR	/19	8,192	11111111 11111111 11100000 00000000	255.255.224.0
CIDR	/20	4,096	11111111 11111111 11110000 00000000	255.255.240.0
CIDR	/21	2,048	11111111 11111111 11111000 00000000	255.255.248.0
CIDR	/22	1,024	11111111 11111111 11111100 00000000	255.255.252.0
CIDR	/23	512	11111111 11111111 11111110 00000000	255.255.254.0
C	/24	256	11111111 11111111 11111111 00000000	255.255.255.0
CIDR	/25	128	11111111 11111111 11111111 10000000	255.255.255.128
CIDR	/26	64	11111111 11111111 11111111 11000000	255.255.255.192
CIDR	/27	32	11111111 11111111 11111111 11100000	255.255.255.224
CIDR	/28	16	11111111 11111111 11111111 11110000	255.255.255.240
CIDR	/29	8	11111111 11111111 11111111 11111000	255.255.255.248
CIDR	/30	4	11111111 11111111 11111111 11111100	255.255.255.252

Example device on a class C network

- Network ID 192.168.0.0/24
- Subnet mask 255.255.255.0
- IPv4 host address 192.168.1.211
- Default gateway 192.168.1.1
- Broadcast ID 192.168.1.255

This example using a class C network means that the network can only provide 256 IP addresses. The assignable range of host addresses is from 192.168.1.2 to 192.168.0.254 plus the network, broadcast, and gateway IPs. This may seem like plenty for a standard home network; however, for a college, this would not be enough IP address to operate. Looking at Table 14.3 and the following examples, we note that changing the subnet mask can increase the number of available IP addresses on the network as shown.

College Z– Employee: (Allocating **4,096** IP addresses)

- Network ID 192.167.0.0/20
- Subnet mask 255.255.240.0
- IPv4 host address 192.167.1.201
- Default gateway 192.167.0.1
- Broadcast ID 192.168.15.255

The range of possible IP addresses in for this network is 192.167.0.2–192.167.15.254

College Z – Guest: (Allocating **65,534** IP addresses)

- Network ID 192.160.0.0/16
- Subnet mask 255.255.0.0
- IPv4 host address 192.160.2.64
- Default gateway 192.160.0.1
- Broadcast ID 192.160.255.255

The range of possible IP addresses for this network is 192.160.0.2–192.160.255.254

Subnetting is one method to partition or segment your network into smaller networks. Actually configuring a network in this manner requires a special networking switch and configuration of that switch and the devices to which it connects.

When considering simulation and the number of learners that participate in a facility, it may be suitable to create several subnets for a network infrastructure.

Examples for users and groups that could be assigned to different subnetworks:

1. Employees and simulation devices within the workplace to connect via wireless connections
2. Guests outside of the workplace to connect via wireless connections
3. Employees and simulation devices within the workplace to connect via a hard-wired connection
4. Voice over IP (VoIP) Phones
5. Video recording system

Dividing a network into a number of subnets provides the following benefits:

- Reduces the network traffic by reducing the volume of traffic and reducing collisions by decreasing the number of hosts
- Can allow for more hosts and surpass the limitations in a local area network (LAN)
- Enables users to access a specific portion of a network, without needing to provide access to the complete network
- Allows prioritization of data over specific subnets [20]

References

1. ATIS Committee PRQC. ATIS Telecom Glossary – Computer Network. [Online] http://www.atis.org/glossary/definition.aspx?id=6555. Alliance for Telecommunications Industry Solutions; 2018 [cited 2018 August 7]. Available from: http://www.atis.org/glossary/definition.aspx?id=6555
2. iplocation.net. What is a MAC address? August 27, 2018. Available from: https://www.iplocation.net/mac-address
3. Techopedia. Wireless Local Area Network (WLAN); August 27, 2018. Available from: https://www.techopedia.com/definition/5107/wireless-local-area-network-wlan
4. Irujo T. OM4 – the next generation of multimode fiber. [Online] http://www.fols.org/fols_library/white_papers/documents/OFSOM4TheNextGenerationofMultimodeFiber.pdf; 2011
5. Meyers M. CompTIA Network+ all-in-one exam guide, exam N10-007. 7th ed. McGraw-Hill Education Group: Houston; 2018. 960 p
6. Association NFP. NFPA 262 – standard method of test for flame travel and smoke of wires and cables for use in air-handling spaces. Quincy: National Fire Protection Association; 2002.
7. National Fire Protection Association. NFPA 262 – standard method of test for flame travel and smoke of wires and cables for use in air-handling spaces. Quincy: National Fire Protection Association; 2002.
8. International Organization for Standardization. Information technology – generic cabling for customer premises – part 1: general requirements. Geneva: International Organization for Standardization; 2017.
9. Khan Academy. How the Internet works – IP addresses and DNS. In: Mejia P, editor. [Online] https://www.khanacademy.org/computing/computer-science/internet-intro/internet-works-intro/v/the-internet-ip-addresses-and-dns; 2015
10. Eisen M. Introduction to PoE and the IEEE802. 3af and 802.3 at Standards 2010. Available from: http://www.sepitam.com/files/editor/downloads/What is difference End-Span and Mid-Span.pdf
11. Datanyze. Microsoft SQL Server market share. [Online] https://www.datanyze.com/market-share/databases/microsoft-sql-server-market-share; 2018. Available from: https://www.datanyze.com/market-share/databases/microsoft-sql-server-market-share
12. iDatalabs. Database Management System Products. [Online] https://idatalabs.com/tech/database-management-system; 2017. Available from: https://idatalabs.com/tech/database-management-system
13. Bednarz A. What is a SAN and how does it differ from NAS? Network World [Internet]; 2018.
14. Cisco. Site-to-site VPN. 2018. In: Cisco Firepower Threat Defense Configuration Guide for Firepower Device Manager [Internet]. [Online] https://www.cisco.com/c/en/us/td/docs/security/firepower/620/fdm/fptd-fdm-config-guide-620.html: Cisco. 6.2. Available from: https://www.cisco.com/c/en/us/td/docs/security/firepower/620/fdm/fptd-fdm-config-guide-620.html
15. Laerdal. SimMan 3G User Guide; 2016 August 27, 2018. Available from: http://cdn.laerdal.com/downloads/f3111/user_guide,_simman_3g_english.pdf
16. Florek B. Laerdal SimMan 3G wireless router upgrade information and troubleshooting; 2013. Available from: http://simulation.laerdal.com/forum/forums/storage/93/4793/Laerdal SimMan 3G wireless upgrade.pdf
17. Clarke GE. CompTIA network+ certification study guide, sixth edition (exam N10–006). 6th ed. New York: McGraw-Hill; 2015.
18. Panko RR. A closer look at HTTP, TCP, IP, and PPP. Business data communications and networking. 3rd ed. Upper Saddle River: Prentice-Hall; 2001. p. 53–74.
19. IPLocation.com. What is a subnet mask? [Online] https://www.iplocation.net/subnet-mask. Available from: https://www.iplocation.net/subnet-mask
20. Techopedia.com. Subnetting. [Online] https://www.techopedia.com/definition/28328/subnetting. Available from: https://www.techopedia.com/definition/28328/subnetting

21. Cisco. Training and certifications. [Online] https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html#~cert [Updated August 27, 2018]. Available from: https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html#~cert

Additional Recommended Readings

CISCO. Training and certifications. [Online] https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html#~cert [Updated August 27, 2018]. Available from: https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html#~cert

The Healthcare Simulation Technology Specialist and Management

15

Amar Pravin Patel and Jennifer McCarthy

Understanding Leadership

Introduction

> A leader is best when people barely know he exists, when his work is done, his aim fulfilled, they will say: we did it ourselves. (Lao Tzu)

What makes all of us unique is our desire to grow as we believe we are ready. Unfortunately, readiness is often linked to one's experiences. As healthcare simulation technology specialists (HSTSs) and educators, we know how valuable a mistake can be. We know that a mistake can create both short- and long-term challenges. A mistake, although accidental, must also be an important lesson. These mistakes allow each of us to learn in order to move forward. As a leader, we learn from others just as others learn from us. What makes a leader is not their unwilling sacrifice for the cause but a burning desire to lead by example, have trust in their team, listen carefully to the environment, and above all be there to provide guidance and support.

For the HSTS, the technological and simulation environment is constantly changing. Each day there is an advancement in the technology that could help the educational environment grow or force individuals out of a job. It is the job of the HSTS to learn how to help an educational program adjust their curriculum or simply be available to provide insight and perspective. We are all leaders in our respective

A. P. Patel (✉)
CAE Healthcare, CAE, Sarasota, FL, USA
e-mail: appatel@me.com

J. McCarthy
School of Health and Medical Sciences, Seton Hall University, Nutley, NJ, USA
e-mail: jennifer.mccarthy@shu.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_15

fields. It is up to us to define the leadership qualities and demonstrate how we have achieved the competencies necessary to be a good leader. At the end of the day, leadership is about what each person does in their role and how they choose to have an impact. Leadership does not come from a title but from the actions portrayed by an individual.

This chapter will focus on defining who can be a leader and what competencies are necessary to be a good leader. In turn, this chapter will provide an overview of how individuals make an educational program successful. Lastly, it will outline how an HSTS can move forward both personally and professionally.

The Role of Leadership

Becoming a leader is about being a mentor. A leader is responsible to those that report to them and to ensure that the program is following the model and parameters that have been established by the parent organization. Leadership is not easy, and it is imperative that those who want to be a leader understand how to differentiate the role of a manager from that of a leader. Being a leader and a manager are different but equally important to a healthcare simulation program. Managers control, while leaders inspire. Managerial skills are key when dealing with nonliving items. Leadership skills are key when dealing with people. Leaders are able to utilize both managerial and leadership qualities as needed to drive positive change for the simulation program.

To become a leader, an individual must understand the role they currently play, acknowledge their own gaps, and develop a plan on how to move forward. A successful leader must be willing to be vulnerable and accept feedback. In the end, everyone is a leader in simulation, and being in the clinical profession is not a requirement to oversee an educational program. One must simply understand what leadership is.

> It's not about how smart you are – it's about capturing minds. (Richie Norton)

What Defines a Leader?

In the simulation setting, a participant may see all of the simulation staff as a leader as they work to understand and apply the materials and information presented to them. In certain environments, individuals falsely rely on credentials and formal education as a requirement for leadership. In the healthcare setting, it can be argued that each person who is part of the patient care team is responsible to lead. Through the past decade, there has been a purposeful initiative in healthcare to reduce the authority gradient. This also applies to the simulation environment. Often, the HSTS is viewed as beneath the educator. This hierarchy is detrimental to providing an environment that enhances teamwork and reduces silo thinking. It is important for the HSTS to be accepted as a peer and an integral part of the simulation team. His or her input and feedback is important for the evolution and advancement of simulation in healthcare.

If HSTSs find themselves in a situation where they are not revered as part of the team, a direct, professional conversation is the best first step to resolving this misunderstanding. It is important that the healthcare simulation technology specialist not take this personally. The healthcare simulation field is maturing as a profession and without a dialogue to share ideas regarding maturation, the field will remain stagnant, or worse, evolve based on factors not driven by professionals in the field. Part of leadership is leading the maturation of the profession.

A leader can be defined as someone who can establish goals, foster innovation, motivate individuals toward success, demonstrate compassion, and be passionate about the field. Most importantly, leaders foster an environment of trust and that trust is key to the success of the team and the leader. Arguably, that should be everyone. Everyone exudes many if not all of these characteristics that define a leader. However, can each of us meet the competencies necessary to be a successful leader? Remember that a leader is not defined by the role within the organization but by their ability to meet the definition stated earlier and achieve the competencies outlined by the organization.

To be a strong and impactful leader, the HSTS must understand what a competency is, how it is defined, and how to achieve them. The Association for Talent Development defines a competency as "something you need to be able to do well in a specific job role" [1]. So, what are the competencies for a strong and impactful leader? In 2016, Sunnie Giles published her leadership research findings on what leaders believe to be core competencies for their role within the organization. Published in the *Harvard Business Review*, Giles found that 195 global leaders revealed 74 different themes. From these themes, the top 10 and most notable were (1) strong ethics and safety, (2) self-organizing, (3) clearly communicates expectations, (4) efficient growth, (5) nurtures learning, (6) connection and belonging, (7) open to new ideas, (8) creates a feeling of succeeding and failing together, (9) helps me grow into the next generation, and (10) provides safety for trial and error [2]. After further evaluating these ten competencies, Giles found that the larger themes focused around leaders having the highest ethical and moral standards and communicating clear expectations [2]. To achieve these competencies, a leader would not only need to understand their role but focus on how they can be true to themselves, their peers, and subordinates.

> Leadership and learning are indispensable to each other. (John F. Kennedy)

A Healthcare Simulation Technology Specialist as a Leader

In addition to exploring the impact innovation and technology has on the simulation and education industries, it is even more imperative that future leaders understand the value or harm that these changes can produce. Simply put, a leader must remain current with technological advances. There are many ways an HSTS can achieve this goal.

Fostering relationships can have a significant impact on the goal of advancing simulation, technology, and achieving programmatic goals. Professional networking allows individuals to learn about new technology and can provide an avenue where access to new technology could improve how the desired outcome is achieved. Attending local and national conferences allows the HSTS to learn more about the industry, the future, and the technology that may impact their respective programs. However, conferences require financial support. The significant expense associated with attending these types of conferences may have a potential apparent negative return on investment. It is always imperative to balance the value added with the need to learn. As an alternative, there are always low-cost options that can help foster knowledge and skill growth. Low-cost ways to remain current and up-to-date with technology can be achieved by participating in webinars. Webinars offered through industry vendors or professional organizations are easily accessible and generally affordable or even offered for free.

Beyond remaining current with technological solutions, leadership as an HSTS can be expressed in many ways during the design, execution, and debriefing process of the simulation experience. Evidence-based design can be greatly influenced by the HSTS. Everything from suggesting the correct simulation modality, the proper location for learning, or method to enhance the realism for the simulation experience, to setting room assignments that allow for proper logistical flow and debriefing support can all be leadership actions demonstrated by the HSTS. Each of these actions positively impacts the learning and experience of the participants. These actions also help others understand the role the HSTS has within the profession.

Leadership Styles

There are many leadership styles promoted as a solution for achieving effective leadership practice. The reality is that there is no one right style for an HSTS or even for addressing specific situations. For those reasons, highlighting three popular leadership styles and evaluating their applicability for common situations in simulation may help clarify the context and the importance of choosing a leadership style that is effective and contextually appropriate.

Transformational Leadership (Selling)

Coordinating the need for change in the areas that the HSTS manages works well with the transformational leadership style. In this leadership style, the HSTS works with everyone, subordinates and peers, to identify areas needing change. A transformational leader creates a vision to guide the change through inspiration and by executing the change in tandem with committed members of a group [3]. Most notably, this particular leadership style encourages leaders to (1) be a role model, (2) clearly communicate expectations, (3) enable employees to question and explore, and (4) personalize engagement [3]. An HSTS can utilize this leadership style while engaging new partners for the educational program or promoting the profession.

Transformational leadership is helpful while formalizing strategic goals for any type of educational program. Strategic goal identification is often left to administrators to develop, yet without engaging the HSTS, the goals may fall short of meeting the program's needs. Transformation can only occur by acquiring input from all stakeholders of the educational program. HSTSs are encouraged to identify areas of growth for the program and outline the required equipment or steps needed to meet the expansion. Engaging and recruiting personnel that meet the program's needs for achieving these goals is always an essential step.

Transactional Leadership (Telling)

This type of leadership is best utilized for structured activities such as managerial oversight, coordination of assets, task-oriented activities, maintenance of equipment, and supervising performance [4]. As a transactional leader, self-evaluation and process improvement are key traits and drivers [4]. This style of leadership is considered a managerial style in which, for example, the HSTSs may promote compliance with policy and procedures or facilitate the completion of a managerial task. In this style, the leader may help others choose the right modality for delivering quality education, while guiding and ensuring all members of the team maintain focus and proper perspective. This style is often directive and does not readily support or allow creativity [5]. This leadership style allows for guiding actionable change to improving the outcomes of the educational program.

Situational Leadership (Adaptability)

Situational leadership is truly a culmination of several different types of leadership styles. The style utilized by this type of leader is dependent on the situation. Giltinane notes that "the core competencies of situational leaders are the ability to identify the performance, competence and commitment of others, and to be flexible" [6]. Situational leadership is about assessing the environment and having the emotional intelligence and political savvy to maneuver and navigate the healthcare hierarchical structure. This is not something easy to do the first day on the job. Becoming a situational leader is about taking pieces from different types of leadership styles and blending them together based on what challenges lie ahead. HSTSs may be forced into situations where they may be tasked with managing a clinical simulation experience gone wrong. As a leader, in that moment, it is imperative that not only do they speak up but carefully analyze the environment and determine if this requires telling or selling peers on how to move forward. Similar to transformational and transactional leadership, a situational leader must be able to see and understand how to manage all of the puzzle pieces while avoiding the trap of assigning blame.

> Teamwork makes the dream work, but a vision becomes a nightmare when the leader has a big dream and a bad team. (John C. Maxwell)

Program Operations

The success of establishing an educational program is dependent on the effectiveness of the leader, the team, and the environment. It is imperative that either the existing or new leader takes time to understand each of these components. By doing a little bit of homework, the leader will not only understand where the challenges exist but what the program's strengths and weaknesses are. It is recommended to start by managing and supporting the strengths, while the team works to repair the areas of greatest concern. One of the most significant and notable challenges the leader will face in their first year is pressure. Pressure to be successful. Pressure to understand where to focus and how to make the program successful. Pressure to develop a highly functional team that is independent and driven, and pressure to make the educational program demonstrate a positive return on investment.

Managing the day-to-day operations of a simulation program is not a clinically-oriented task. As noted earlier in this chapter, a leader can be anyone who is willing and capable of achieving the core leadership competencies. Remember, leaders do their homework and are always willing to admit they were wrong.

As a simulation leader, the groundwork to advancing a program involves completing a needs analysis of the existing program. By taking a hard look at the current conditions, determining the gaps, and outlining where the future state should be (the want), the leader has an opportunity to develop a plan to take the program from the current state to the future one. In addition to a needs analysis, an HSTS, an educational specialist, or even a program director may feel compelled to reach out to other programs. As a leader, researching best practices, outlining industry standards, and learning from others is key to ensuring the success of the program, and avoiding the folly of others. The education and simulation industries have well-established societies. It is always appropriate and most effective to follow a series of established standards and best practices than to develop something from the ground up. It is appropriate to seek assistance by calling these professional organizations and asking for a contact that could assist you. Remember, to be successful, a leader must know his or her own limits. It is always okay to say, "I do not know, let me check." It is perfectly acceptable to ask for help as you are developing a leadership style and developing a relationship with a new or an existing team. In the end, a leader is simply applying the knowledge learned for studying a situation and developing a plan to meet a real-world need.

Support of education or simulation-based operations has three core focus areas: (1) administration, (2) coordination, and (3) specialty support (Fig. 15.1). Each of these areas has its own time commitment and challenges, and each requires a strong leader to focus on areas where there is the greatest need. As a new leader, it is important to outline where to focus first. There is no single system that will help a leader determine how to best balance their time and resources. However, it is imperative that leaders learn how to prioritize, and it is strongly recommended that a leader attend courses that teach time management and prioritization techniques. Although each of the three core focuses may have some hurdles to navigate, once the leader has a system in place, the hurdles become a normal routine.

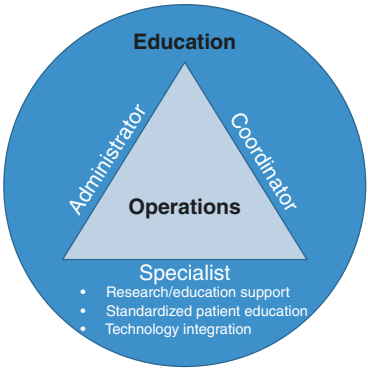


Fig. 15.1 The required areas to support simulation-based education

Administration

Many HSTSs are put in or grow into director positions where they are tasked with designing and supporting the administrative role of simulation operations. Program administration and oversight is no easy task. A leader hopes to leverage the knowledge and experience of the educational team to drive the program forward. A new leader should work to leverage existing experience and apply this background into the day-to-day operations of the program. However, relying only on one's own experience is limiting. The power of managing a program is driven by using the collective minds of experienced individuals with various backgrounds that may be in your parent organization or on your team. As a result, a leader should seek assistance in developing the program's mission, vision, values, and aspirational goals. Although it may seem like a simple task, it requires an understanding of the programmatic needs, completion of a needs analysis, development of a business plan, and understanding where the program will be in the next month, next year, or even 5 years into the future [7].

Mission, Vision, and Values

A mission statement tells us "who the company is and what the company does" [8]. Mission statements are powerful and extremely useful in helping the organization meet its purpose. It reminds individuals about why the program was established. Mission statements should never be developed by one individual. It should be developed in conjunction with the involved stakeholders and requires consideration and care to ensure the program can reach its full value [8]. Additionally, a mission statement "must be communicated frequently to employees and stakeholders in a way that meaningfully integrates the vision of organizational leaders to the actual daily activities of the employees" [8].

Like the mission statement, an organization's vision is equally important. The vision statement expresses all of the hopes and dreams for the future of the organization [8]. It highlights what the leadership wants to become, what they would like

to build, and what the future may look like for their organization. Vision statements are not a roadmap but simply an expression that helps the organization see where they would like to go. People often confuse the mission with the vision statement; they are not the same. They simply complement each other. To achieve your mission and vision, an organization must also have strong values.

The values are ideals or beliefs that are shared by the organization and driven by the culture of the organization. Values are important and help outline the expectations of its employees. If the organization determines that one of its values is to have a high ethical standard, and an employee fails to achieve that standard in the work they do in the simulation center, are they the right fit for the organization? Values tell us what is good and bad. Developing values requires input from not only your stakeholders, but also the employees who are tasked with the work.

One of the most important elements to ensure the organizing is looking at the road ahead is the aspirational goals. An aspiration is about looking into the future. As the aspirational goals are being considered and established for the organization, consider what the organization wants to be or would like to achieve. For programs in simulation, an aspiration goal could be to be a top-10 simulation program. As the program develops its infrastructure and works toward identifying how to achieve that aspiration goal, there becomes a clear desire and driving force to ensure the organization becomes a top-10 program. Aspirational goals truly help programs focus on the future and lay out a plan on how to achieve that goal.

> Leadership is the capacity to translate vision into reality. (Warren Bennis)

Stakeholders

The mission, vision, values, and aspiration goals cannot be developed without the coordinated efforts of a strong program leader, an education team, and a group of committed stakeholders. Stakeholders are an invaluable resource that will not only help sell the program to other departments, but offer valuable feedback on areas where the program can focus. A stakeholder can help manage politics, provide a new leader with an understanding of the organizational and political landscapes, or simply offer guidance and support as a member of the team is looking to grow into a leadership role. Stakeholders are individuals that demonstrate a passion to advance education, improve patient and provider safety, and foster the growth of innovation across the organization. Individuals that could become a stakeholder are those that could help the organization foster change. Individuals that are in key leadership roles are an important stakeholder to involve in an educational program. Additionally, those that may help sell or utilize the technology are important as they help foster buy-in. Lastly, a stakeholder could be members from Information Technology; Finance, Quality, and Patient Safety; Risk Management; or even the Marketing and Communication teams, who would be tasked with helping the educational program develop a business and communication plan. These individuals need to be involved at some level or ensure there are both short- and long-term successes.

Policies and Procedures

The development of a program's Policy and Procedure Manual requires knowledge of both the parent organization and any regulatory bodies that provide programmatic oversight. In cases where multiple agencies require oversight, it is important to understand what the needs of each regulatory body are and identify if the parent organization's policy is or is not sufficient. The development and management of a Policy and Procedure Manual is not an easy task. Any individual tasked with developing, approving, managing, and enforcing these policies must ensure there are both a stakeholder and legal review conducted. A simple human resource policy developed for the competency and performance evaluation could get both the parent and educational entities in legal trouble. It is always important to seek guidance as these documents are developed to ensure compliance with regulatory bodies and applicable law. When developing a simulation or education policy, seek guidance from a professional society. For example, the Society for Simulation in Healthcare has a Policy and Procedure Manual that may be an invaluable reference [9].

When developing a program policy or procedure, the first step is to understand the difference in the two terms. A policy is a "set of basic principles and associated guidelines, formulated and enforced by the governing body of an organization, to direct and limit its actions in pursuit of long-term goals" [10]. Whereas, a procedure is "a fixed, step-by-step sequence of activities or course of action (with definite start and end points) that must be followed in the same order to correctly perform a task" [11]. An organization can have a policy in place without having a set of procedures directly associated with the policy. However, an organization should not have a set of procedures without a clear policy. A policy is the enforcement statement, the end goal, while the procedure is the steps to successfully achieve the desired policy. The complex nature of developing a policy and/or procedure is even more challenging when written documents utilize words like shall, may, should, or even could. This leaves the policy to interpretation by the reader thus creating a potential loophole in the overall ability to enforce the policy itself.

Organizational policies and procedures should undergo a review, at a minimum, every 36 months. Some documents may require more frequent reviews, while others may be acceptable for the full 3 years. Nevertheless, leaders are obligated to establish a review cycle for their educational policies and ensure that the appropriate group of reviewers have an opportunity to provide feedback and recommend changes. Regardless of why a policy has been developed, consider having your legal team, human resources department, key stakeholders, and even your compliance office review any documents that may pertain to their areas. If parent organizations have an established process for policies and procedures, it is always recommended that a leader use the existing process.

One of the most crucial conversations a leader can have with their team is about performance. Leaders are obligated to know their organizational policies and ensure that they enforce the policy. Failure to enforce a policy or an established procedure

can create long-term challenges for both the individual and the department. Additionally, individuals may feel that the lack of enforcement is a window into how a leader may be "favoring" one employee over another. If the educational program has a clear policy, it is imperative that the policy be enforced unless the policy is not appropriate for the situation and needs to be changed. Policy enforcement is a crucial conversation that requires focus. Leaders are asked to sit with the individual, discuss their concerns, and develop a written plan to ensure there are no future violations. One of the most challenging conversations a new leader may have is with a physician providing education in the simulation center. In situations where the leader is not comfortable providing this feedback or having a crucial conversation, involve a medical director and/or human resources office for support. These individuals will be able to assist with coaching and use of terms and phrases. Some individuals may be willing to sit with you as you are having these important conversations. Although extremely difficult to do, performance and expectation feedback is an important skill to master in the workplace just as it is in simulation. Unfortunately, these crucial conversations may never be a skill that a leader will be comfortable with. There are always new and unique conversations which create their own inherent challenges.

Coordination

One of the hardest aspects of management is to efficiently and effectively balance time for personal tasks and evaluating the function and needs of the educational program. There is no magic trick to ensure that this balance will be successful. However, there are opportunities to use existing tools such as a Leader Standard Work tool or an online task management and calendaring tool that can help adjust schedules to ensure they allocate enough time to a particular task [12]. Ensuring that leaders have enough time to meet the needs of the parent organization, the department or program, and their own activities is no easy task.

As a leader becomes more involved in the day-to-day decision-making for the parent organization and begins to promote and integrate the educational program to outside departments and stakeholders, it may be more difficult to adequately manage time and complete tasks. Unfortunately, this often results in leaders feeling like they have abandoned their teams, while they focus on managing the day-to-day operations of the program and are making the direct connection with the needs of the parent organization. Coordinating the needs of the department with the leader's desire to be involved is possible. However, there will always be a point in time where the educational program will need to function without significant oversight by a leader. It is important for a leader to develop a process to help the team schedule classes, manage their educational programs, and connect in the event they need guidance or support. Although there is not one solution to ensure a program is coordinating well, there are always ways to leverage online project management tools and calendaring systems. It is up to the team and the leader to decide how the program should function on a daily basis.

Support

One of the key roles of an HSTS at all levels of leadership is to provide ongoing support to the educational programs being offered within the organization. It is equally imperative that a leader understand all of the various job roles that their team members may play and the tools needed to succeed. To do so requires a leader who has a level of experience and understanding about each role. There is no reason to master all of the job roles personally, but having an understanding of the role of an educator is just as important as understanding the role of the HSTS or even the program assistant. To ensure that a leader is able to interact with the members of the educational team and support their needs, the team must be comfortable with the knowledge and experience of their leader, and they must feel like they can be heard, and their leader understands, respects, and supports them.

Scenario Design

As HSTSs grow into the role of a leader, they must gain knowledge of educational theory and have a clear understanding of how a program is planned, developed, studied, and evaluated. In 2016, the International Nursing Association for Clinical Simulation and Learning (INACSL) released the updated Standards of Best Practice [for] Simulation. This document outlines the framework for developing an effective simulation-based experience. It is important for a simulation leader to understand what the key components are for a simulation-based experience. By understanding what the standards outline, the leader can then compare the standard against their program and make changes. The standards outlined in the INACSL framework are extremely valuable regardless of the type of program conducting a simulation-based experience. A leader's responsibility is to first see the value of the educational theories. Second, understand how valuable and impactful it is to preplan. Third, ensure that there are key objectives developed for any experience. Fourth, allow an educator and technology specialist the opportunity to setup the scenario. And lastly, at the conclusion of the scenario, obtain feedback from the participants to ensure that there is an opportunity for the program to make changes and the educators to make improvements. Participant and educator feedback is important. It is truly the only way a program is able to determine where there are opportunities for improvements and how this can be accomplished. These components not only allow a leader to ensure they have a high-quality program, but allow the team to have a common purpose and create an opportunity to build a stronger and more effective team.

It is the leader's responsibility to ensure that the work does not end with a completed simulation experience, but becomes an ongoing process of developing, testing, implementing, and evaluating each educational program offered. It is also a leader's responsibility to ensure that the team has access to meet with content experts prior to conducting the simulation experience. If possible, it is important for an HSTS, a simulation educator, and a content expert to meet. The HSTS can provide valuable information on the type of modality that should be used for the proposed

simulation experience, while the educator outlines the educational methods and delivery principles. The content expert must help both the educator and HSTS understand the content desired to be included in the simulation. The case writing meeting should follow a scenario design template as the framework to support those involved to deliver a consistent and valuable educational experience. If there are hurdles that need to be managed, it is the leader's responsibility to work with the team. Creativity is often driven by opportunity, and when the team has an opportunity to be creative, it is the leader's role to help nurture and grow that creativity.

> Nobody forces a company to become innovative. Converting the desire into action requires an intentional initiative, systematically planned and organized like any other important management activity. (Dr. Edwards Deming)

The Road Ahead

When pursing a leadership role, guidance and support from others in leadership is imperative. This often means that one must extend their comfort zone and give themselves over to increasing knowledge, skills, and abilities in leadership. Leadership is a learned skill that requires patience, the desire to succeed, and the willingness to lead others to success without claiming the accolade or gratification for oneself.

For those with a passion to become a leader in healthcare, education, or simulation, the first step is to understand what leadership is about. Future leaders invest in themselves, and they seek assistance from a mentor and ask for help from their current leadership. The experience gained simply by asking to be involved, taking on a new project, or even shadowing can be invaluable and help in developing a leadership style. In addition to real-world experience, taking advantage of opportunities to attend leadership courses can not only provide new leadership knowledge, but also help identify areas for growth by evaluating existing experiences and knowledge. Leadership programs help individuals evaluate if they have the knowledge, skills, and abilities in place to meet the demands of leadership.

The road ahead is full of opportunities. Individuals should not be discouraged about the challenges that they may face, and it is imperative that they look at each obstacle as an opportunity to learn more about themselves and leadership. Looking forward, the HSTS can learn to shape experience into opportunity. By developing leadership skills, the HSTS can shape local culture and influence the larger simulation-based education industry.

The Profession and the Culture

> The only constant is change. (Heraclitus)

As the simulation profession matures, the culture and roles will adjust to address the natural changes. People are naturally drawn to patterns of comfort, and adapting to change can be difficult even if the change appears positive. Leaders greatly

impact the way change effects the people involved. It is natural to be anxious about change as it evokes the unknown. Mild forms of anxiety can be helpful and adaptive; higher levels of anxiety can interfere with team cohesion and adherence to a policy and procedure and ultimately become maladaptive. As health systems and academic institutions of learning evolve and merge, the impact can be significant to the simulation profession by inducing change and uncertainty within the organization. This is important to understand while growing the simulation program and recruiting new stakeholders. A participant's state of mind can greatly impact how they interact within the simulation experiences. Opportunities for growing a simulation program extend beyond recruiting new users. Program growth is possible by evaluating the use of simulation modalities not currently used in the program. For example, a manikin focused program could expand into in situ standardized patient activities, or providing follow-up training and educational material to learners supporting a flipped classroom learning model.

As simulation is fully integrated within healthcare, regulatory oversight may drive more of the need for simulation programs and activities. Leadership skills and strategic planning will be required from the HSTS to expand and grow with a proper infrastructure that supports the initiative and ultimate success of a simulation program. Obtaining certifications such as the Certified Healthcare Simulation Operation Specialist (CHSOS) is a way to acknowledge a minimum standard within the profession. Individual certification and program accreditation are expected to be a part of the future of the profession. Taking steps toward adopting these standards prepares the program for the future and sets a validated culture.

Lifelong Learning

> There's no secret to success. It is the result of hard work, preparation and learning from failure. (Colin Powell)

Lifelong learning is a key quality of an effective leader, especially in a profession that is still maturing. Lifelong learning is a result of purposeful expansion and understanding. The learning can be through formal and informal pursuit of knowledge. In relation to leadership, lifelong learning is often believed to be driven by obtaining formal education. While this is one mechanism toward being a lifelong learner, it is only one approach. Learning from personal failures can be more important than obtaining formal education because it is a result of self-reflection. Self-reflection greatly impacts the influence of the leader by embracing personal process improvement. Demonstrating self-evaluation after a failure is an example of managerial effectiveness. Modifying practice to avoid future failure is an example of leadership excellence.

Formal education courses are easily accessible and often covered by employee tuition reimbursement benefits. Many healthcare entities offer coursework through human resources and are held on-site making them easier to attend. With hybrid and online formats available, both access and quality improve, especially for working professionals. Informal learning can be achieved through membership from

professional organizations, remaining current with industry evidence and best practice, and process improvement self-assessments. Seeking feedback from peers and mentors is another way to gain insight on areas that need improvement.

The HSTS will benefit from lifelong learning by professional advancement opportunities and by being viewed by peers and coworkers as a proactive leader. It is difficult to be considered a leader without being a lifelong learner. In part, leaders are revered as such by their colleagues. The leadership label is awarded to those who have followers or who are sought after for input and guidance. This following is built from relevant practice, current knowledge, and cutting-edge theory. Lifelong learning assists with maintaining competence in these areas.

Conclusion

Leadership is not about your background and although it is imperative that future simulation leaders have relevant experience in the fields of education and simulation, anyone can become a leader. It is important to remember that the driving force behind being a good leader is bringing your experience to the role, having trust and faith in your team, communicating, establishing, and maintaining a high level of ethical and moral standards, and being able to meet the competencies for the leadership role. Leadership is all about leading people in a positive path forward and driving the organization to become the best it can be. All of the other core responsibilities for the leader can be developed over time. A desire to review financial cost models or take a dive into policy writing is a nicety, but these skills are not a necessity and are not required to be immediately successful in the job. By leveraging the team and resources, you can do anything and be an amazing leader.

> Education is the mother of leadership. (Wendell Willkie)

References

1. Lasse C. What is competency? Association for Talent Development; 2015 [cited 2018 August 7]. Available from: https://www.td.org/insights/what-is-a-competency
2. Giles S. The most important leadership competencies, according to leaders around the world; 2016 August 7, 2018. Available from: https://hbr.org/2016/03/the-most-important-leadership-competencies-according-to-leaders-around-the-world
3. Direction S. Transformational leadership: the impact of its behaviors on manufacturing strategy. Strateg Dir. 2015;31(2):25–7.
4. Cope V, Murray M. Leadership styles in nursing. Nurs Stand. 2017;31(43):61.
5. St. Thomas University. What is transactional leadership? How structure leads to results; 2018 August 8. Available from: https://online.stu.edu/articles/education/what-is-transactional-leadership.aspx
6. Giltinane CL. Leadership styles and theories. Nurs Stand. 2013;27(41):35–9.

7. INACSL Standards Committee. INACSL standards of best practice: simulationSM operations. Clin Simul Nurs. 2017;13(12):681–7.
8. Walker JL. Mission statement creation and dissemination in service organizations: reaching all employees to provide unified organizational direction. Commun Theater Assoc Minnesota J. 2012;39(1):6.
9. Society for Simulation in Healthcare. Simulation Center Policy and Procedure Manual. [Online] http://www.ssih.org/Portals/48/Docs/Resource Library/SSH_Policy_Manual.pdf?ver=2014-03-11-162512-770; 2012.
10. Business Dictionary. [Online] http://www.businessdictionary.com/definition/policy.html. WebFinance, Inc policy.
11. Business Dictionary. [Online] http://www.businessdictionary.com/definition/procedure.html. WebFinance, Inc procedure.
12. Poksinska B, Swartling D, Drotz E. The daily work of Lean leaders–lessons from manufacturing and healthcare. Total Qual Manag Bus Excell. 2013;24(7–8):886–98.

Additional Recommended Resources

Wong BBM, Candolin U. Behavioral responses to changing environments. Behav Ecol. 2015;26(3):665–73. https://doi.org/10.1093/beheco/aru183.

Dongilli TA. Professional development for the next generation of simulation operations specialists. In: Gantt LT, Young HM, editors. Healthcare simulation: a guide for operations specialists. Hoboken: Wiley; 2016. https://doi.org/10.1002/9781118949443.ch14.

Gaba DM. The future vision of simulation in health care. BMJ Qual Saf. 2004;13:i2–i10.

Smith, E. Teaching critical reflection. Teach High Educ. 2011;16(2):211–223. Retrieved from https://doi.org/10.1080/13562517.2010.515022.

The Healthcare Simulation Technology Specialist and Research

16

Stormy M. Monks

This domain acknowledges that simulation is used not only to educate existing healthcare practitioners, but is also used to conduct research and improve the methods that are used to teach and evaluate learners. This process aims to improve the delivery of healthcare within more complex systems. Whether in a supporting role, or as a primary researcher, all individuals involved with simulation-based education must understand and develop the necessary knowledge, skills, and expertise in the area of research to advance the field. For the simulation technology specialist, it is imperative that a level of research proficiency be developed. Even the ability to review the quality of other research can enhance understanding and lead to better practice. (*SimGHOSTS*)

The Healthcare Simulation Technology Specialist as a Researcher

Like all careers, Healthcare Simulation Technology Specialists (HSTSs) are seeking a pathway to promotion and advancement. Much of what the HSTS does serves as a support to the other faculty and staff of the simulation center. However, the HSTS can and should be encouraged to engage in and take the lead in research activities. Demonstrating ability and prowess in this domain will be well received and can help the individual toward advancement, especially in an academic setting.

S. M. Monks (✉)
Department of Emergency Medicine, Texas Tech University Health Sciences Center El Paso, El Paso, TX, USA
e-mail: stormy.monks@ttuhsc.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_16

Writing Abstracts

Often times, the first step in becoming a published researcher is writing an abstract. An abstract is a summary of all the major areas of a research study. It is typically between 120 and 250 words [1–4]. When writing an abstract, it is important to make the most of the limited word count. Spark the reader's interest as soon as possible, keep the writing clear and concise, and explain the importance and significance of the research [3]. It is not necessary to use in-text citations; however, do have references on hand. An abstract can be structured or unstructured. A structured abstract is typically written in a five-point form meaning that these areas are each addressed and labeled: Introduction, Purpose, Method, Results, and Conclusion [1, 2]. These labels are sometimes different based on the organization calling for abstracts. See Fig. 16.1 for lists of the common features of each abstract area.

An abstract can be submitted to a conference meeting as a way of getting a poster presentation, a podium presentation, and potentially a published abstract. Once submitted, the abstract will go through a peer-review process that is discussed below.

Poster Presentation

Typically, an abstract will be accepted as a poster presentation; thus a poster will need to be created. Many researchers receive notification that their abstract has been accepted and then wait until the last minute to complete the poster. Keep in mind that the poster is not simply a regurgitation of the submitted abstract. On the contrary, the poster should expand upon each topic area and be made visually appealing by incorporating tables, graphs, and/or figures [1, 5–8]. The poster should also have any additional findings that have been discovered since the original submission. References are also a required portion of a poster.

There are many helpful hints to remember when creating a poster. First and foremost, follow the directions that have been provided by the organization. Ensure that the poster is sectioned by content headings and that it flows for the reader. Keep the title short yet intriguing, remember to put author and institution information, and select a font that is easy to read and large enough to read from at least 4 ft away. Use bullet points, tables, figures, and/or graphs to highlight the important content [1, 5–8]. Do not overwhelm the reader by simply placing paragraphs on the poster. Design, color, logo, and font guidelines may be available for those who are part of a larger institution and should be easily searchable using the term "Identity Guidelines" if present.

The poster can be created using PowerPoint or more sophisticated graphics programs such as Photoshop or InDesign or a specialty poster making software program. Photos and graphics will need to be high resolution to look good (150 dpi minimum, 300 dpi recommended) [1, 5–8]. The poster file size may be quite large and may be blocked by some email accounts, thus requiring thought and planning for file transfer to get it printed. Some print shops may require several days to provide a hard copy for display.

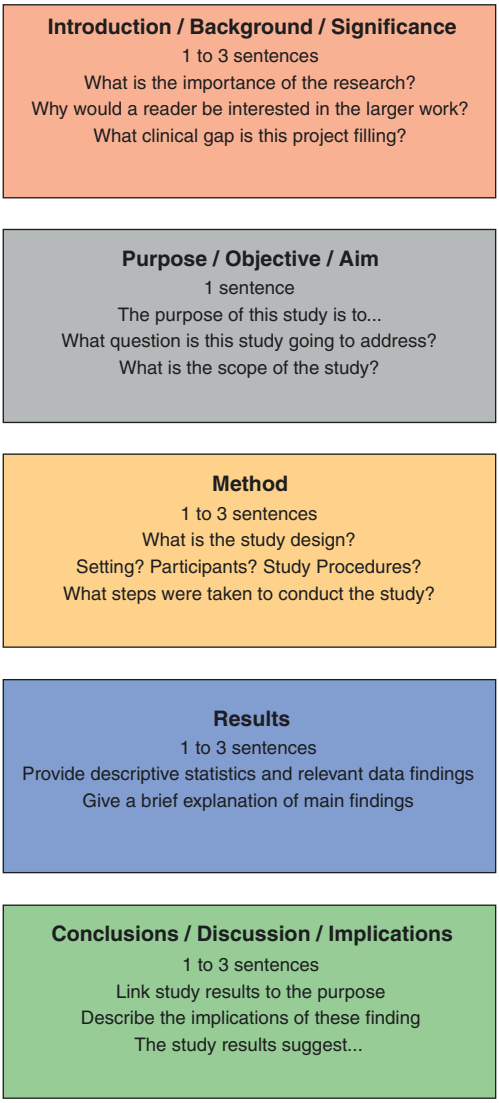


Fig. 16.1 Five-point abstract (1, 4, 5)

On the day of the poster presentation, arrive early and set up the poster in its designated location. Be present during the entire poster session to answer questions and provide a brief (3–5 minute) summary of the research [9]. Be prepared to function as a resource person for those interested in the research. Bring paper copies of the poster to share as well as business cards to provide to possible collaborators or mentors. If feasible, bring samples, models, manikins, etc., so the audience can get a better sense of the work [5–8]. Figure 16.2 is a picture of a typical poster presentation. Within the last few years, there has been movement toward electronic posters (e-posters) rather than printed posters. An e-poster essentially has the same areas of a traditional poster but may be viewed on a rotating basis during the conference.

Fig. 16.2 Poster presentation with model for demonstration

Submitting Ideas for Podium Presentation

Organizations that are accepting abstracts for poster presentation are typically also accepting abstracts for podium presentation. In addition to the information above regarding writing an abstract, there is additional information that will be required [1, 9]. This information includes but is not limited to the target audience (novice, intermittent, or expert level), learning objectives, presentation outline, mechanism(s) to engage the learner (lecture, hands-on activities, etc.), presentation timeline, and immediate and/or long-term evaluation of the presentation. Remember to follow the submission directions exactly, as incomplete submissions are not considered for presentation. If accepted for a podium presentation, the researcher will be required to submit the presentation prior to the conference as the presentation materials are often provided to the learners [9].

Submitting to a Journal

The ultimate goal of submitting an abstract is publishing a peer-reviewed manuscript [10, 11] (Fig. 16.3). A manuscript allows the researcher to gain academic credit for their work. To better understand the writing process that leads to a manuscript, refer to Chap. 8. Each journal has different instructions for manuscript submission [3]. Remember that following submission instructions is imperative as the review process will not take place unless it gets through the initial phase [10–12]. Specifically, make sure that the submission abides by the journal format such as the American Medical

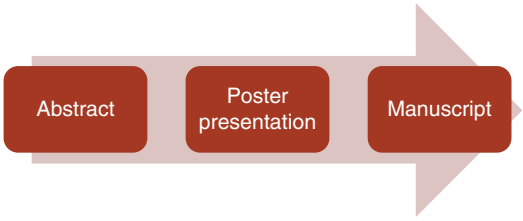


Fig. 16.3 Goal of abstract writing

Association (AMA) or the American Psychological Association (APA) [4, 13]. These formats not only include reference requirements but include style directions such as spacing, margin size, font, font size, heading styles, etc. [4, 13].

Literature Search

A literature search is the process of looking for literature that is pertinent to the research topic. The research process begins with a research idea and moves to a literature search and review (see Chap. 8) [2, 9]. The literature search will assist with gaining background information for a research proposal, help the researcher understand what has already been done, and assist with determining what needs to be done to enhance research on a particular topic [14, 15]. Other questions such as how does previous research apply to different study populations or different settings (simulation versus hospital) can also be answered by conducting a thorough literature search and review. Overall, a literature search and review should assist the researcher to align the research study with evidence-based medicine, theoretical frameworks, and/or proven models [9, 11, 14, 15].

Resources for the literature search process include local academic libraries as well as online resources. Electronic databases such as PubMed, Medline, Clinical Key, and Google Scholar are free and available to the general public [9]. There are other electronic databases that are only accessible through a subscription [11]. Check with your local library or academic institution to determine what is available. Search strategies are often as simple as entering keywords, manuscript titles, or authors' names. Moreover, researchers can refine the literature search process by creating questions using the mnemonic PICO (Fig. 16.4) [16–19]. For example, the researcher may want to find literature concerning the best type of training to decrease infection rates during central line placement. First, the researcher would define the learner population; is the training for medical students, residents, faculty, etc.? Is the outcome of interest patient outcomes or learner outcomes? Next, what is the training intervention of interest (general simulation or a training developed specifically for central line placement)? Is the study going to compare two types of simulation methods or will there be a control group? What outcome is being sought and how is success measured? [16–19] If these types of specific questions cannot be answered by the research plan, the data collected will be of little benefit to advancing the knowledge of the field.

Fig. 16.4 PICO components for a literature search

Matrix Method

The matrix method is a simple and efficient tool that is used to synthesize the literature used for a project [15, 20, 21]. This method is used by researchers to keep track of pertinent research sources for a specific topic or question. Rather than keeping stacks of highlighted journal articles that are revisited each time you write, or a computer folder that can also be cumbersome to go through, the matrix can serve as a quick guide to find relevant research quickly. It can also serve as a way to store your citations if you aren't confident in working with citation manager [15, 20, 21].

The matrix method is often formatted as an Excel spreadsheet or table [15, 20, 21]. It is imperative that time is spent creating the matrix on the front end to meet the needs of the research. Label the columns and rows clearly, and have a way to organize the order of the research (chronologically or alphabetically). While the researcher is reading the literature and other research resources, he/she should take notes based on the headings of the matrix (see Tables 16.1 and 16.2). As research on the topic expands, continue to add to the matrix [15, 20, 21].

Citing the Literature

It is imperative that all literature used as a reference is cited [2]. There are several different citation styles and formats. Be sure to use the style that is specified in the submission instructions [3]. Do not wait to do this once the document is written as it will be difficult to go back and link text with references. Citing should be a part of the writing process just like adding punctuation [4]. Below

Table 16.1 Potential headings for the matrix method

Authors
Year of publication
Title of article
Name of journal
Purpose/research question
Study design
Sample size
Inclusion/exclusion criteria
Results
Strengths
Limitations
References to review
Implication for future research
Implications for clinical practice
Inconsistencies with other research
Reference in style of choice

is a journal article reference that has been formatted for five different styles: MLA, APA, Chicago, Harvard, and Vancouver. Guides for each style and format can be found online, or a citation manager can be used. Citation managers such as EndNote, RefWorks, and Citavi are available with a subscription, so it is important to find the one used by the academic institution with which the research is affiliated. Mendeley, Docear, Referencer, and Zotero are free citation managers that can be used to assist with both in-text citations and reference formatting [15].

- *Modern Language Association (MLA)*
  - Monks, Stormy M., et al. "Sexual victimization in female and male college students: Examining the roles of alcohol use, alcohol expectancies, and sexual sensation seeking." Substance Use & Misuse 45.13 (2010): 2258–2280.
- *American Psychological Association (APA)*
  - Monks, S. M., Tomaka, J., Palacios, R., & Thompson, S. E. (2010). Sexual victimization in female and male college students: Examining the roles of alcohol use, alcohol expectancies, and sexual sensation seeking. Substance Use & Misuse, 45 (13), 2258–2280.
- *Chicago Manual of Style*
  - Monks, Stormy M., Joe Tomaka, Rebecca Palacios, and Sharon E. Thompson. "Sexual victimization in female and male college students: Examining the roles of alcohol use, alcohol expectancies, and sexual sensation seeking." Substance Use & Misuse 45, no. 13 (2010): 2258–2280.
- *Harvard Format*
  - Monks, S.M., Tomaka, J., Palacios, R. and Thompson, S.E., 2010. Sexual victimization in female and male college students: Examining the roles of alcohol use, alcohol expectancies, and sexual sensation seeking. Substance Use & Misuse, 45 (13), pp.2258–2280.

Table 16.2 Matrix method sample template

Author	Date	Sample size	Theoretical/ Conceptual Framework	Research Question	Hypothesis	Methods	Analysis	Results	Conclusions	Implications for Practice	Implications for future research

- *Vancouver Style*
  - Monks SM, Tomaka J, Palacios R, Thompson SE. Sexual victimization in female and male college students: Examining the roles of alcohol use, alcohol expectancies, and sexual sensation seeking. Substance Use & Misuse. 2010 Jul 1;45 (13):2258–80.

Accept or Reject

Once the researcher has submitted the abstract or manuscript, there is a review process completed by others in the field. The review process time frame varies depending on the type of submission, but researchers are notified of an acceptance, rejection, or, in the case of a manuscript, request for revision [9, 10]. Typically, the submission reviewers are given a rubric in which the submission is scored [3]. The selection criteria vary depending on the type of submission (abstract, podium presentation, manuscript, etc.); however, the questions below are commonly taken into consideration:

- Does the work fill a gap in research, expand the current literature, etc.?
- Is the research novel and/or innovative?
- Is the purpose of the research and research objectives clearly stated?
- Was the study design appropriate for the research purpose?
- Was a clear description of the research procedures given?
- Were the results clearly presented?
- Were the conclusions consistent with the study results?
- Does this research have clinical significance or implications for practice?
- Was the submission well-written, organized, free from grammatical errors, and submitted in the stated format? [1, 3, 9, 15].

Surprisingly, it is the simple things like following directions and basic editing and punctuation that can make the difference from a submission that is accepted to one that is rejected [9, 10].

Curriculum Vitae

Rather than a résumé, a curriculum vitae (CV) is kept by those in academic and research fields [1]. The CV is a formal way to keep track of one's accomplishments and opportunities in the field of research. There are several ways to format CVs; however, the list below provides common headings used [1, 22].

- Name, Degrees, Titles
- Contact Information
- Education
- Employment/Experience
- Peer-Reviewed Publications
- Peer-Reviewed Published Abstracts
- New Manuscripts in Preparation
- Book Chapters
- Other Publications
- Conference Presentations
- Other Abstracts/Presentations
- Awards
- Reviewer/Ad Hoc Reviewer
- Teaching/Mentoring Experience
- Grant Writing Experience
- Professional Organization Membership
- Honors/Activities
- Certifications
- Training
- Academic/Research Interests

As noted, the HSTS wears many hats while functioning across the eight domains. For the research domain, the HSTSs often provide support to the faculty and educators they work with. They may be tasked with collecting data, supporting the storage and evaluation of data, and assisting with the research documentation. However, the HSTS should also be provided the opportunity to move up the career and academic ladder by engaging in research as a main player.

References

1. Gastel B, Day RA. How to write and publish a scientific paper: ABC-CLIO; 2016.
2. Bem D. Writing the empirical journal article. In: Darley JM, Zanna MP, Roediger III HL, editors. The compleat academic: a practical guide for the beginning social scientist. 2nd ed. Washington, DC: American Psychological Association (APA); 2004.
3. Silvia PJ. Write it up: practical strategies for writing and publishing journal articles. Washington, DC: American Psychological Association; 2015.
4. American Psychological Association, editor. Publication manual of the American Psychological Association. 5th ed. Washington, DC: American Psychological Association; 2001.
5. Taggart HM, Arslanian C. Creating an effective poster presentation. Orthop Nurs. 2000;19(3):47–54.
6. Block SM. Do's and don't's of poster presentation. Biophys J. 1996;71(6):3527.
7. Gundogan B, Koshy K, Kurar L, Whitehurst K. Surgery. How to make an academic poster. Ann Med. 2016;11:69–71.
8. Erren TC, Bourne PE. Ten simple rules for a good poster presentation. PLoS Comput Biol. 2007;3(5):e102.

9. Cottrell RR, McKenzie JF. Health promotion and education research methods: using the five-chapter thesis/dissertation model. Sudbury: Jones & Bartlett Publishers; 2010.
10. Silvia PJ. How to write a lot: a practical guide to productive academic writing. Washington, DC: American Psychological Association; 2007.
11. Palaganas JC, Maxworthy JC, Epps CA, Mancini ME. Defining excellence in simulation programs. Philadelphia: Lippincott Williams & Wilkins; 2014.
12. AAMC. The AAMC Standardized Video Interview: Essentials for the ERAS® 2019 Season, May 11, 2018. Available from: https://aamc-orange.global.ssl.fastly.net/production/media/filer_public/1d/5b/1d5ba522-c182-4700-9147-d90a68db3952/sviessentials-eras2019-20180405.pdf
13. Iverson C, editor. AMA manual of style: a guide for authors and editors. 10th ed. New York: American Medical Association; 2007.
14. Hulley SB, Cummings SR, Browner WS, Grady DG, Newman TB. Designing clinical research. Philadelphia: Lippincott Williams & Wilkins; 2013.
15. Rocco TS, Hatcher TG. The handbook of scholarly writing and publishing. Hoboken: Wiley; 2011.
16. Miller SA, Forrest JL. Enhancing your practice through evidence-based decision making: PICO, learning how to ask good questions. J Evid Based Dent Pract. 2001;1(2):136–41.
17. Huang X, Lin J, Demner-Fushman D, editors. Evaluation of PICO as a knowledge representation for clinical questions. AMIA annual symposium proceedings; 2006: American Medical Informatics Association.
18. Hastings C, Fisher CA. Searching for proof: creating and using an actionable PICO question. Nurs Manag. 2014;45(8):9–12.
19. Schardt C, Adams MB, Owens T, Keitz S, Fontelo P. Utilization of the PICO framework to improve searching PubMed for clinical questions. BMC Med Inform Decis Mak. 2007;7(1):16.
20. Galvan J. Writing literature reviews: a guide for students of the behavior sciences. 3rd ed. Glendale: Pyrczak Publishing; 2006.
21. Garrad J. Health sciences literature review made easy: the matrix method. 4th ed. Boston: Jones & Bartlett Publishers; 2014.
22. Darley JM, Zanna MP, Roediger HL III, editors. The compleat academic. 2nd ed. Washington, DC: American Psychological Association; 2004.

The Healthcare Simulation Technology Specialist and Simulation

17

Lawrence M. Rascon

Simulation Equipment

Manikins

The most important part of healthcare is the patient; therefore, the most important unit of equipment for simulation-based education is the manikin. Specific tasks require specific adherence to realism to most effectively teach skills or allow opportunities for effective learning; therefore, the manikins and task trainers vary in fidelity and purpose.

Fidelity

Based on their purpose, manufacturer, and price, manikins are offered in various degrees of function and feedback to the learner. These features are still commonly referred to using the terms high-, medium-, and low-fidelity, but a growing discussion now supports moving away from these categorical terms and focusing more on the specific functions or feedback offered during training [1, 2]. This was introduced into the simulation literature as the "affordance" that each device offers [3]. The purchasing cost, as well as the cost in time, effort, and inevitably expenditure for regular and situational maintenance of the manikins, ranges with the complexity of the device. Keep in mind that the educational utility is not always directly correlated with the monetary expense but is related to the application of the tool to the simulation scenario design [4].

L. M. Rascon (✉)
Division of Simulation Education, Department of Emergency Medicine, Texas Tech University Health Science Center El Paso, El Paso, TX, USA
e-mail: lawrence.rascon@ttuhsc.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_17

High-Fidelity

As a technological achievement, high-fidelity manikins have an unbelievable range of realism that, for some manufacturers, bend the concepts of robot and machine into something fleshy, responsive, and altogether frighteningly lifelike. Among the very top tier of high-fidelity medical simulation manikin manufacturers is SynDaver Labs, which offers a highly detailed generation of the *SynDaver synthetic human* (SDSH) product line (see Fig. 17.1). The *SynDaver patient*, which features a programmable "open-source physiology engine that controls all aspects of synthetic biology, in addition to body motions," boasts a real-time response autonomic nervous system, animated and articulate limbs, and complete systems (cardiopulmonary, vascular, digestive, and proprietor-synthesized whole body skin tissue) [5]. This tool has been used for small and large surgery simulations, is compatible with x-rays and CT imaging, and is customizable for patient-based pathologies, with wireless control of mechanisms through customizable proprietary software. Additionally, all SDSH products come with replacement parts, a 1-year warranty, maintenance guides and scheduling charts, proprietor-created cleaning solutions, and a special storage apparatus [5]. Because of the method of manufacturing and material creation, these simulated humans require very meticulous care and maintenance. When stored, they must be submerged in a liquid bath, carry a distinctive if not pungent smell, and can cost more than most luxury cars. Other manufactures known for high-quality and robust full physiology human manikins include Laerdal Medical, Gaumard Scientific, CAE Healthcare, and Simulaids [6].

Medium-Fidelity

Medium-fidelity manikins are generally considered to feature less anatomical detail (i.e., subcutaneous fat, fully articulating joints) and may have fewer options for physiologic control but retain a handful of more narrowly focused functionalities specific to the model. These manikins are often paired with corresponding software to control the observable vital signs. The maintenance of these devices by

Fig. 17.1 An example of a SynDaver manikin submerged in the required water tank. The realism of this product, to many, is at the expense of convenience and upkeep

comparison is less intricate and, therefore, more manageable for many centers and have fewer complex systems to break. The cost for maintenance and upkeep is similarly lower. Storage of most full-sized human manikins is a separate issue due to the physical size of these devices. Other than storage space, most do not have any specific requirements other than some degree of climate control for heat.

Low-Fidelity

Low-fidelity manikins are often synonymous with task trainers and are usually low-complexity task-oriented devices that may or may not double as detailed models. Examples of these might be a cricothyrotomy trainer or a silicone arm for IV cannulation. HSTSs are also building their own tools for specific skills and educational needs. Some of these devices may still have many components or computer add-ons that enhance functionality and learner engagement but do not have the full physiologic representations to classify them as "high-fidelity." Simulab's *PacerMan*® might be considered a low-fidelity task training tool as it allows training of only a single medical skill and is only a manikin torso. However, it has an integrated computer and sensors for real-time feedback about procedural conditions and learner's actions, thus making it a "high-feedback" tool for this procedure.

Feedback

The takeaway about feedback in this context is to understand the information and cues provided by the equipment to the learner and discern why manufactures might classify their system in one manner or another. Consider the functionality of the tool, not just the brand label. Start with an evaluation of what skills for which learners need to train, and then select the appropriate equipment for those needs. Evaluate "What 'feedback' does this tool provide learners?" and design scenarios considering what "affordance" each tool can offer toward the necessary realism and educational value sought [3]. Affordance as defined in this context is a relationship between the properties of an object and the agent acting upon it [7]. Using an $85,000 high-fidelity manikin to teach IV insertion is not an effective use of resources.

Maintenance and Repair

Every manikin comes with an owner's manual that includes a schedule of maintenance and testing practices to ensure the function of the equipment. Depending on the frequency and intensity of use, however, it may be necessary to create a schedule that is specific to a program to offer the best longevity for its equipment. Tracking utilization will help identify which products are either at greatest risk for failure or determine which products need to be kept in tip-top shape for continued educational use based on demand.

Along with the manuals, manufacturers will include some necessary tools for maintenance. These tools are either specially designed for or specific to the

mechanisms within the manikin or task trainer. Using generic tools may work but may also damage parts, so be sure the manual does not call for specialty tools before engaging in maintenance. The most commonly used tools are as follows: cable ties, cable tie puller, small straight and curved needle-nose pliers, scissors/snippers of various sizes, screwdrivers (Allen, Slot, Phillips, and Torx), and heat guns.

Ensuring manikins are maintained properly and diligently is imperative as they can be expensive to replace and are more likely to need larger repairs if small defects or damaging use practices are not identified and corrected early.

Warranties

Manikins can be costly and, therefore, usually have limited-time warranties that can range from 1 to 5 years, depending on the manufacturer, model, and available sales options. Noncertified individuals should not perform extensive work on equipment while under warranty as it may void the warranty. After the initial warranty has expired, there remains an option to pay for additional time on a warranty. The decision to extend a warranty should depend on a few factors: frequency of use, intricacy of parts, expense of ad hoc repairs, cost of full replacement, and level of damage sustained over time relative to the price of any additional warranty. These are the same factors that should be consider before purchasing any equipment.

At this point, the simulation program should weigh the options in the form of dollars and cents as to whether the investment should be made to extend the warranty, provide in-house repairs, and/or replace the equipment. This decision will require a collaborative discussion between the HSTS and the administrative team. Regardless of the assurance of a warranty, the HSTS should aim to repair damages as they occur with the intention of a long-functioning utility. It is not uncommon for very low-complexity task trainers to last decades if properly maintained and even the highest-fidelity manikins to last 10 years or more at many centers with persistent function and utility.

Training and Operation

The device's owner manual should be consulted frequently to allow the HSTS to be consistent with the vendor's procedures and troubleshooting strategies. Manuals and documentation (electronic or paper) should be kept in organized areas for quick and easy access. With much of the included software, there is a "Help" tab that will connect to the electronic manual of the respective equipment. Many HSTSs have found ways to improve upon the existing function and utility of their simulation equipment (see Chaps. 19 and 20); however, do not assume that because someone has been doing something with a simulator that they have been doing it correctly. Similarly, upon purchase of a simulator, the vendor representative will usually provide training for the hardware features and software installation, as well as a

comprehensive training course. It is important to attend these sessions, take notes, and if possible, record specific sections for review in the event of staffing turnover or for use in training a new hire.

The equipment itself may change as a manufacturer releases new models or additional functions are programmed into existing equipment. This may be in the form of a software upgrade or a hardware add-on. It is essential to stay current with the changes made by the manufacturers, which will most likely be released through newsletters and/or email notifications. These upgrades or newly designed models may also have workshops, seminars, and/or representative-initiated orientations to learn about the new adjustments for hardware and software upgrades.

Not only does equipment change, but also the techniques and standards for simulation are perpetually improved and revised. Hopefully, most simulation spaces are either endorsed by and/or follow guidelines by one or all of the following: International Nursing Association for Clinical Simulation and Learning (INACSL), Society for Simulation in Healthcare (SSH), National Council of State Boards of Nursing (NCSBN), and the American College of Surgeons (ACS) [8, 9, 10, 11]. Each of these groups produces resources, current standards of practice, and practice improvement ideas, which are promoted through their websites, representative journals, webinars, or conferences. Even when the available equipment is up-to-date, the practices are constantly changing, being refined by analysis and praxis experts.

Manufacturer Differences and Similarities

There are various manufacturers to choose from when considering the purchase of manikins and simulation equipment; there is no one absolute choice. Each manufacturer has its own training demographics and their own material and equipment specialties. While certainly designed to make a profit, these companies are motivated by practical medical training, patient safety, repeat purchasing, and market perpetuation. Much of the deliberation for acquisition should be focused on the equipment's intended purposes, current and prospective clientele, and compatibility with the existing training activities within a simulation center. Although impressive to own, it would be a shame to spend $85,000 on a state-of-the-art high-fidelity manikin including proprietary software that would go under- or unused. One should consider whether the intended clientele can afford the fair contractual compensation to use the device during training, if the learners have the required knowledge and practice background to effectively utilize the features, and/or if the simulation center has properly trained and sufficient staffing to operate an educational scenario using the device. The goal is to be aware of the educational and training needs for a simulation curriculum. This must be balanced with the finances, knowledge, training and expertise of the HSTS, and the function of the equipment. While the purpose of this technology and educational theory is to prepare learners to save lives, the invaluable price of life is, in one indirect way or another, itemized in someone's ledger book. Medical

simulation expenses worldwide were estimated at $790.1 million in 2012 and were estimated to grow to $1930.5 million in 2017 [12]. For nursing education, the cost-utility of medium-fidelity vs. high-fidelity manikins is in favor of medium-fidelity manikins [4]. This does not mean that high-fidelity manikins should not be used; rather it suggests that careful consideration of the actual application and utility of features relative to the learners must be considered.

The distinctions between manufacturers' equipment vary in the features available and compatibility to external monitors and components. For example, one manufacturer may feature a manikin with ECG (electrocardiogram) lead posts already attached to the surface of the skin, whereas another maker may not have the attached-lead post feature and therefore necessitate/allow the learner to be prepped with those supplies needed to attach the leads. As far as functionality, there are standards issued by the aforementioned simulation organizations for how a simulation is conducted, but no such standard exists for the equipment itself. Some specific groups have worked with manufacturers to improve the quality and functionality of equipment to train necessary skills but are not yet held to a specific standard [13].

Scenario Development and Case Operations

Delivering Education Through Simulation

There are three primary parties for the design and delivery of any simulation case: the content expert/curriculum designer who has written or reviewed the simulation; the simulation center operations team (HSTS) that will be providing the equipment, logistics, and technical expertise to execute the curriculum; and the learners for which the simulation is being conducted. The simulation program may provide education to hospitals; medical schools; nursing and allied health schools; emergency response and law enforcement agencies, including regional or national government agencies (see Chap. 2); and any other institutions involved in professional healthcare services. These activities may be for the purpose of initial training and education, implementation of new techniques or protocols, planning for specific training required to meet standards, or even high-stakes testing to prove abilities or competence related to initial hiring and certification or to allow continued employment or practice [14, 15]. All simulation sessions should be taken seriously, but clearly in high-stakes simulation testing, the importance of a high-quality, professional, and realistic training activity is paramount. These education and training sessions may incorporate any member of the healthcare team and at any level of training. When planning and implementing an activity, every detail is important and shapes the experience for the participant. The type of simulator selected, the location that the training takes place, and the information provided to the participant about their expectations must be carefully considered and planned before beginning any simulation-based activity. All of this information should come back to and be

planned around the curriculum objectives that drive the need for the case to be designed. A simulation should never be run just to run a simulation but should have a specific educational objective with a targeted plan for how to meet that need and a plan to assess the effectiveness of the education provided [16].

Simulation Operations: Planning for Implementation

While a great deal of research has already occurred relative to how simulation should be designed and constructed, the methodology will be forever changing. Such changes will be based on the available technology, specific equipment, personnel, training, available space, and, as always, financial resources available. While several standards have been created, every simulation develops out of its own parameters of necessity and intention. There is no single conventional structure that one diligently abides by, but there are features that should be considered to help ensure consistent, effective, feasible, and sustainable training activities.

Roles

Content expert: The content expert will often be available and observe the simulation activity directly. This individual should review the planned case and its operation to ensure medical facts and expected technical skills are up-to-date and appropriate for the learners and scenario objectives.

Facilitator: The facilitator should ensure that the orientation and case-specific pre-brief have occurred. He or she will also provide any necessary guidance during the simulation activity to ensure active and appropriate engagement by all participants. The facilitator may be either the content expert or the healthcare simulation technology specialist.

Embedded participant (confederate): This is an individual who is a participant of the simulation scenario and part of the operations team. He or she may serve as a facilitator, a standardized patient, family member, distractor to the care team, or another member of the team to assist with the care of the patient. It is a good practice to inform the participants if someone else will be part of the simulation and how they should expect to interact with such individual(s). A system of name tags or labels is commonly used both for the scenario learners and any additional participants.

Healthcare simulation technology specialist (HSTS): The healthcare simulation technology specialist is the person who is responsible for making the scenario logistics come together. They will ensure that all equipment is set up and functioning properly and that the equipment technology was correctly selected to meet the educational needs for the scenario objectives. This individual must be familiar with the case and the expected learner actions. While not frequently the content expert, this individual may be involved in both facilitation and debriefing. This latter suggestion

is not yet mainstream, but one of the important tenets of debriefing theory is that every perspective has value, and while self-reflection is the goal, the ability to pose querying observation can help illuminate subtle actions or personality features that may have gone without review in the absence of this extra observation. However, most programs rely on the HSTS to set up the next scenario, while debriefing is taking place for learners.

The case designer: The case designer should be the content expert, but this person may or may not be present to see the results of the scenario they designed. Many cases are produced, trialed, and then shared across institutions or sold as part of a training package. A large-scale example of this are the cases produced for advanced cardiac life support (ACLS) training. The local content expert may be more of a facilitator or implementer, as the existing and available equipment is evaluated to meet the case's written expectations, but the case content is predetermined.

Debriefer: This individual helps to guide the learners through self-reflection about the events of the case and the actions taken by the team including their medical knowledge, technical skill, communication, and patient evaluation.

Considerations for Case Creation and Implementation Planning

Be sure the scenario addresses the "who?," "what?," "when?," "where?," "why?," and "how?" in the design of each case. The HSTS can help guide faculty to the appropriate facilities, equipment, and processes to maximize learning outcomes. Each case is a miniature live-action improvisational play, and the learners participate within the construct presented. Being able to think about what each person will experience and plan to do will help them to engage without the need to pause or redirect the scenario. This is best performed by writing such content into a script with the following sections considered [17]:

- Objectives
- Personnel and equipment
- Computer setup and operator instructions (opening parameters)
- Supporting materials (labs, x-rays, medical chart)
- Context
- Knowledge and teaching information
- References
- Notes

What is the situation and backstory?

- Part of creating a realistic and full experience for everyone involved is having a reason as to why the simulation is taking place. By creating a backstory, the learners will have an affective reason as to why they are willing to suspend their

disbelief and engage fully in the experience. In this way, they will be better able to transfer simulated learning to practical application. It will also help the HSTS and embedded participants understand the context in which they are working.

What is the expected clinical progress of the simulation and what are the cues to place the learners in the proper setting for the simulation?

- Simulation spaces can be designed to look like a primary care clinic, an emergency department shock/trauma bay, the back of an ambulance, a computerized tomography (CT) scanner, an intensive care unit room (ICU), an operating room, or any other space imaginable through innovative room design, props, and even wallpaper-style imagery. One of the most powerful uses of space design and consideration is the concept of in situ simulation, where the simulation equipment and learning are brought directly to the learner in the actual setting when a scenario might occur. This removes any requirement for suspension of disbelief related to the environment.
  - In situ example: Trauma is almost never centralized to one location. The location where the injury has occurred is often in the prehospital environment; this may include extrication from a vehicle, stabilizing care on scene, and interventions provided during transportation on a helicopter or ambulance. Once the care team arrives at the hospital or treating facility, a care exchange will occur, and critical information needs to be efficiently exchanged, while the next level of care is performed.
- While in situ may seem like the best method to conduct simulation, it is necessary to ensure that actual patient care practices are not interrupted. Not all healthcare facilities have the space to set aside for this type of training, and the ability to separate learners from the work environment can actually help to improve training engagement.
- In addition to the physical environment, the available equipment, props, manikin presentation, moulage, and even the appearance of medications may play a significant role in the ability to get transference from the experience to clinical practice. If the tools are different from those used in the care environment, muscle memory or subtle visual cues may be lost. In some cases, the appearance of the vial or box that a medication comes in may be the link to allow care to be delivered. In circumstances where medication administration is a primary activity of a scenario objective, the realistic appearance of such vials can be critical. It has been proposed that medications can be simulated through one of four methods: water-filled syringes, use of real expired medications, commercially purchased simulated medications, and in-house production of simulated medications [18]. The reported economic benefit in an article from UCLA for creating simulated medications and labels in-house is significant. The online tool Simulated Online Pharmaceutical Image Editor (SOPHIE) [https://www.sim.ucla.edu/sophie] was created to allow sharing of medication label designs including the critical warnings on the labels "Simulated" and "Warning: Not for human consumption or medical use."

What is the time frame?

- How fast is this scenario happening? This is the temporal portion of the scenario's backstory, which can include the elapsed time between the presentation or scenario start and the actual or accelerated response to treatment. Each situation will be different, and the time scale should be addressed at the design stage of the simulation and explained to the simulation team. Some scenarios that portray an evolving clinical situation can be designed to have a pause where learners physically exit the room. This can emphasize a longer time progression with the appearance of two separate scenarios, rather than trying to incorporate a false timeline into the scenario just for the benefit of efficiency. The flow of the case can also be adjusted by controlling when labs or clinical data is revealed.

What exactly is going to happen? Follow the script

- There will be a script to follow. This script is for the benefit of the simulation team to keep themselves on task and remain coordinated during the scenario, ensuring consistency of the activity each time the scenario is run. A well-designed script will include not just the backstory and expected actions of the learners, but it will also address situations that are not beneficial to the case, potential missteps in care, and the expected progression that should occur under these circumstances. This can include planned cues to keep the learners on track if they have not recognized a critical component of the case.
  - For example, five minutes into the case, if the care team has not initiated a blood transfusion to treat hemorrhagic shock, the embedded participant in the room will ask "Why is the patient so tachycardic?" If by 10 min there has been no therapy, the blood pressure will decline to 70/40. If by 15 min, treatment has not begun, the embedded participant will palpate for and announce they do not feel a pulse.
- Not all actions can be planned or scripted. Sometimes a learner-initiated care intervention is so novel, or so wrong, that it was never considered in the design. Depending on the level of the learner and scenario objectives, it may be important to allow these actions to play out or stop them immediately. This is why it is necessary to have the educator or content expert observing the activity to direct a natural or realistic response to these unanticipated events.
- An area of similar and constant debate centers around the physiological control of the simulator. This debate relates to the planned "programming" vs. free-form or "on-the-fly" control of vital signs. Each major manikin manufacturer allows control of vital signs using a computer or control pad interface. Every numeric parameter and electrical cardiac rhythm can be set using this interface. If an HSTS is knowledgeable about medical interventions, the scenario objectives, and progression, then on-the-fly control allows more realistic and natural control of parameters based exactly on interventions performed, but if not performed correctly, it can lead to major errors in realism. For example, if a patient who is

supposed to be comatose and unresponsive begins blinking because a software checkbox was forgotten, leaners may doubt the other stimuli they receive. Pre-programmed control removes these errors yet can prevent or limit following learners down uncharted care pathways. There will likely never be a single answer to this debate, but it is important to understand the complexity of parameters and importance of subtle cues that learners may fixate on in identifying how to provide care and when to alter treatment. In truth, the best system is likely a hybrid of these extremes where a known or expected progression is planned and programmed in advance, while adjustments can be made if significant management differences occur. One of the most innovative techniques for manikin programming is referred to as "The Hub" [19]. This tool was first demonstrated on the Laerdal system and allows each physiological parameter adjustment to be additively applied to the manikin's physiologic response. This helps to prevent sudden jumps if moving from programmed to "on-the-fly" and back. Moving into and out of a programmed "frame," with many physiologic parameters, where only one change may have occurred, can cause problems if the new frame includes multiple new parameters.

Identification of Critical Actions and Performance Measures

Always keep in mind the ultimate objectives of the scenario set by the educator. It is impossible to know exactly how a simulation will play out or how the learners will respond to any given stimuli. The HSTS must act in conjunction with the educator/facilitator, to keep the scenario and learners directed toward the case objectives and maximize the understanding and learning available to them. Depending on the level of the learner, it may be required to stop the simulation in the middle of a case to redirect the learners if there is a critical mistake or deviation from the script, but the goal should be to keep the distractions and stops to a minimum to maintain the realism and engagement.

Simulation Design Components

Along with considerations for the physical design, components, and implementation of the simulation scenario, there are fundamental necessities that should be understood about the simulations' purpose and educational design (see Chap. 12). Collectively these describe the standard for simulation design. This list is adapted from the INACSL Standards of Best Practice: Simulation Design Standard [16].

- *Criterion 1*: Assessment of Need
  - Even though simulations can be quite a bit of fun, there should always be a purpose behind why the simulation is being conducted. The purpose, derived from a needs assessment or curriculum objective, will provide the foundation for the design of the simulation and should guide all components and techniques selected.

- *Criterion 2*: Measurable Objectives
  - There should be relevant, temporally appropriate, and measurable objectives incorporated into any simulation case. This will identify if the educational need was achieved and guide improvements or changes to the scenario.
- *Criterion 3*: Format of Simulation
  - Once the educational objectives are known, the operations team, including the HSTS, administration, and coordination roles, can structure the simulation in the most appropriate manner to facilitate the best and most efficient learning plan based on available resources to meet the identified need.
- *Criterion 4*: Fidelity
  - Utilizing various equipment features can lend added realism to the exercise. Appropriate tool selection depends on use and utility described as "affordance" of "feedback" from the equipment. Not everything can or should be high-fidelity. Choose conscientiously.
- *Criterion 5:* Facilitator/Facilitative Approach
  - The HSTS has the expertise about the simulation tools available and the function of the room and equipment. The role of facilitation may or may not fall on this individual depending on specific expertise, staffing, and scenario design. This role will be actively engaged in directing the simulation and ensuring all participants are involved as expected based on the case design. This role is a careful balance of situational awareness and knowledge of participant expectation and learner observation. Equipment utilization and simulation-specific knowledge may be more important than medical knowledge in this role.
- *Criterion 6*: Briefing [Pre-briefing]
  - Briefing, or orientation, is presented at the beginning of the exercise before any hands-on action has taken place. The scenario is described to the learners, as well as instructions required to meet the planned learning objectives. The learners should be given an orientation to equipment and supplies that they will be using, where they are located, how engaged they are expected to be with the scenario including procedures, interaction with embedded participants, and spaces outside of the simulation room.
- *Criterion 7*: Feedback and/or Debriefing
  - At the end of the simulation, the learners will be asked questions and/or evaluated on their experience during the activity. Feedback and debriefing are two tools used for this purpose. Feedback is a direct objective report of performance meant to transmit specific knowledge such as the dose of a medication. The larger piece of the learning experience is derived from debriefing which is a structured but open-ended self-reflective activity where the educator or facilitator will guide the learners through an evaluation of their performance in order to highlight knowledge gaps or a greater understanding of the scenario. Items such as a learner's reactions to the content, engagement level, understanding of the objectives and stimuli, communication effectiveness, use of protocols and methodology, and ability to creatively problem-solve within the internal framework of the simulation are targets of this latter activity.

- *Criterion 8*: Evaluations
  - The simulation center and the operations team must conduct its own evaluation to understand how the learners felt about the simulation, as well as identify what was effective or what could be improved in the design and implementation of each scenario. These improvements should again be directed back to the learning objectives of the case, or decide if a different objective may be needed.
- *Criterion 9*: Participant Preparation
  - During the planning stage, the educator and HSTS should consider the level of individual and collective engagement the simulation will be provoking from the learners and adjust the level of stimuli to meet the desired levels. Similarly, the estimate of the quantity of learners that will be participating is a major consideration for the layout and design of the simulation.
- *Criterion 10*: Rehearsals of the Simulation Operation
  - Upon completion of the design of the simulation, rehearsals, or "piloting," should be conducted. Once as a passive activity with the intent to add or subtract features of the design; and a second time to refine any staging or programming with the learners' participation and desired engagement in mind.

    A final review should occur after the session has been completed and does not involve the learners directly. This should include a review of the actions of all members from the simulation operations team as well as logistics, scheduling, and resource availability. Additionally, the actual functioning of the room, equipment, simulation tools, audio/video equipment, scenario implementation, specific case resources, and future planning for any unanticipated learner events that were encountered should also be discussed.

Pre-simulation Planning: Involvement of the Simulation Operations Team

Upon the initial meeting between the educator and the simulation operations team, the educator will explain the scenario and its objective(s) so that the simulation operations team can then offer and describe the most appropriate equipment, and describe the logistics, including costs and availability, in order to conduct the planned activity. If there are objectives that were not originally written into the case design, the educator will have an opportunity to adjust the simulation at this time. If there are limitations to the available equipment, then the educator will be able to augment the simulation to fit the capabilities of the simulation center. Either way, this is the compatibility stage, where all the kinks are worked out between the goals of the educator and the capabilities of the simulation center.

Example

- *Educator*: "We're looking to run a simulation about new emergency response protocols for some of the doctors and residents at our facility. We have one scenario with three objectives: (1) Provide culturally appropriate care to patients of

all ethnicities and backgrounds; (2) Utilize appropriate physiologic parameters when evaluating patients from a broad age range from infant to elderly; and (3) Attend to trauma patients with pre-existing medical conditions – with patient-centered care being the paramount focal point."

- "So, HSTS, can your lab help us run this training?"
- *HSTS*: "We can definitely help you run this sim. We can offer you our high-fidelity manikins for the emergency medical conditions and can apply moulage to show realistic trauma and injury findings of burns or gunshot wounds on a range of mid-fidelity manikins. Actually, we also have a feature where we can alter the voice of an operator to both genders and allow the operator to talk through the speakers of the manikins. That would really benefit your sim. Would you like for us to add that to your scenario design?"
- *Educator*: "You have programs for that? Yes, I think that would work really well for our cases. It might even make a nice surprise element for the learners involved. We will make an amendment for that feature."
- *HSTS*: "Where are you planning to run the simulation?"
- *Educator*: "We want to show the learners' new procedures for the field setting and how to load patients onto the ambulance, as well as within the hospital after the patients have been transported. We can conduct the activity at the hospital, and we can park an ambulance outside to simulate in situ field responses situations."
- *HSTS*: "Perfect! We can start prepping today."

Records and Data

In order to track simulation center utilization and demonstrate/document the need for space, equipment, and personnel, having a system in place to record and track use is imperative.

In addition to a calendar scheduling system or inventor tracking system, it is important to identify the number of times each piece of equipment is used, how many learners were impacted, and the number of hours of exposure to simulation that was encountered.

This calculation is often termed a contact hour. A contact hour is best defined as the number of hours that a simulation was run multiplied by the number of learners impacted. This number can be used to quickly document and compare relative quantities of activity between centers. While the calculation is straightforward, deciding what constitutes a simulation activity may not be as straightforward. Should time spent preparing for the activity by reading or lecture in advance be counted? Or is time spent observing in addition to active participation and debriefing all used for these calculations? These decisions remain institution specific, but each program should plan to consistently document the data that supports and demonstrates the type of education they provide.

References

1. Stump R, Crawford S, Monks S. "High-feedback" simulation for enhanced cognitive stimuli and learner immersion. San Diego: International Meeting for Simulation in Healthcare; 2016.
2. Hamstra SJ, Brydges R, Hatala R, Zendejas B, Cook DA. Reconsidering fidelity in simulation-based training. Acad Med. 2014;89(3):387–92.
3. Schoenherr JR, Hamstra SJ. Beyond fidelity: deconstructing the seductive simplicity of fidelity in simulator-based education in the health care professions. Simul Healthc. 2017;12(2):117–23.
4. Levett-Jones T, Lapkin S, Hoffman K, Arthur C, Roche J. Examining the impact of high and medium fidelity simulation experiences on nursing students' knowledge acquisition. Nurse Educ Pract. 2011;11(6):380–3.
5. SynDaver Labs. SynDaver patient. [Online] http://syndaver.com/shop/syndaver/synthetic-humans/syndaver-patient/; SynDaver. Available from: http://syndaver.com/shop/syndaver/synthetic-humans/syndaver-patient/
6. Cooper J, Taqueti V. A brief history of the development of mannequin simulators for clinical education and training. BMJ Qual Saf. 2004;13(suppl 1):i11–i8.
7. Norman D. The design of everyday things: revised and expanded edition: constellation; 2013.
8. International Nursing Association for Clinical Simulation and Learning. Standards of best practice: SimulationSM. [Online] https://www.inacsl.org/inacsl-standards-of-best-practice-simulation/; INACSL. Available from: https://www.inacsl.org/inacsl-standards-of-best-practice-simulation/.
9. Society for Simulation in Healthcare. SSH Accreditation of Healthcare Simulation Programs [Online]. http://www.ssih.org/accreditation; SSH. Available from: http://www.ssih.org/accreditation
10. Alexander M, Durham CF, Hooper JI, Jeffries PR, Goldman N, Kesten KS, et al. NCSBN simulation guidelines for prelicensure nursing programs. J Nurs Regul. 2015;6(3):39–42.
11. American College of Surgeons Accredited Education Institutes. Accredited education institutes [Online]. https://www.facs.org/education/accreditation/aei; American College of Surgeons. Available from: https://www.facs.org/education/accreditation/aei
12. Tiwari P. Global medical simulation products & services market growth forecasts to 2017 in a new research report at RnRMarketResearch.com; 2016 July 24, 2018. Available from: http://www.prweb.com/releases/medical-simulation-market/healthcare-products-tech/prweb10839359.htm
13. Argani CH, Eichelberger M, Deering S, Satin AJ. The case for simulation as part of a comprehensive patient safety program. Am J Obstet Gynecol. 2012;206(6):451–5.
14. Rutherford-Hemming T, Lioce L, Jeffries PR, Sittner B. After the national council of state boards of nursing simulation study—recommendations and next steps. Clin Simul Nurs. 2016;12(1):2–7.
15. Dawson SL, Kaufman JA. The imperative for medical simulation. Proc IEEE. 1998;86(3):479–83.
16. INACSL Standards Committee. INACSL standards of best practice: SimulationSM simulation design. Clin Simul Nurs. 2016;12(Supplement):s5–12.
17. Seropian MA. General concepts in full scale simulation: getting started. Anesth Analg. 2003;97(6):1695–705.
18. Soto C, Stiner J, Noji DO, Rusheen JM, Huang YM. Creating a simulated pharmacy. Simul Healthc. 2016;11(3):218–22.
19. Kozmenko V, Wallenburg B. The hub – the concept explanation and development instructions; 2015. Available from: http://www.usd.edu/~/media/files/medicine/parry-center/hub-tutorial.ashx?la=en

The Healthcare Simulation Technology Specialist and Standardized Patients

18

Karen L. Lewis

A standardized patient is defined as "A person who has been carefully coached to simulate an actual patient so accurately that the simulation cannot be detected by a skilled clinician" [1].

Introduction

SP-based work has increased significantly over the last three decades. The United States and Canadian SP-based licensing exams that certify physician competencies have been major drivers for this rise in North America [2, 3]. Ninety-six percent of US medical schools now report integrating SPs into their curricula for teaching and assessment [4]. Concurrent with the rise in SP-based simulation has been the development of the educators who train them. In 2001, the Association of Standardized Patient Educators (ASPE) was created to support this new profession. ASPE's mission is to promote best education, assessment, and research practices in the application of SP methodology; disseminate SP methodology research and scholarship; and advance the knowledge and skills of its members [5]. Its membership is comprised of educators from allopathic medicine, allied health, dentistry, nursing, osteopathy, pharmacology, veterinary medicine, and others. Currently, healthcare simulation technology specialists (HSTSs) interact with SPs in varying degrees depending on their individual contexts. With the development of hybrid scenarios, wearable simulators designed for SPs, and technology designed to give SPs physical findings, the collaboration between these professionals is bound to increase in the coming years. To aid in that work, it is important for HSTSs to be familiar with

K. L. Lewis (✉)
The George Washington University School of Medicine and Health Sciences, Clinical Learning and Simulation Skills (CLASS) Center, Washington, DC, USA
e-mail: kllewis@gwu.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_18

Box 18.1 Definitions of Terms Used to Describe Standardized Patient Scenarios [1]

- *Formative*: Term to describe an activity meant to provide information or instruction with minimal consequence to grading or performance. Often used to describe activity meant for teaching and feedback.
- *Summative*: Term to describe high-stakes educational decisions, such as testing. Common with objective structured clinical examinations (OSCEs) used for clinical licensing.

the role and function of SPs, guidelines for recruiting and training them, the challenges of giving voice to the manikin, and the ways the simulation setting and scene offer opportunities for collaboration.

The meaning of SP has broadened over the last two decades. It can stand for standardized patient, simulated patient, or simulated participant. All of the terms have distinct nuances. The ASPE Standards of Best Practice (SOBP) explain that the terms standardized and simulated patient (SP) are "often used interchangeably and refer to a person trained to portray a patient in realistic and repeatable ways" [6]. The consistency and accuracy, or standardization, of an SP role portrayal depends upon the context in which the SP is working. In formative simulation activities, SPs may play roles that allow them to respond to the learner with flexibility and authenticity depending on the needs of the learners. In this context, the patient behavior is that of a simulated patient. In a summative assessment, individual SPs as well as SPs portraying the same role are trained to behave in a repeatable manner to ensure consistency and fairness to all learners. In this context, they are standardized patients [6, 7]. In the last decade, the roles that SPs may play have grown in scope to include clients, family members, and healthcare professionals, and there is evidence that SP methodology can be applied successfully when working with any individuals portraying humans in simulations [6, 8, 9]. As a result, the term simulated participant is beginning to gain recognition as a more inclusive term. References to SPs in this chapter include all nuances of the term. The person training the SP is referred to as an educator. This trainer may be someone who exclusively works with SPs, or the trainer may be a faculty or staff member who trains SPs in addition to performing other clinical or administrative roles.

The Role and Function of SPs

With training, SPs are well suited for inclusion in a wide range of simulation scenarios that address the learning needs of healthcare professionals at all stages of their training. Nestel, Morrison, and Pritchard point out that "SPs are employed to represent patients with multiple characteristics—across the life span and with different personalities, cultures, life and work experiences, sensory abilities, and personal needs" [10]. SPs are ideal for scenarios that focus on communication exchange such as history taking, developing management plans, sharing bad news, teaching patients about self-care, teamwork, error disclosure, conflict resolution, and ethical dilemmas. Clinical reasoning, physical examination, procedural, and operative

skills are also within the scope of SP work. Additionally, SPs can serve as teachers when trained to give feedback to learners on communication, physical examination, or procedural skills [10].

The advantages of including SPs in health professions training are many [4, 10, 11]. First and foremost is that with proper training, their patient presentations are highly authentic. Additionally:

- SP portrayals are not limited by place. They can participate in simulations wherever healthcare professionals in training work and learn.
- SPs can simulate a broad range of clinical presentations and a variety of characters.
- SPs can lend authenticity to manikin-based simulations by portraying family members, bystanders, or the voice of the patient.
- Faculty can create exactly the kind of SP scenario they need to accomplish their teaching objectives.
- SPs can provide feedback to learners from a patient perspective which is a unique feature of SP-based work.
- SPs can portray the same patient at various points in time to provide learners with continuity of practice experiences.
- Including SP scenarios in healthcare professions training reduces the risk to real patients from repeated exposure from novice learners and protects learners from the anxiety created when practicing skills on real patients.
- SPs can be trained to reproduce the simulation for multiple learners.
- SPs can provide evaluation data on learner competencies.
- Standardized SP encounters reduce the possibility of bias and allow for equitable treatment of learners.
- Including SPs in teaching physical examination and procedural skills training can provide cost savings by freeing up faculty time.

Limitations of SPs include [4, 10]:

- SPs must be trained by someone with expertise in recruiting, training, and developing SP case materials.
- Because they are usually healthy individuals, there are physical conditions and symptoms SPs cannot simulate without the assistance of simulation devices (e.g., stethoscope that provides programmed heart and lung sounds).
- SP participation in simulations involving procedures and operative skills is limited without the use of task trainers, body suits, or moulage.
- SPs are not appropriate for simulations in which the patient is not conscious.

Recruiting SPs

People who portray SPs come from many vocations and backgrounds. In general, SPs can be recruited from the acting community, lay people, and healthcare professionals. Common avenues for finding SPs are in Box 18.2 [12, 13]. The role's

Box 18.2 Common Avenues for Finding SPs

- Academic and healthcare institutions that already use SPs
- Acting agencies
- Acting internet sites that post job listings
- Service user, charity, and community groups
- Local theaters and amateur dramatic groups
- Internet searches for freelance simulated patients
- Drama departments in universities and colleges
- Retirement communities and organizations
- Alumni groups in colleges and universities
- Homeschool network (for children SPs in the United States)

complexity and the expected SP behaviors factor into which group to approach. For highly emotional roles, activities that require the SP to slip in and out of role or change their behavior at the direction of a facilitator, educators may prefer to recruit actors, if available [14]. However, there are SPs without formal acting training who are just as capable of performing these tasks. When SPs are trained to understand and feel what it is like to be the patient with the patient's feelings and problems, they can deliver a very believable performance [11]. If actors are chosen, they will still need SP training. While both an actor and an SP portray a character, the SP's performance relates to the purpose of teaching. The SP embodies a patient to serve as the patient's proxy for healthcare professions training. The needs of the learner guide the performance [6]. If the role requires medical knowledge, the educator may prefer to recruit from the healthcare community. Again, lay people can convincingly play the role when trained appropriately, but the educator will have to provide them a considerable amount of medical information to be successful. The role demographics also factor into recruitment. What is the age, gender, ethnicity, and weight of the patient? Miscasting an SP can undermine the credibility of the scenario and the learning objective of the simulation activity.

There are several core competencies to consider when recruiting SPs [12, 13, 15]. At a minimum, all SPs should be conscientious and punctual and demonstrate a professional demeanor consistent with a member of a healthcare education team. They should be able to accurately recall script details and deliver the information according to case instructions and training. SPs should be willing to accept the educator's feedback on their performance and incorporate it into their portrayals. They should be active listeners who are able to adapt to different learner interview styles. If feedback is a requirement of the scenario, they should have excellent communication skills, be good observers of learner behavior, have awareness of their biases, and be able to reflect on the encounter with the learner. They will also need training to understand the institution's protocols for the content and delivery of any constructive feedback provided to the learner. If they are going to participate in assessments, they must be able to remain consistent in the role through multiple encounters. In addition, they will need to be able to make objective assessments of the learner's performance and accurately complete a checklist.

When recruiting prospective SPs, the educator will need to collect sensitive information about them. As a result, there must be policies and procedures in place to protect the confidentiality of the SP information [6]. SP program applications typically ask applicants to describe feelings toward and experience with healthcare professionals to screen for medical professional bias. Another common application question asks SPs to describe piercings, scars, tattoos, and other physical attributes so that they are not cast into roles for which these attributes would compromise the SP's credibility [14]. Similarly, knowing about SPs' medical conditions and past medical history is paramount when casting them in roles that include physical exams. For example, an SP with a heart murmur or edema could compromise the learner's accurate diagnosis and plan if these conditions run counter to the case objectives. It is also necessary to ask whether a potential SP is willing to participate in physical examinations. Not all will be comfortable bearing their chests or abdomens, especially if the encounter is being recorded. Depending on the context, genitourinary teaching associates (GTAs) and male urogenital teaching associates (MUTAs) may be hired to teach sensitive examinations such as female pelvic exams and male prostate and testicular exams, respectively [16–18]. This should not, however, be routinely considered a part of SP recruiting. Task trainers do exist for practicing these examinations, but cannot replace the feedback about patient comfort, nuances of language, and sensitivity provided by a well-trained teaching associate.

When assigning roles to SPs, it is incumbent on the educator to respect the SP's self-identified boundaries and not place them in roles they would be uncomfortable performing. Educators should give SPs clear information about what the simulation activity entails so they can make informed decisions about whether to accept the work. Educators also need to check with SPs to see if they have had any personal negative or recent experiences with the role. For example, placing an SP who has experienced abuse in her personal life into a role in which she is a child abuser may be too emotionally charged for the SP. Finally, before accepting an assignment, SPs should be informed if and how they will be compensated [6].

Training SPs for Role Portrayal

At the heart of training is a good case. When the case is well crafted and the SPs are well trained, they cannot be distinguished from real patients [19, 20]. According to the ASPE SOBP, there are three principles SP educators should follow when training SPs for role portrayal: preparation, leading the session, and reflecting on the training process [6]. Preparation begins with reviewing the objectives and outcomes of the case and the logistics of the activity. Educators should determine if there are any gaps in the case information or if they are unfamiliar with any of the scenario components and research them or follow up with the case writers. Barrows argued that SPs should not intellectualize their scripts. Instead, they should focus on understanding the feelings and problems that the characters they are playing are experiencing [11]. When SP cases do not include this information, the educator should include in the training plan questions such as [21]:

- Why is the patient seeking healthcare?
- What is the patient's understanding of the problem?
- What does the patient want from the encounter?
- What are the patient's main concerns?
- What healthcare provider behaviors will influence the patient's emotions and how?

When creating the training plan, the educator should consider the context and format of the simulation activity. If several SPs will be playing the same role, group training would be the best format for standardization of SP performance. If simulation equipment is a part of the activity, the plan should allow SPs time to become familiar with the environment and practice with the equipment. The educator may also need to gather additional resources to supplement the training (e.g., videos of real patients with behaviors or symptoms the SP needs to replicate; glucose monitors to enhance understanding of the diabetic patient's daily life). Finally, the educator should gather any administrative documents or special instructions that may be necessary to review with SPs.

Next, the educator should schedule SPs who fit the scenario demographics. Care should be taken to make sure an SP's physical attributes such as scars, tattoos, piercings, etc. do not conflict with the character in the script. If the case requires a physical exam, giving feedback, a very emotional performance, or interacting in a hybrid scenario, the educator should select SPs who are comfortable with and capable of performing these tasks.

There are many ways to prepare SPs for their roles. The SOBP directs educators to review with SPs the objectives of the case and their responsibilities. SPs will also need to understand the context of the simulation, including if the activity is formative or summative, the level of the learner, how the activity fits into the curriculum, the instructions to the learner, where the encounter takes place, how long it will be, and whether they will be asked to give feedback or participate in a debrief. The educator should also lead the SPs in a discussion and practice of their roles [6]. This can be done in a variety of ways, but practice and specific feedback following general principles of deliberate practice are essential to ensure SP readiness for the role [21–26]. Methods to prepare SPs for their roles include:

- Quizzing SPs to check for retention
- Asking SPs to demonstrate affect, behavior, and physical findings
- Asking SPs to perform the lines that must be delivered verbatim
- Asking SPs unscripted questions to help them practice how to respond to different learners
- Portraying a variety of learner behaviors to allow SPs to adapt to different learner approaches
- Showing exemplar videos of an SP portraying the role
- Asking the SP to portray the role with a clinical consultant to understand and refine responses to the physical exam

As Smith, O'Byrne, and Nestel note, if standardization of portrayal is a feature of the simulation activity, the educator should train SPs portraying the same role

together. This allows each role portrayal to be developed collectively to ensure consistency, also known as "Mutual Benchmarking" [15]. For all SP portrayals, educators should include a dress rehearsal to ensure SP readiness for the role. If an SP is not ready, the educator will have to consider whether the SP needs feedback or additional practice or should not be allowed to play the role.

How much time it takes to train an SP is determined by the outcomes and objectives of the case and the experience of the SP. For instance, Kneebone and colleagues report training SPs for 20 minutes for a formative hybrid scenario involving an SP and a partial task trainer. The learner objectives of the encounter were to perform the procedure accurately and communicate about the procedure with the patient [27]. The scenario focused on procedural skills with minimal interaction between the learner and the SP. Five minutes of tutor-led feedback followed the encounter in which students commented from their perspective, SPs commented from the patient perspective, and tutors gave focused feedback on the technical and communication skills [27]. In a scenario such as this, minimal SP training was required because the SPs were already experienced with providing feedback on communication skills and their tasks were few and relatively simple. A more interactive hybrid or manikin-based simulation would require additional SP training time with attention to and practice with the simulation environment. At the other end of the spectrum is training SPs for high-stakes summative exams. Training must be done in several stages and can take many hours. Moreover, SPs new to assessment will require more time than experienced SPs. For example, the tasks for a typical medical student clinical skills exam call for learners to demonstrate their ability to perform a focused history and physical exam and discuss next steps with their patients. The consequence of not performing appropriately on this exam for a learner means not being able to graduate from medical school or become a doctor, so standardization, reproducibility, and objectivity are paramount for SPs working with this activity. In this setting, all SPs need to be oriented to their roles and responsibilities, learn the SP case material, how to perform their role, what physical exam maneuvers to expect, how to complete the evaluation tool, how to deliver oral or written feedback, and then be given multiple opportunities for practice until they can demonstrate role readiness. There are many more tasks for the SPs to complete, their roles are more complex, and the stakes for the learner are higher in this setting than a simple educational or instructional activity [15]. For formative scenarios, Barrows suggested that a lay person who has never played an SP role before can be trained for role portrayal in 2–3 hr and an experienced SP can learn a new role in about 1 hr [11]. Of course, if giving feedback is part of the scenario, feedback training would increase the time spent training the new SP. See the ASPE SOBP for guidance on training SPs to give feedback [6].

The HSTS as an SP

As mentioned above, SPs come from all vocations and backgrounds, so there is no reason why the HSTS cannot serve as the SP and give voice and personality to the manikin in manikin-based simulations. In order to prevent any negative side effects from playing the role, the HSTS should be screened for role appropriateness.

For example, an HSTS who has recently lost a loved one in a car crash should not portray a patient who is in the ER as the result of an auto accident. When preparing the HSTS for the role, the same training principles described above would apply. Additionally, educators should take into account the HSTS's cognitive load. Newlin and colleagues found that SPs who had to observe learner behavior and improvise answers to learner questions were not as accurate in recording behaviors as when they were scripted and could rely on memory to answer questions [28]. Similarly, the HSTS should be scripted, practiced, and role ready to split tasks between running the simulation technology and portraying the patient.

The Effect of the Setting and Scene on the Simulation Experience

The simulation scenario setting must be very clear to all participants. If the setting cannot be simulated, it is important to emphasize the environment to the learner before the scenario begins. If it can be simulated, the HSTS can play a significant role in establishing the setting by arranging the furniture and equipment to add realism to the scenario. Thought should be given to what visual, auditory, and olfactory cues need to be included to suggest the setting to the learner. Location is also important. Is the encounter taking place in an outpatient or inpatient room, the emergency room, critical care or surgical unit, the patient's home, outdoors, or at an accident site?

Establishing the scene can go a long way toward lending authenticity to the simulation activity. It can easily be accomplished by carefully considering what the learner will encounter when first entering the scenario. Questions to ask are: What is the SP wearing? Is the SP in a patient gown? Does the SP wear undergarments? Will the SP need to wear clothes that can be cut away to examine a moulage wound? Does the SP need to wear clothing that supports the role? For example, if playing an attorney, should the SP wear a business suit? Where is the SP when the scenario begins? Is the patient on an exam table, seated in a chair, lying in a hospital bed, standing at the pharmacy counter, alongside a partial task trainer, at the bedside of a loved one represented by a manikin, or standing next to family members played by other SPs? What does the patient look like when the scenario begins? Should the patient seem disheveled, sleepy, worried, nervous, or angry? What is the patient doing when the scenario begins? Is the patient pacing the floor, crying, fidgeting, coughing, or doubling over in pain? Are there smells associated with the scenario? Does the patient smell of smoke or alcohol or have body odor? Having a clear understanding of these features will help the HSTS contribute to the simulation experience.

Traditionally, SPs have worked in outpatient and classroom settings. However, with the advances in technology, wearable simulators and moulage, SPs are now engaging learners in a number of settings and are much more likely to work with and need training from the HSTS. SP training will require practice in these settings, and the HSTS must understand training principles to help the SP prepare for and

learn their roles. For example, SPs will need instruction on how to work with the technology. If using a stethoscope that plays programmed heart and lung sounds, SPs will need practice selecting the right button on the remote just as the learner places the stethoscope on the chest [29]. SPs required to wear procedural skills simulators will need to practice to respond appropriately and credibly [30]. SPs in scenarios with task trainers need to practice how to sit or stand so that they seem aligned with the device (Fig. 18.1) and they should have an understanding of the clinical procedure so they can respond authentically. The HSTS may also need to train and provide practice for the SP wearing an earpiece for on-the-fly portrayal instructions. The SP playing a family member in a manikin-based simulation may need camera blocking training so they do not interfere with the HSTS's ability to video record the learner's performance. Finally, moulage use in SP scenarios is on the rise. The HSTS may need to apply moulage to SPs and show them how to maintain it over the course of the simulation activity.

What is unique about working with SPs is that they are actual people. They are not an educational tool for educators to use. Instead, they are part of a dynamic educational team engaging in a simulation scenario. SPs are "educational allies and contributors" to the simulation field and health professions education [31]. As the field grows and SP-based technology advances, SPs and the HSTS will have more opportunities to collaborate to create credible scenarios. Together they can advance new ideas and techniques that will inform both of their scopes of practice and improve the quality of healthcare simulation.

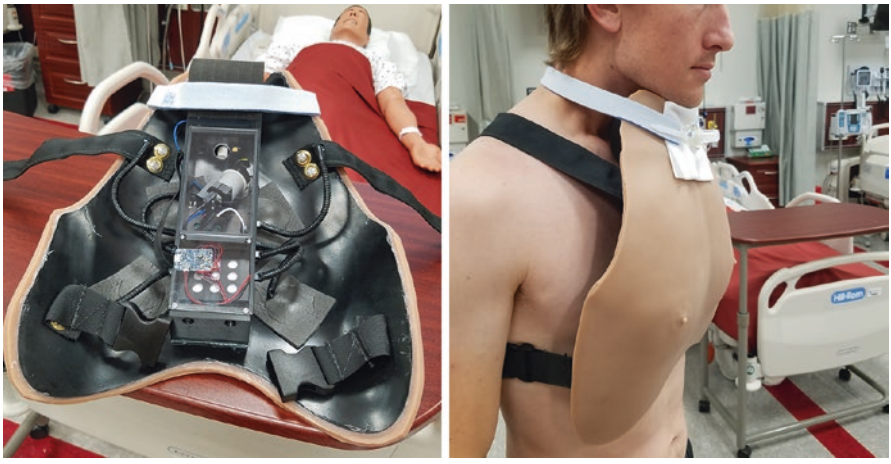


Fig. 18.1 Shows an example of a wearable task trainer to teach suctioning of a tracheostomy (a surgically created opening in the trachea to allow a patient to breathe). The left side of the image shows the embedded electronics that will signal the wearer to respond to actions performed by the learner. The right side shows the task trainer positioned on the standardized patient

References

1. Lopreiato JO, editor. Healthcare simulation dictionary. Rockville: Agency for Healthcare Research and Quality; 2016.
2. Klass DJ. "High-stakes" testing of medical students using standardized patients. Teach Learn Med Int J. 1994;6(1):28–32.
3. Reznick RK, Blackmore D, Dauphinee WD, Rothman AI, Smee S. Large-scale high-stakes testing with an OSCE: report from the Medical Council of Canada. Acad Med. 1996;71(1):S19–21.
4. Howley L. Standardized patients. In: Levine A, DeMaria S, Schwartz AD, Sim AJ, editors. The comprehensive textbook of healthcare simulation. New York: Springer; 2013. p. 173–90.
5. Association of Standardized Patient Educators. About ASPE. [Online] https://www.aspeducators.org/about-aspe; ASPE – The Global Network for Human Simulation Education. Available from: https://www.aspeducators.org/about-aspe
6. Lewis K, Bohnert C, Gammon W, Hölzer H, Lyman L, Smith C, et al. The Association of Standardized Patient Educators (ASPE) standards of best practice (SOBP). Adv Simul. 2017;2:10. https://doi.org/10.1186/s41077-017-0043-4.
7. Nestel D, Bearman M. Introduction to simulated patient methodology. In: Simulated patient methodology: theory, evidence and practice. New York: Wiley; 2014. p. 1–4.
8. Nestel D, Mobley BL, Hunt EA, Eppich WJ. Confederates in health care simulations: not as simple as it seems. Clin Simul Nurs. 2014;10(12):611–6.
9. Nestel D, Sanko J, McNaughton N. Simulated participant methodologies: maintaining humanism in practice. In: Healthcare simulation education: evidence, theory and practice. New York: Wiley; 2017. p. 45–53.
10. Nestel D, Morrison T, Pritchard S. Scope of contemporary simulated patient methodology. In: Simulated patient methodology: theory, evidence and practice. New York: Wiley; 2014. p. 5–15.
11. Barrows HS. An overview of the uses of standardized patients for teaching and evaluating clinical skills. Acad Med. 1993;68:443.
12. Adamo G. Simulated and standardized patients in OSCEs: achievements and challenges 1992–2003. Med Teach. 2003;25(3):262–70.
13. Dudley F. The simulated patient handbook: a comprehensive guide for facilitators and simulated patients. London: Radcliffe; 2012.
14. Tierney T, Gill EE, Harvey PJ. Simulated patient programme management. In: Simulated patient methodology: theory, evidence and practice. New York: Wiley; 2014. p. 93–101.
15. Smith CM, O'Byrne CC, Nestel D. Simulated patient methodology and assessment. In: Simulated patient methodology: theory, evidence and practice. New York: Wiley; 2014. p. 85–92.
16. Fisher KA, Shobeiri SA, Nihira MA. The use of standardized patient models for teaching the pelvic floor muscle examination. Female Pelvic Med Reconstr Surg. 2008;14(5):361–8.
17. Nikendei C, Diefenbacher K, Köhl-Hackert N, Lauber H, Huber J, Herrmann-Werner A, et al. Digital rectal examination skills: first training experiences, the motives and attitudes of standardized patients. BMC Med Educ. 2015;15(1):7.
18. Wånggren K, Pettersson G, Csemiczky G, Gemzell-Danielsson K. Teaching medical students gynaecological examination using professional patients—evaluation of students' skills and feelings. Med Teach. 2005;27(2):130–5.
19. Cleland JA, Abe K, Rethans J-J. The use of simulated patients in medical education: AMEE guide no 42. Med Teach. 2009;31(6):477–86.
20. Rethans JJ, Gorter S, Bokken L, Morrison L. Unannounced standardised patients in real practice: a systematic literature review. Med Educ. 2007;41(6):537–49.
21. Nestel D, Fleishman C, Bearman M. Preparation: developing scenarios and training for role portrayal. In: Simulated patient methodology: theory, evidence and practice. New York: Wiley; 2014. p. 61–70.

22. Wallace P. Coaching standardized patients: for use in the assessment of clinical competence. New York: Springer; 2006.
23. Zabar S, Kachur E, Kalet A, Hanley K. Objective structured clinical examinations: 10 steps to planning and implementing OSCEs and other standardized patient exercises. New York: Springer; 2012.
24. Furman GE. The role of standardized patient and trainer training in quality assurance for a high-stakes clinical skills examination. Kaohsiung J Med Sci. 2008;24(12):651–5.
25. May W. Training standardized patients for a high-stakes clinical performance examination in the California consortium for the assessment of clinical competence. Kaohsiung J Med Sci. 2008;24(12):640–5.
26. Ericsson KA, Krampe RT, Tesch-Römer C. The role of deliberate practice in the acquisition of expert performance. Psychol Rev. 1993;100(3):363.
27. Kneebone R, Kidd J, Nestel D, Asvall S, Paraskeva P, Darzi A. An innovative model for teaching and learning clinical procedures. Med Educ. 2002;36(7):628–34.
28. Newlin-Canzone ET, Scerbo MW, Gliva-McConvey G, Wallace AM. The cognitive demands of standardized patients: understanding limitations in attention and working memory with the decoding of nonverbal behavior during improvisations. Simul Healthc. 2013;8(4):207–14.
29. Lecat P. Lecat's Ventriloscope. [Online] www.ventriloscope.com. Available from: www.ventriloscope.com
30. Avkin. Avkin wearable technology for patient centered simulation. [Online] http://www.avkin.com/. Available from: http://www.avkin.com/
31. McNaughton N, Anderson M. Standardized patients: it's all in the words. Clin Simul Nurs. 2017;13(7):293–4.

Part III

Technology, Innovation, and Industry

Technology and Innovation

19

Nikita Joshi and Teresa Roman-Micek

Introduction

Simulation and technology go hand in hand. Healthcare simulation is the use of technology to recreate a clinical encounter or generate an experience with a procedure or patient interaction. Even though the term technology conjures images of complex machines and robotics, the reality is that simulation technology does not have to be expensive, complicated, limited to commercially available products, or challenging to set up and use. Consider this – one of the first methods nurses were taught to administer medications was to inject oranges with fluid filled syringes. While appropriate for the time, new technologies have enabled for a more realistic training experience through simulated skin pads, arms, and even computerized injection simulators. Each training tool represents a different level of fidelity, and this chapter hopes to provide an introduction to the various aspects of technology used in simulation. This discussion should inspire the creativity of the healthcare simulation technology specialist (HSTS) to explore beyond commercially available products, to dream beyond financial restraints, and perhaps to develop their own technology and ideas for simulation manikins, task trainers, and moulage – possibly even for commercial opportunities.

There are an increasing number of simulation companies that provide a variety of simulation equipment, from low-fidelity to high-fidelity manikins, task trainers,

N. Joshi (✉)
Department of Emergency Medicine, Alameda Health System, Oakland, CA, USA

T. Roman-Micek
Center for Immersive and Simulation-Based Learning, Stanford University School of Medicine, Stanford, CA, USA
e-mail: tromicek@stanford.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_19

and haptic devices. These companies also charge premium prices for their technologies, which can be challenging for smaller programs when working within budget constraints. One must understand that expenditures do not end once the training tool is purchased. There are often accessories that also need to be purchased regularly, such as skins on procedural task trainers. For example, a tube thoracostomy (chest tube) task trainer has an initial cost for the device, but additionally there is the cost of consumables necessary to use the device properly beyond the initial set of provided skins.

Many academic budgets are limited and have constraints on the costs of supplies after they have funded the initial equipment purchase. Often to save costs, task trainer skins are used repeatedly until they are ragged with puncture holes. This is clearly not ideal and can degrade the learning experience.

This creates the dilemma within educators to determine if the specific product cost of simulation technology is worth the educational returns in their curriculum. A review by Stunt et al. argues that "93.5% of the commercially available simulators are not known to be tested for validity," so clinical faculty should review each training device to ensure it meets their specific training needs [1]. An educator uses simulation technology as an adjunct to enhance the teaching that they do, but there is only so much money available to spend, and so purchases must be made carefully through a needs assessment.

Needs Assessment

Before choosing a simulation technology modality, a needs assessment must be performed. Educational curriculum should incorporate instructional design theory, using PADDIE+M or Kern's six-step model at the time of project planning and curriculum design (reviewed in Chap. 12) [2–4]. An important step in these models is deciding on the appropriate educational intervention. Simulation as a methodology consists of high-fidelity, low-fidelity, task trainers, standardized patients, and computer-based tools. When planning the program, the educator needs to explain and discuss the learning objective and the training expectations with the HSTS.

Consider the differences of resource and technology requirements in the two following examples:

1. *Design a curriculum to teach medical students how to suture – with each student provided their own model/pigs feet to practice upon.*
2. *Design an ultrasound-guided IV placement curriculum in an international and low-resource setting.*

In the first example, the HSTS will need access to refrigeration and suture materials from the medical school. Safe storage and disposal of the pig materials will not be an issue. Disposing of sharps and needles will also not be an issue. In the second example, there are many constraints. The most obvious is that cost is a factor, but also consider transportation of teaching materials. Is it more effective to bring

equipment from another country to teach, or is it easier to use locally available resources? An ultrasound arm model may be unavailable or cost-prohibitive. Instead, low cost, lightweight, and portable gelatin models that transmit ultrasound waves may be the best solution. An educator can either purchase gelatin powder locally, or pack the powder into their luggage, and then make it once they reach the final location.

Creation of Commercial Products

Andy Smith from Halldale Media, publisher of Medical Training Magazine, reported a database of over 560 companies that make products or services related to healthcare simulation-based training [5]. Many of these companies specialize in low-fidelity manikins, task trainers, or peripheral devices used in simulation, but a minority also produce high-fidelity manikins. These products can be expensive and do not vary significantly from year to year, but do have differences between competitors and from series to series. This reflects that the innovation life cycle is slower for higher-end products, due to the additional development of robust support systems and the high cost of product redesign. Outside of product warranties, an HSTS is not limited to company rules or expectations and can use "design thinking" and rapid prototyping to innovate [6, 7]. In the simulation workplace, there is an opportunity to trial virtually anything and truly embrace the mindset of an innovator!

Adopting the Mindset of an Innovator: Overview

The Makers Movement is a "contemporary culture or subculture representing a technology based extension of DIY (Do it Yourself) culture that intersects with hacker culture (which is less concerned with physical objects as it focuses on software) and revels in the creation of new devices as well as tinkering with existing ones" [8]. Rather than encouraging profit and proprietary design, the Makers Movement identifies with open source, creativity, and innovation. It is a culture that emphasizes and encourages exploring currently existing technologies, finding novel applications, reuse opportunities, and creative redesigns to meet unique needs. Most HSTSs would benefit from identifying with the "Makers Movement" concept that anyone can provide solutions to educational problems, not just companies. Outside of voiding warranties, opening up simulators when they no longer provide adequate training opportunities and to explore the parts is recommended by the chapter authors.

Design Thinking is another concept that encapsulates the mindset of an innovator. According to the Interaction Design Foundation, "Design Thinking is a design methodology that provides a solution-based approach to solving problems" [9]. It describes a process by which an innovator can conduct a needs analysis, interview end users, and create solutions for their problems. Through design thinking, an HSTS can figure out ways to modify or enhance an existing simulator or the surrounding environment to meet the specific needs of the learner and educator through

the process of prototyping. Multiple individuals have published examples for the design of a low cost tube thoracostomy task trainer model using pork ribs [10, 11]. This design is useful if there are a large number of students who need to learn how to place chest tubes in a setting that has budget constraints, where it may not be feasible to use commercially available task trainers and skins that must be replaced for each student.

Functionality over Fidelity

Considering how much fidelity is required is also an important consideration to make when innovating and prototyping. Within healthcare simulation, the concept of fidelity is generally thought to refer to how realistic a customized model is to its intended form. Fidelity can refer to the human body, components of the human body, the room environment including the sights, sounds, and smells associated with it, among anything else that is required in a simulation. Trying to make all of these aspects completely realistic may not be necessary. The HSTS needs to weigh the importance and limitations of what cost, time, and human effort will be expended to this end.

It may seem logical that high-fidelity is critical, and that learners require high-fidelity to learn concepts within simulation. However, Hamstra and colleagues. concluded that focusing upon functionality is far more useful to meet educational goals than simply focusing upon fidelity [12, 13]. Remembering the previously mentioned thoracostomy example, if the educational goal is to have learners develop the tactile skill of using surgical instruments to place a tube through layers of muscular tissue for chest tube placement, then using pork ribs that provide multiple tissue planes and rib spaces may be more effective than a costly trainer. This is even though the trainer resembles a human more closely than a set of pork ribs. Embracing the concept of functionality over fidelity will require learner participation and their willingness to suspend disbelief.

While Modifications Can Be Helpful, Consider Operational Priorities

While simulation program administrators should appreciate innovative product design that does not void warranties, some may feel strongly that working directly with vendors provides the best results for learner training using simulated devices. While innovative products can be more cost effective, the knowledge of how to create and utilize each solution may be limited to specific individuals, and are rendered ineffective if the implementation of the innovation is not well documented. A useful innovation requires that someone else could duplicate the use of a design whether at the same program, or by someone at another site. Each moment an HSTS spends innovating a product is time spent away from other responsibilities. Many innovations that claim cost-saving do not take into account the cost associated with human

capital required for innovation and creation. Some program administrators may encourage use of existing equipment to enable staff to focus on specific day-to-day roles. It is important that the HSTS connect with administrators to best determine how much time should be spent on, and how the team should prioritize innovation within their simulation program.

Technologies to Enhance Simulation Education

One of the goals of an HSTS is to improve the educational experience of the learner. While manufacturers create manikins and task trainers, they are relatively "one size fits all" simulation tools. The HSTS is the most knowledgeable about what their program's educators and learners specifically need, and this next section will review a multitude of technologies and methods to help with adapting existing devices and prototyping new ones.

Devices

Devices are ubiquitous in the patient care area, and as such are plentiful in most simulation labs. In general, ultrasound machines, video laryngoscopes, and other medical devices that come with an attached video display can also be connected to overhead screens for group sharing of media and images (Fig. 19.1). Classroom or network video and file sharing can be incorporated. A very robust example of this is the "Emergency Department Ultrasound Simulator" project.

This open source project with images and information (at www.edus2.com) will allow an HSTS to construct a mock ultrasound simulator based on a Linux

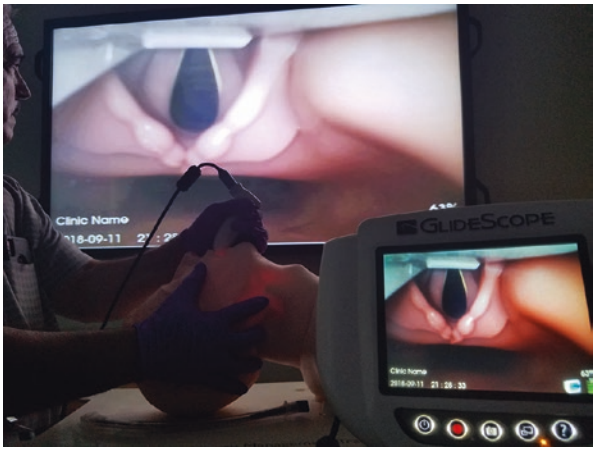


Fig. 19.1 A video laryngoscope is used for intubation and is connected to a large wall-mounted display via an HDMI cable for other learners to observe the procedure and technique

Fig. 19.2 Blackmagic Design UltraStudio Express media adapter. This type of box can convert High-Definition Multimedia Interface (HDMI) or Serial Digital Interface (SDI) signals into one of several digital formats for local display, recording, or internet broadcast

computer platform and radio-frequency card reader to display live images at anatomically appropriate sites on a manikin or standardized patient [14]. Procedural or diagnostic video sharing can be pursued using a home-built system with direct cable connections to computer monitors or television displays in the simulation room space or through integration with larger video management solutions using video encoders. Video adapters can help to convert signals from any of the common video output signals VGA, DVI, or HDMI to a digital stream for recording or broadcasting (Fig. 19.2). The adapter shown can be used with YouTube for local live streaming, shared viewing, and large group debriefing.

By using the internet in this way, it is even possible to engage with learners located far beyond the classroom walls of your simulation center and educate distant and international audiences.

Animal-Based Biologic Products

Animal products can make excellent models in simulation, especially when teaching procedural skills. Obtaining animal models is not very difficult and is actually relatively low-cost. The best place to secure these products is from local grocery stores, butcher shops, and farms. This section will refer to food grade or discarded materials from existing industries and not cadaveric or live animal specimens.

Animal products are particularly well suited for procedural training because of their similarity to human anatomy. Other mammals match humans particularly well, such as the neck, thorax, and abdominal cavities, and muscle tissue of any animal is structurally and functionally similar. Examples of some commonly used animal models include chicken breasts to teach abscess drainage or central venous access [15, 16]. Pig's feet are commonly used to teach suture skills. Pork ribs are often used to teach chest tube placement. Sheep tracheas are used to teach cricothyroidotomy [17]. Deer eyes can be fixed to allow for eye examination and foreign body evacuation [18].

While animal products have many advantages in fidelity, cost, and access, there are also a few challenges that have to be addressed. One consideration is the ability to safely store the animal products. It can be difficult to store large amounts of animal products for a long period of time unless one has access to a freezer. If freezer space and access is not available, then the products can be obtained the same day or the day before a simulation session. However, that may result in time constraints or scheduling difficulties that would have to be planned. The other consideration is the disposal of the animal products after the simulation session. Depending upon the location of the lab such as within an academic center, animals may be considered biohazard material and may have to be specially disposed in specific containers and following particular protocols. This process may also be time- and labor-consuming and possibly expensive. Another consideration is for sterility and cleanliness. Animal products have bacteria associated with them and it is important to provide for hand washing and proper cleaning of instruments or other tools to prevent the spread of disease.

Elastomer (Rubber)

An elastomer is a natural or synthetic polymer with elastic or flexible properties. Most manikin skins are an elastomer, usually silicone. Latex is another commonly used elastomer that can be sealed to contain pockets of fluid. Elastomeric products are easily created using a combination of pourable or shapeable techniques. Using molds allows for reproducible shapes and consistency of product creation.

Latex

Latex is sold as a clear-white liquid that can be painted on for moulage of standardized patients or added to seal plastics for abscess, etc. It can be purchased from costume and makeup stores. Additionally, many tubes used inside of manikins or task trainers are made from latex. Latex is characteristically opaque and will tend to have a yellowish color in its natural form. Unfortunately, it is best to avoid this product in the healthcare setting as a general use material as healthcare workers have a higher incidence of latex allergy than the general population [19].

Silicone

This is the primary substrate for manikin skins and task trainer forms. Liquid silicone is sold as a two-part craft product under brand names such as Alumilite and Smooth-On [20, 21]. Each two-part brand and type must be matched or else the final product will not cure. These epoxy style mixtures are available in different

Fig. 19.3 Shows a collaboration project to make a reproducible full-body manikin and ultrasound task trainer with silicone casting

densities and can be used to make skins for suture models, manikins, and task trainers. The mixing ratio of A and B product components varies by manufacturer and specific compound. The cure time and pot life (length of time for mixing and pouring) differ for each product and should be investigated for each planned application, but in general most vary from minutes to hours. Longer pot life time allows air bubbles to come out when poured. The pot life is also affected by temperature with shorter usable times in warmer temperatures. Even whole body models can be created using casting negatives for pourable reproducible task trainer parts (see Fig. 19.3) [22]. Specialized oil-based "Plasteline" modeling clay can be used to make the initial positive form for reproducible casting. Any planned casting clay must not contain sulfur as this interferes with the silicone curing process. Other examples of this clay include Sculptex and Chavant. This type of clay can be heated and liquefied for pouring, but is flammable if overheated. The melting point is around 175 °F [23].

Clear plastic cling wrap and sandpaper, among other instruments, can all be used with the modeling clay to add skin-like texture. Talc can be used to visualize texture in the model being created and assist with smoothing of the surface. Bracing and support structures can be built to accommodate larger or awkwardly shaped molds. Some may even need to be supported with wooden, fiberglass, or plaster supports. The clay can be lightly sprayed with a clear lacquer to prevent small pieces from coming off into the casted mold. Mold Star from Smooth-On is one silicone-based

product to make a mold negative for later reproducible product replication. Alginate is a powder-based product that can be used to make a temporary semi-elastic mold. Alginate is commonly used to make dental molds and impressions and is sold in hobby and mold making supply shops as a single-use quick curing mold material that is skin safe [24].

Examples of Smooth-On silicone product types:

- EcoFlex Gel is soft and stretchy, and almost tacky to the touch. It is commonly used for adipose tissue layers.
- EcoFlex 0030 is minimally tacky and moderately flexible and is commonly used for skin surface structures.
- Dragon Skin is firmer to the touch but is still stretchy and can be used for skin or deeper muscle tissues.

Silicone additives are specific to each manufacturer and can be added to increase the flexibility of the final product (example: Slacker for Smooth-On). Other additives can be combined during mixing to increase the thickness of the product during pouring.

Silicone will harden and form a durable, flexible, and heat resistant form that matches the container or shape into which it was poured. This includes subtle and intricate details carved or added to a model before pouring. The different densities of silicone material can also be colored for use in various settings. Virtually nothing sticks to cured silicone, which helps for mold making and cleanup but make repairs difficult. This requires the use of release agents to allow silicone forms to separate easily from silicone casting models. Petroleum jelly is one method to assist the silicone with removal from a mold (see Fig. 19.4). 3D print molds can also be used for easy casting, but will capture the characteristic print line in the final product. Isopropyl alcohol can assist with cleanup, but unless the liquid silicone contacts a porous surface, waiting until cure for removal is easiest.

Once a final product is created, water-based fake blood can be added and easily cleaned up. If permanent coloring is desired, a silicone-based paint such as FuseFX can be added. Again, only silicone will stick to other silicone.

Once a piece of silicone is cut, it is not easily resealed or repaired. Some repair is possible using a product like Sil-Poxy® silicone rubber adhesive [25]. An improvement on simple elastomeric skin incorporates a substrate within a poured skin substance [26]. The incorporation of this fabric mesh within the silicone or other mold limits tearing and can allow for suturing and will increase the final strength of the model. PVC tubing can also be successfully imbedded in a model for rigidity, as well as to decrease stress on a flexible form. Silicone comes in platinum-based and tin-based forms, and the two products are not designed for use together. Platinum-based products are recommended for use with human contact due to health risks associated with tin [27].

Fig. 19.4 (**a**-**d**) Shows the tools and processes required to make the initial positive casting of a skin wound for use in moulage. Panel (a) shows a brick of plasteline modeling clay that can be used to make an initial mold for use in silicone casting. Panel (b) shows the process of using cellophane, shaping tools, and sandpaper to create the texture and outline of the wound and skin surface. The model was made on a piece of laminate wood and surrounded by a ring of clay to create a well, as seen in panel (c). Talc was applied to the model during final smoothing to assist with form creation and visibility of subtle skin textures. This is the reason for the shiny appearance of the model in panel (c). Panel (d) shows a can of aerosol mold release lacquer used on the model in panel (c) to help the poured silicone casting mold come off cleanly later.

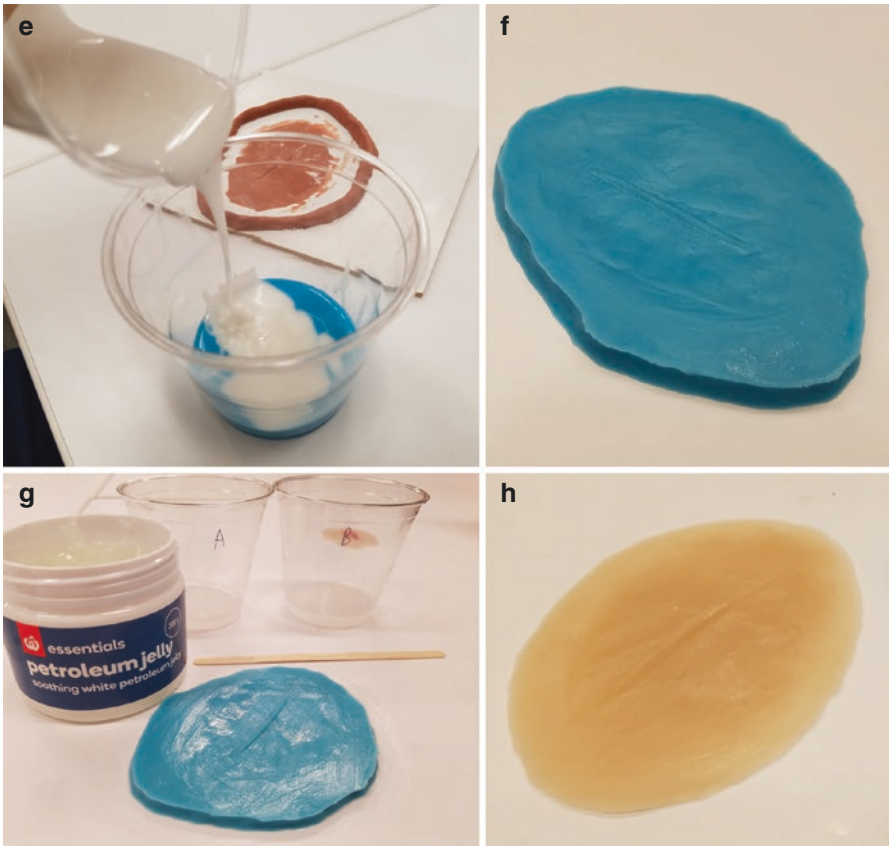


Fig. 19.4 (**e-h**) Shows the continuation of the process from Fig. 19.4. Panel (e) shows the mixing of Smooth-On Mold Star parts A and B. This mixture was poured over the model from panel (c) of Fig. 19.4. Once cured, the casting negative in panel (f) was obtained. To prevent the final silicone cast from sticking to the mold, petroleum jelly was applied across the entire surface of the blue mold in Panel (g). Parts A and B of the silicone casting (seen in the back of panel g) are mixed with a skin-toned color and then poured into the blue mold to create the final silicone wound casting pictured in panel (h)

Gelatin

Ballistics gelatin is a collagen-based animal product produced by mixing a gelatin powder into liquid. Most commonly, it is produced from a 10% solution. Originally, it was created for testing projectile penetration in firearms. This is due to the substance's high viscosity that is described as similar to human and animal tissue. Different types of gelatin are now being developed and have a wide range of applications in healthcare simulation. Standard food grade gelatin can be melted and is able to be poured and reused for skin and tissue models. It also has an advantage of transmitting ultrasound waves for imaging of contained structures. This standard form must be refrigerated however, and can mold with prolonged use [28]. Ballistics gelatin on the other hand, while still sonographically pure, does not require refrigeration or have the problem of growing mold [29].

Instructions for making ballistics gelatin are described in an unclassified military report from 1987 [30].

1. Start with a container of cold water (7–10 °C).
2. Add powder to water; using a 1:9 ratio by weight of 250 bloom gelatin powder.
3. Stir slowly to wet all particles, but minimize air bubbles.
4. Let stand 2 hours in refrigerator.
5. Heat in hot water bath (or crock pot); DO NOT EXCEED 40 degrees C, again stirring gently to prevent entry of air.
6. Pour into molds and cool overnight in cold water bath (7–10 °C) or refrigerator.
7. Store at 4 °C in airtight containers.

Synthetic Gelatin

Very similar to the animal-based gelatin products described above, Clear Ballistics gelatin is a non-animal based gel that can be melted and molded without need for refrigeration and has been used for ultrasound and other task training models. It has been successfully used in making anatomic models to practice surgical procedures, including simulating brain tissue [31].

Gel Wax

Various densities of wax are used for candle making and are available for purchase in hobby shops. These meltable resins can be used to mimic tissue. Similar to ballistics gelatin, gel wax has properties that can also be used for ultrasound transmittance [32].

Learning the art of creating your own synthetic rubbers is also highly useful as an HSTS. There are many different recipes available and they all share the common trait of being easy to make even when laboratory facilities are not available. Liquid elastomers can be fit into any type of mold and therefore shaped for true customization, because the initial stage is in liquid form. The materials are cheap and readily available, which makes the process easily reproducible.

3D Printing

Three dimensional (3D) printed models can be created from CT or MRI image data or created from personally created 3D designs. Self-created designs can be modeled using many software programs. Autodesk ® TinkerCAD™ is one commonly used option (see Fig. 19.5). It is a free online computer aided design (CAD) system. Digital Imaging and Communications in Medicine (DICOM) images from CT and MRI scans can be converted into 3D CAD files. The DICOM image file must be processed to create a 3D image that can be used by the 3D printer. One suggested method for this is to use a program called Osirix (for Macintosh) or Invesalius (for Linux, PC, and Macintosh) to convert the original DICOM file into a 3D surface rendering. This is the format required to produce a .OBJ or .STL file that can be

Fig. 19.5 Lower portion of a 3D-designed model of a cricoid cartilage. This piece was designed in TinkerCAD for use in a cricothyroidotomy task trainer (Autodesk screen shots reprinted courtesy of Autodesk, Inc)

processed by most 3D printers. If designing and converting images is too daunting a task, many open-source 3D print files have already been produced and are available for download through the website Thingiverse.com.

One additional method to create 3D designs for use in a 3D printer is to use 3D scanning cameras to produce surface renderings. 3D scanning tools come in many forms, including both hand held and desk mounted options. These systems use a binocular camera system for scanning and creating 3D imaging files. These products are hitting consumer availability with prices ranging from under $100 (USD) for an iPad accessory to high-end professional models costing thousands of dollars.

The actual printing process can be accomplished in several formats, the most common being Fused Deposition Modeling (FDM). FDM is what is most commonly referred to when describing current home or consumer 3D printing systems [33]. This process uses thin layers of material, melted and extruded through a nozzle onto a printing bed, where the material will begin to cool and form a solid structure. The printer software will electronically "slice" and convert the .OBJ or .STL files into a mesh outline of the object that when layered will have a solid outer surface. The slicing program will convert the layer information into 3D printer movement commands or "G-code" that the printer actually uses to create the print. It sounds complicated, but the hard part of software and device design has already been done, and actually using the printer to create models from 3D print files is relatively straightforward as the printer commands and coding are automated within the device.

Once a prototype is developed, a plaster or thermoplastic cast can be developed for single or large scale reproduction. 3D printing can be used to make a stiff structure for rapid prototyping, but mold pouring using a cast negative is better for mass production. 3D printing and the mold creation and pouring process are being used to develop prosthetic devices and simulation models [34].

Molding and Casting

Injection molding has been utilized by dentists for many decades with acrylic plastics used to make denture molds. This process allows a thermoplastic resin to be melted and injected into a "negative" mold and allowed to harden or cure to make a completed and reproducible form [35]. This is a common method for mass production of materials in an inexpensive manner. One notable example of this production method is the LEGO building block.

Thermoforming is a method of heating plastic materials, and either pressing them or pulling them (vacuum forming) into a mold. This form is held until the plastic cools and the material will retain its shape (see Fig. 19.6) [36]. This method for part creation was even sold as a children's toy by Mattel in the 1960s under the name Vac-U-Form.

Food Products

Food products are easily available at local grocery stores and often available in large quantities. Once used for training however, these products are usually not suitable for consumption. Example applications include using hard boiled eggs for teaching eye exams with slit lamps. Tofu has the ability to transmit ultrasound waves and can therefore be used by ultrasound machines (see Fig. 19.7) [37]. Gelatin, which was

Fig. 19.6 Shows a thermal formed plastic mold of a thyroid cartilage for use with a cricothyroidotomy task trainer

described in more detail in a previous section, is clear and liquid when heated which allows for molding and shaping before it hardens during refrigeration. With fruit bits, Metamucil, and noodles, it is also an inexpensive and easily portable ultrasound model. Mushroom soup can be used to create pus or other infected fluids that can be placed within rubber pockets. Food coloring can be used to help create the appearance of blood. Food dyes can also be incorporated during the rubber-making process to make skins of different colors or even to create skin parts that can be used in wounds. Always be sure to test for color staining of skin and training models before exposing them to colors and dyes. Corn can be used to make vomitus very realistic. In fact, do not be limited to this section or this text book, take a meander down the aisles of the grocery store and let your imagination soar. One additional emesis recipe involves the use of lemon juice and parmesan cheese to add in the olfactory stimulation that would normally go with this substance.

One disadvantage to food products in simulation however, is they can decay or attract insects or other vermin. Always keep in mind that some materials, particularly fruits, may stain even non-porous surfaces such as silicone skins and should be checked before use to prevent any unintended dying effects. This is especially important for maintaining warranties of simulation equipment.

Off-the-Shelf Products

Hobby and arts and crafts stores are also a treasure trove of supplies and equipment. Styrofoam heads are drillable and easily modifiable for any procedure involving the head, face, or neck area. Circular shapes can be adapted to create

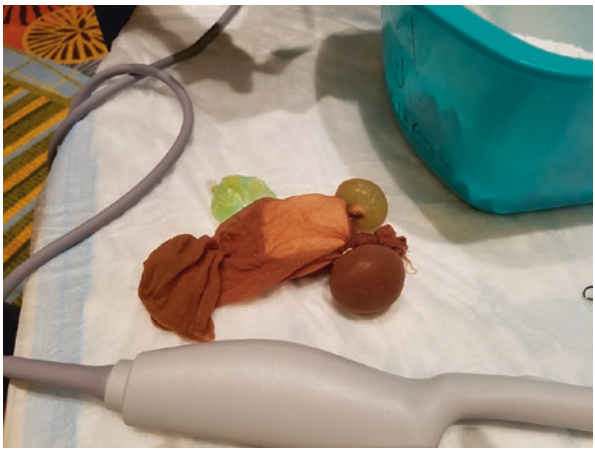


Fig. 19.7 Shows a piece of tofu secured in nylon legging next to an endocavitary ultrasound probe. This combination in addition to gummi bears, Boba pearls, and chocolate pudding secured in an ultrasound probe cover allowed ultrasound representation of early uterine pregnancy and various ovarian cysts. The model was submerged in a water bath and termed the "Tofuterus" [37]

any circular body cavity. Drilling will create holes and cavities to allow for the insertion of tubes such as practicing nasogastric tube placement. Vinyl sheets from fabric and upholstery stores are inexpensive and come in a variety of colors. They can be used to mimic a training environment such as an outdoor area, or it can be draped and used in the place of skins. Hobby stores also have a nearly unlimited supply of molds and cookie cutter shapes that can be repurposed. Many hobbyists swear by their glue guns, and perhaps the day will come when simulation technicians do the same. Salvation Army, Goodwill, and consignment shops can help bring manikins and confederates to life through clothing, wigs, shoes, hats, and jewelry.

Adhesives

Adhesives are useful in medical simulation. The ability to keep two components of various materials, whether it be rubber, metal, or plastic together is very helpful in prototyping. There are numerous types of adhesives. They are made with different chemical compounds, textures, dispensing devices, and have a variety of inherent properties, which are rarely considered or known by most consumers. This section will attempt to describe best practices and expected utility for many adhesive substances.

Tape

- Duct Tape: Plastic/cloth adhesive tape with good strength characteristics. It may leave an adhesive residue and is considered water resistant. It is good for many repairs that are not visible.
- Scotch Tape: A brand name used to describe common clear office pressure tape. It has low strength and minimal adhesive abilities compared to others. It is best used on smooth dry surfaces.
- Medical paper tape: This is a weak tape used to secure some IVs or light bandages. It is best used on people with sensitive skin and has little use for repairs or securing devices permanently.
- Medical plastic tape: This is often used to secure IVs and is usually easy to remove. It leaves little residue and holds slightly stronger than paper tape.
- Medical fabric tape ("Silk tape"): A medium strength tape, usually slightly shiny on use side. This adhesive is common in medical facilities. It can be used so secure bandages or to assist during procedures. It can pull hair and may leave a residue if left in place for a long period of time.
- Electrical tape: Often black, but can come in colors, smooth vinyl-based tape designed for covering electrical connections. It is known for its mildly elastic properties. Correct use of this tape requires some stretch at its termination for maximum adherence.

- Gaffer tape ("Gaff tape"): Heavy duty usually black cloth tape often used in video/film or conference events to secure wires in a temporary setting to prevent a tripping hazard.

Glues

This section will describe a variety of glue and liquid adhesive products. General principles for any gluing or bonding recommend using clean dry surfaces at room temperature, 70–80 °F. Eye protection is commonly recommended, and for best results of bond strength, only use the minimal amount of glue required. Extra glue can often weaken the joint or slow the cure time [38].

- Acrylonitrile: Bonds to porous and nonporous materials. It is not recommended for wood, but can be used for flexible and waterproof repairs similar to rubber cement.
- Cyanoacrylates ("super glue"): Clear liquid adhesive that can be used to bond plastic, metal, and rubber but will harden rigid and may chip or crack with recurrent stress. It is nonporous and is safe for use, once hardened, in oil and water and in contact with most chemicals. Cyanoacrylate should not be used to fill gaps and should be used with gloves. Caution is advised when using this glue because it will bond in less than 5 seconds, and will bond skin. It is used in a sterile version in the medical field for this exact purpose as a tool for laceration repair.
- Epoxy: A two-part resin adhesive that will harden in minutes, but some varieties may take days to weeks to fully cure. It can be used on plastics, wood, metal, and rubber. It is very hard when set and resists solvents and acids. Cleanup before cure can be assisted with acetone.
- Glue Gun ("Hot Glue", "Hot Melt Glue"): This common household and craft glue is usually Ethylene Vinyl Acetate (EVA) resin. It has a melting point of 150–210 °C [39]. It is primarily suited for plastics, wood, fabric, and some rubbers. It will retain some flexibility upon setting and is waterproof.
- Contact Cement: This is a solvent-based viscous liquid adhesive designed to secure a variety of materials, including plastics, paper, and metals. The application technique for this product is different from many adhesives in that it should be applied to both sides of the material to be secured, and then allowed to dry until tacky. Once tacky, the two pieces can be pushed together to make a strong bond. Keep in mind that this adhesive has a strong odor as it is based with toluene and acetone; both of which are volatile organic solvents [40]. This allows for its semi-rapid drying and function but requires good ventilation for use. Examples of other rubberized contact adhesives include spray adhesives for foam, and vinyl as well as standard rubber cement. The process for application is the same for all types of contact cement products, requiring each side to dry before securing for maximum hold, but the solvent within the product may differ. 3M vinyl

spray adhesive uses toluene and cyclohexane as solvents [41]. Rubber cement uses the solvent n-Heptane [42].

- Polyurethane glue: Is a single part yellow-brown liquid adhesive sold under the brand name "Gorilla Glue". It can be used on many materials, but is best suited for wood. Optimal bonding requires pressure and moisture to achieve adhesion and takes 1–4 hours for 90% cure, with full cure in 24 hours. Gluing using a vise or clamp is suggested.
- Elmers White "school" glue: Is a trade name for polyvinyl acetate (PVA). PVA is a low-strength glue that dries semi-clear and can be used on many surfaces but is best on solid, non-porous surfaces with minimal texture. This substance can be dissolved with warm water and soaking. Some hobbyists have even used a laundry steamer to assist with removal [43].
- Latex-based adhesive: Latex is an adhesive liquid (usually white) made from natural rubber. It has weak adhesive properties but is highly flexible, waterproof, and can be used on cloth and other rubbers. It can also be used for moulage on manikins and plastic skins. Use on humans and standardized patients is also common, but caution should be exercised as a latex allergy could be present.
- Silicone based adhesive: This is sold as a clear, or sometimes colored, paste often for caulking or flexible waterproof repairs. It can bind many substances, but has weak adhesive properties and can often be peeled or removed once hardened. Setting time can take from 2 hours to 2 days depending on the formulation. Most silicone is highly heat resistant and can tolerate temperatures up to 400–600 °F.
- Solder: while not the same as most other adhesives in this list, solder can be thought of as a glue for metals. Solder is a mixture of easily malleable metal alloys. It was previously commonly found with a lead base but now more commonly manufactured with tin, silver, bismuth, or zinc alloys. Soldering pronounced "Sod-er-ing" is the process of melting a metal, dissimilar to one or more other metals, to secure and bond them together. Most soldering materials melt at ~190–220 °C [44]. The process by which this material is applied is with the use of a soldering iron, or soldering pen. The free end from a spool of solder is applied to the metals to be joined as they are heated with the soldering iron. The solder should be applied to one of the metals to be connected and not to the soldering iron itself; this will allow the solder to "wick" into place as the metals are heated. The proper technique requires some patience and practice, but is an important skill in electronics repair.

Solvents and Cleaners

Whether through the application of moulage, adding to or modifying existing equipment, or the accumulation of incidental inks or sticky residue from EKG leads, many healthcare simulation technology specialists may encounter times where they must clean manikins, work spaces, or other surfaces. The following list of common solvents will describe specific features and uses as reported in the literature or common practice. Some risks with the use of organic solvents in general is the potential

to dissolve some plastics, a flammability risk, and concern for inhalation if used in enclosed areas. Remember, as a general chemical property that "like dissolves like." Understanding this property will help with adhesive residue removal by selecting a solvent product with a similar chemical base as the material to be removed [45].

- Soap (surfactant): One of the most commonly used solvents. Sometimes referred to as detergents, these wide ranging group of cleaning products allow for miscibility in water but have properties of both polar (hydrophilic) and nonpolar (hydrophobic) substances allowing them to help break up and dissolve both water-soluble and oily substances and can decrease surface tension [46]. These substances are ubiquitous and well known to remove most dirt and oil from hands, rubbers, and other surfaces safely, and with low toxicity. This is likely a safe method to start for cleaning almost any simulation product.
- Rubbing Alcohol (isopropyl alcohol): Isopropyl alcohol in a 70% solution is used to decontaminate surface contaminants on skin and many other spaces in the healthcare setting, including stethoscopes [47]. While its bactericidal properties are important in preventing infection and contamination, its properties as a polar solvent are of greatest use in the simulation space. Isopropyl alcohol is recommended and provided by many simulation manufactures to assist in cleaning rubberized surfaces, including silicone skins. Isopropyl alcohol was found as the predominant solvent in many commercial inks [48]. This would explain its potential utility in removing them from surfaces, by bringing them back into solution where they could be wiped away.
- Goof-Off: (Benzenemethanol [benzyl alcohol], diethylene glycol monobutyl ether (2-(2-butoxyethoxy) ethanol) [49]. This cleaning product is a mixture of alcohols and, although listed here as a specific brand name, it is listed because of its use for dissolving and removing many stickers, inks, and adhesives with wide availability.
- Toluene: Is a clear liquid and produced from oil produced by the Tolu tree [50]. It is a volatile organic solvent found as one of the most common solvents in commercially produced paints, inks, and adhesives [48]. Due to its use as a solvent in these products it can be used to dissolve and remove many of these substances as well.
- Xylene: Is an organic solvent derived from crude oil. It is found most commonly in paints, varnishes, adhesives, and inks [48, 51]. It can pose a flammability risk with heat or spark in addition to its high volatility and odor.
- Cold Cream: Is a product with surfactant properties, much like soap, created for makeup removal. It can be used to solubilize the color and oil-based portion of lipstick or other makeups. The remaining residue can then be washed with water. Some HSTSs apply this product to manikins and standardized patients (SPs) before applying any additional moulage as a barrier layer to help with removal later.
- Acetone (2-propanone or Dimethyl ketone): Is a polar solvent and therefore dissolvable in water and alcohol. It can be used to clean epoxy glues, ink, contact cement, and many adhesives. It is most effective when used before these items

dry fully. It should be used with caution on plastics as it may soften or dissolve them. It should be used in a well-ventilated area and poses a flammability risk with heat or spark. Acetone is most commonly used and sold as fingernail polish remover.

- Gojo Hand Cleanser: This hand cleanser is a petroleum-based cleanser to assist with dissolving makeup, tar, or similar agents. It is similar in function to Cold Cream [52].
- Abrasives: Stubborn residues may require mechanical force to assist with removal. Some cleaning agents specifically have grit integrated to apply this type of mechanical force. In addition to cleaning agents with this incorporated, emery board, sandpaper, rough plastic scrubbing pads, or steel wool can be used to assist with cleaning.

Foams

While there are too many types and uses of foams to discuss each in detail, this section will cover some of the most commonly encountered foams in home, consumer, and craft markets. Plastic-based foams have density variation 0.1–60 lb./ft^3. Flexible and semi-flexible foams are most commonly found in furniture, carpeting, and cushioning applications but also in the form of gaskets. Rigid foams are common in thermal insulation, building, construction, or sporting goods.

(Poly)urethane Foam

(Poly)urethane foams can be made both rigid or flexible depending on the cross linking of the urethane subunits. Flexible polyurethane foams are "open cell" (have a communication between contained air spaces) and will reform after compression. Open cell foams can hold water, melted petroleum jelly, ultrasound gel, gelatin, or gel wax because small holes connect to one another. This type of foam can be used to make adipose tissue or soft support between skin or tissue layers. This type of foam is commonly available as furniture cushioning and comes in a variety of shapes. It can even be cut, molded, or shaped to meet specific needs [53].

Rigid urethane foams are, as implied by the name, minimally flexible and will deform if compressed without returning to their original shape. They tend to be "closed cell" (having individual air spaces that are separate from one another) and deformity indicates a rupture of the enclosed air spaces. This type of foam can be sprayed, poured, or molded to make a lightweight form that holds and supports a structure, usually for thermal insulation effect, but may have utility as a lightweight structural component of models. A can of spray foam insulation from the hardware store that is used for sealing gaps around doors or windows is an easily available form of this type of foam. Creating a lightweight rigid tubular foam piece from a can of foam insulation will make a realistic visual mimic for eviscerated bowel, especially when lightly painted, coated with baby oil, and applied to the abdomen of a manikin [54].

Latex Foam

Latex cushioning foams are generally of greater density than urethane foams. Latex foam products typically have good flexibility when cold, but can degrade in warm temperatures and can tear easily [55]. This type of foam material is sold in many types of bedding and pillows.

Latex has similar cushioning properties to what has become known as "memory" foam or viscoelastic foam. Although memory foam is actually a modified polyurethane foam, it is now thought of and classified separately by many. It was originally created by NASA to provide cushioning against the gravitational forces generated by space flight [56]. This type of foam is readily available in large sheets as a mattress topper and is known for retaining an imprint when pressure is applied to it for a period of time, thus giving rise to the term "memory" in its name. In simulation, it can mimic the effect of pitting edema (a swelling caused by fluid retention) that is present in the lower extremities of patients with congestive heart failure or liver disease. This effect is possible when the foam is applied in a thin layer to the front portion of a manikin or standardized patient's leg and then held in place with a sock or nylon legging.

Vinyl Foam

Vinyl foam used in cushioning has high tensile and cushioning strength and although capable of withstanding flame has poor resistance to solvents, making it a poor choice if expected to be exposed to chemical cleaning agents.

Ethylene-vinyl acetate (EVA) foam is commonly sold as a thin sheet in fabric and craft stories under multiple brand names, and is also known for cushioned flooring in some home gyms, shoe soles, and even yoga mats. This product is easy to work with and can be cut with razor blades or scissors, but some hobbyists will use soldering irons or a "hot knife" to trim thicker pieces of this material. Because of its low thermal resistance, it can be similarly shaped instead of just cut. This means that sheets of EVA have the ability to be shaped and formed using a heat gun. Heating this type of foam, even if it will remain flat, will stiffen it and improve paint adherence if it will be later colored. It can also be glued and layered using a hot glue gun or contact cement type adhesive [57].

Adoption and Integration of Technology to Enhance Learning

Applications (apps) and social media devices also fall into the category of electronics that can be used to enhance simulation. There are apps that allow for real-time question and answer sessions that allow educators to project answers for all to see. This is an especially helpful way to enhance debriefing post simulation. An example of this is the company Poll Everywhere which allows the educator to project questions through the app and over the internet at particular times in the simulation

session. This also allows those who are not actively participating in the simulation at the time to still be involved through question answering. Social media platforms such as blogs and Twitter can also be used before or after a simulation session to post educational content. The educator can post background articles or important videos for their learners to use.

Knowing about and understanding technology is vital to implementing an innovation. It is also important to know how to integrate technology for enhanced learning, and that is the role of the HSTS which goes back to the principles of curriculum design. While the HSTS is not the primary educator, they are charged with working alongside the educator to bring the curricular vision to life. The HSTS is the simulation expert and is tasked with the important role of ensuring that the simulation technology is optimally used for education, and not just because it is something exciting to incorporate.

Conclusion

In conclusion, embracing technology and innovation can lead to enhanced learning opportunities. Do not to be scared to experiment with various types of technology from electronics and AV equipment, to arts and crafts techniques, molding, apps, and more. The HSTS can harness the power of the Makers Movement and Design Thinking principles to improve fidelity and learning outcomes for simulation participants. Realize the role of an innovator and creator, then prototype, prototype, and prototype again. Infinite possibilities await!

References

1. Stunt J, Wulms P, Kerkhoffs G, Dankelman J, Van Dijk C, Tuijthof GJM. How valid are commercially available medical simulators? Adv Med Educ Pract. 2014;5:385.
2. United States Navy. Naval Education and Training Command Integrated Learning Environment Course Development and Life-Cycle Maintenance [Online]; http://www.netc.navy.mil/ile/_Documents/NAVEDTRA136/NAVEDTRA_136.pdf; 2010. Available from: http://www.netc.navy.mil/ile/_Documents/NAVEDTRA136/NAVEDTRA_136.pdf
3. Kern D, Thomas P, Hughes M, editors. Curriculum development for medical education: a six-step approach. 2nd ed. Baltimore: Johns Hopkins University Press; 2009.
4. Molenda M. In search of the elusive ADDIE model. Perform Improv. 2003;42(5):34–6.
5. Smith A. Simulation vendors. In: Crawford S, editor. Halldale Media, Publisher of Medical Training Magazine; 2018.
6. Brown T. Change by design: how design thinking transforms organizations and inspires innovation. New York: HarperCollins; 2009.
7. Bustamante S, Bose S, Bishop P, Klatte R, Norris FJ. Novel application of rapid prototyping for simulation of bronchoscopic anatomy. J Cardiothorac Vasc Anesth. 2014;28(4):1122–5.
8. Wikipedia. Maker culture. Wikipedia [Internet]; August 30, 2018. Available from: https://en.wikipedia.org/wiki/Maker_culture
9. Dam R, Siang T. 5 stages in the design thinking process; August 30, 2018. Available from: https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process.

10. Saxon KD, Kapadia AP, Juneja NS, Bassin BS. How to teach emergency procedural skills in an outdoor environment using low-fidelity simulation. Wilderness Environ Med. 2014;25(1):50–5.
11. Ching JA, Wachtel TL. A simple device to teach tube thoracostomy. J Trauma Acute Care Surg. 2011;70(6):1564–7.
12. Hamstra SJ, Brydges R, Hatala R, Zendejas B, Cook DA. Reconsidering fidelity in simulation-based training. Acad Med. 2014;89(3):387–92.
13. Schoenherr JR, Hamstra SJ. Beyond fidelity: deconstructing the seductive simplicity of fidelity in simulator-based education in the health care professions. Simul Healthc. 2017;12(2):117–23.
14. Kulyk P, Olszynski PA. Emergency Department Ultrasound Simulator: 35. Acad Emerg Med. 2012;19:S409–S10.
15. Heiner JD. A new simulation model for skin abscess identification and management. Simul Healthc. 2010;5(4):238–41.
16. Nachshon A, Mitchell JD, Mueller A, Banner-Goodspeed VM, McSparron JI. Expert evaluation of a chicken tissue-based model for teaching ultrasound-guided central venous catheter insertion. J Educ Perioper Med. 2017;19(1):E503.
17. Pettineo CM, Vozenilek JA, Wang E, Flaherty J, Kharasch M, Aitchison P. Simulated emergency department procedures with minimal monetary investment: cricothyrotomy simulator. Simul Healthc. 2009;4(1):60–4.
18. Coleman K, Fortuna T, Kuehl D. A novel eye model for simulation in slit lamp examination, ultrasound and foreign body removal using animal tissue. West J Emerg Med. 2017;18(5.1)
19. Bousquet J, Flahault A, Vandenplas O, Ameille J, Duron J-J, Pecquet C, et al. Natural rubber latex allergy among health care workers: a systematic review of the evidence. J Allergy Clin Immunol. 2006;118(2):447–54.
20. Alumilite. Alumilite mold making and casting materials [Online] https://www.alumilite.com/. Available from: https://www.alumilite.com/
21. Smooth-On. Mind blowing materials for a world of applications [Online] https://www.smooth-on.com/. Available from: https://www.smooth-on.com/
22. Pierce N, Jackson C. Project AIMMEE: a Cross-Continental SimulaitionBuild. Peoria: SimGHOSTS USA; 2016.
23. Artmolds.com. Chavant – NSP Plasteline Clay – Green [Online]; https://www.artmolds.com/chavant-nsp-plasteline-clay-green.html; August 30, 2018. Available from https://www.artmolds.com/chavant-nsp-plasteline-clay-green.html.
24. Fairchild JM. Versatile Uses for alginate impression material. J Prosthet Dent. 1974;31(3):266–9.
25. Smooth-On. Can A Rubber mold that has torn in production be repaired? [Online]. https://www.smooth-on.com/support/faq/98/: Smooth-On; Available from: https://www.smooth-on.com/support/faq/98/
26. Lewis LA, Nusbaum BP, Leeds HR. Simulated skin and method. Google Patents; 1986.
27. ATSDR. Public Health Statement for Tin. Toxic Substances Portal [Internet]; 2005. Available from: https://www.atsdr.cdc.gov/phs/phs.asp?id=541&tid=98.
28. Kendall JL, Faragher JP. Ultrasound-guided central venous access: a homemade phantom for simulation. Can J Emerg Med. 2007;9(5):371–3.
29. Morrow DS, Broder J. Cost-effective, reusable, leak-resistant ultrasound-guided vascular access trainer. J Emerg Med. 2015;49(3):313–7.
30. Fackler ML, Malinowski JA. Ordnance gelatin for ballistic studies. Detrimental effect of excess heat used in gelatin preparation. Am J Forensic Med Pathol. 1988;9(3):218–9.
31. Ploch CC, Mansi CS, Jayamohan J, Kuhl EJ. Using 3D printing to create personalized brain models for neurosurgical training and preoperative planning. World Neurosurg. 2016;90:668–74.
32. Vieira SL, Pavan TZ, Junior JE, Carneiro A. Paraffin-gel tissue-mimicking material for ultrasound-guided needle biopsy phantom. Ultrasound Med Biol. 2013;39(12):2477–84.
33. Rengier F, Mehndiratta A, Von Tengg-Kobligk H, Zechmann CM, Unterhinninghofen R, Kauczor H-U, et al. 3D printing based on imaging data: review of medical applications. Int J Comput Assist Radiol Surg. 2010;5(4):335–41.

34. Chimento J, Jason Highsmith M, Crane N. 3D printed tooling for thermoforming of medical devices. Rapid Prototyp J. 2011;17(5):387–92.
35. Pryor WJ. Injection molding of plastics for dentures. J Am Dent Assoc. 1942;29(11):1400–8.
36. Throne JL. Thermoforming. In: Encyclopedia of polymer science technology; 2002.
37. O'Reilly M, Hoffmann S, Hess L, Peterson-Perry S, Martin A, editors. Low-tech, High-fidelity Models for a Robust Ultrasound Curriculum. Council on Resident Education in Obstetrics and Gynecology (CREOG) and the Association of Professors of Gynecology and Obstetrics (APGO) Annual Meeting; 2017; Orlando.
38. Glover T. Pocket ref. 4th ed. Littleton: Sequoia Publishing, Inc.; 2010.
39. AdCo. Proflex 970 hot melt glue sticks; 2011. Available from: https://www.westmerciasupplies.co.uk/media/catalog/PDF/COSHH/80051.pdf
40. DAP Products Inc. Safety data sheet – original contact cement bottle [Online]. http://www.dap.com/media/52165/00030202001english.pdf; 2015. Report No.: 00030202001.
41. 3M. Material safety data sheet 3m(TM) Rubber & Vinyl 80 Spray Adhesive [Online]. http://www.layogev.co.il/wp-content/uploads/2014/05/3M-%d7%aa%d7%a8%d7%a1%d7%99%d7%a1-%d7%93%d7%91%d7%a7-801.pdf, Division IAaT; 2011.
42. Elmer's Products, Inc. Safety data sheet – Elmer's No-Wrinkle Rubber Cement [Online]. http://www.elmers.com/docs/default-source/sds%27s-(safety-data-sheets)/se904.pdf?sfvrsn=2; October 21, 2016. Contract No.: SDS-34.
43. Wilsonart LLC. Material safety data sheet – Wilsonart PVA wood Glue Series [Online]. https://www.wilsonart.com/sites/default/files/docs/resources/technical-information-msds-wilsonart-pva-wood-glue-series.pdf; April 20, 2015. Contract No.: 19023.
44. Puttlitz KJ, Stalter KA. Handbook of lead-free solder technology for microelectronic assemblies. Boca Raton: CRC Press; 2004.
45. Durkee J. Cleaning with solvents: science and technology. Oxford: William Andrew; 2013.
46. Schramm LL. Surfactants: fundamentals and applications in the petroleum industry. Cambridge: Cambridge University Press; 2000.
47. Lecat P, Cropp E, McCord G, Haller NA. Ethanol-based cleanser versus isopropyl alcohol to decontaminate stethoscopes. Am J Infect Control. 2009;37(3):241–3.
48. Kumai M, Koizumi A, Saito K, Sakurai H, Inoue T, Takeuchi Y, et al. A nationwide survey on organic solvent components in various solvent products. Ind Health. 1983;21(3):185–97.
49. Barr WM. Material safety data sheet – Goo Off Heavy Duty [Online]. https://goofoffproducts.com/wp-content/uploads/2017/08/HeavyDutyRemoverMSDS.pdf; April 16, 2015.
50. ATSDR. Toluene. Toxic Substances Portal [Internet]; 2011, August 30, 2018. Available from: https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=29
51. ATSDR. Medical management guidelines for Xylene. Toxic Substances Portal [Internet]; 2014 August 30, 2018. Available from: https://www.atsdr.cdc.gov/mmg/mmg.asp?id=291&tid=53 - bookmark01.
52. Gojo Industries Inc. Material safety data sheet – GOJO® ORIGINAL FORMULA™ Hand Cleaner. Gojo Industries, Inc.; 2018. Contract No.: 400000000198.
53. New England Fabric and Foam. Foam-fit-function [Online]. http://www.newenglandfoam.com/.Available from: http://www.newenglandfoam.com/
54. Merica BJ. Medical moulage: how to make your simulations come alive. Philadelphia: F.A. Davis Company; 2011.
55. Engineers NBoC. Handbook on pet film and sheets, urethane foams, flexible foams, ridgif foams: Asia Pacific Business Press; 2018.
56. Cornell J. The 6 best things about memory foam matress: Lulu Press, Inc; 2015.
57. Props T. Creating a costume/Cosplay from E.V.A foam [Online]. https://www.instructables.com/id/Creating-a-CostumeCosplay-from-EVA-Foam/. Available from: https://www.instructables.com/id/Creating-a-CostumeCosplay-from-EVA-Foam/

Common and Best Practices for Do-It-Yourself Enhancements

20

Robert F. Stump

Introduction

Medical simulation is a relatively new area of medicine, with historical roots [1]. There is much to be discovered and much to be learned. There is considerable low-hanging fruit, with many inventions, techniques, and discoveries to be found and crafted. It is clear that simulation is the right place for students and experts alike to make their mistakes. Simulation also provides a venue to learn the appropriate response to high risk, infrequent events that must be trained, even though they are unlikely to occur.

Medical simulation is like a "Large Piece of Turf" (Fig. 20.1) encompassing vast regions of medicine [2]. Simulation now is a critical part of training in emergency medicine, surgery, obstetrics and gynecology, disaster medicine, nursing, and many other medical fields. Simulation has demonstrably made medical professionals better and has likely saved many lives. The use of simulation has spawned entire industries dedicated to the manufacture of medical skill trainers, manikins, simulated drugs, and much more. This chapter mainly focuses not on the commercially available simulation devices or manikins but on the do-it-yourself, home-brew approaches to simulation enhancements. However, a few commercial products are named, if they provide a role in the technologies described.

As a new field, it has been difficult to properly publish the many creations of those involved in this fledgling area. Often, simulation journals have stipulated that any new medical simulation device or technique must be evaluated using medical residents, nursing students, or medical students prior to publication. This policy recently has been reaffirmed [3].

R. F. Stump (✉)
Department of Emergency Medicine, Texas Tech University Health Sciences Center, El Paso, TX, USA
e-mail: robert.stump@ttuhsc.edu

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_20

Fig. 20.1 Albrecht Dürer—The Large Piece of Turf, 1503

These requirements have allowed many important ideas to be lost, only to hopefully be rediscovered later. Even upon rediscovery, it is difficult to obtain peer-reviewed publication without studies showing application among learners. Without a way to document and build upon this knowledge, the field of simulation runs the risk of losing new technologies. Events like this have happened before on an exaggerated level with the burning of the Library of Alexandria during the reign of Julius Caesar in 48 BC. There is a serious and compelling need for a venue for peer-reviewed publication of new devices and techniques in simulation. It is an extraordinary researcher who can design a meaningful simulation experiment, but innovation too should be documented and allowed to be displayed for evaluation and improvement by others.

The hard sciences of mathematics, physics, electrical engineering, and many other fields long ago have implemented the appropriate solution to this publication dilemma. New techniques, improvements, and inventions are readily published. There is no requirement for population testing, and in fact, no evidence of immediate utility is usually necessary. Without this facile, unimpeded declaration, devices like the transistor, the laser, and the cell phone would not have prominent places in human advancement today.

Because of the difficulty publishing novel simulation ideas in hardcopy, peer-reviewed form, most of the truly original simulation topics only are found during

meetings (i.e., Spectrum of Ideas at IMSH) and without published summaries. The themes of these unusual thoughts are like apparitions in the night—transiently seen, but rarely recorded.

Other ideas are exclusively published online. The problem with online sources is that they are dynamic. An attempt to access information that was readily available yesterday may find moved or broken links and be lost today. Tips and tricks that are considered valuable today may be "obsolete" and deleted from a website tomorrow. An occasional page even contains a virus or other malicious software. All of this is a disservice to individuals new to simulation, who may have never seen many of these tricks. Due to the ephemeral nature of websites and simulation information ("simformation"), this chapter will attempt to briefly summarize the content of the sources referenced.

Many true innovations in simulation have their roots in the fields of physics, chemistry, mechanics, electronics, and biomedical engineering. As such, ideas may be submitted to the journals of these disciplines, beyond the niche of simulation. However, this denies publication to the real intended audience—individuals who devise and practice medical simulation. Many simulation journals have difficulty recruiting qualified research-minded reviewers to assess and advocate for publication and dissemination of these ideas.

This chapter is an attempt to elucidate some of the buried ideas in simulation. It is just a peek, and not an encyclopedia. Many of the original inventors of these techniques have been lost to time. Many of the techniques are simply repeated from unknown and unreferenced original sources, and have become part of the folklore of simulation. This chapter is an effort to make available innovations and technologies to be used as tools and a building block for others in the pursuit of technical and educational advancement for healthcare and patient safety.

Best Practices Versus Common Practice

The Merriam-Webster dictionary defines a best practice as "a procedure that has been shown by research and experience to produce optimal results and that is established or proposed as a standard suitable for widespread adoption" [4].

In the field of medical simulation, almost everything is a common practice instead. The optimal results in simulation are at this point unrealized, and likely not yet discovered. Experience requires substantial time to occur. Decades from now, the best practices will be more obvious.

Manikins, Modifications, Makeup, and Food Products

A careful approach to the modification of manikins is advised. While a manikin is still under warranty, any homemade adaptation may void the warranty. After the warranty period, feel free to make any changes that do not negatively alter the manikin. Manikins that do not have fully functioning systems or computer interfaces are still valuable, since they can be hacked in good conscience.

Additionally, the use of makeup and moulage merits discussion. Many moulage products, especially ones with color, can be difficult to remove from manikin skin and may permanently damage the skin. It is always wise to test makeup, adhesives, and moulage on an old manikin skin or in a place on the manikin where permanent damage is less noticeable.

A multitude of the modifications and homemade simulation models discussed use food products. Many simulation laboratories object to this approach because food grows bacteria or mold, and it attracts insects like ants and flies.

The prime reason that food is so frequently used is that there is no cheap, convincing substitute for actual tissue. There are wound suturing trainers available, but they are relatively expensive. A high-end 3D printer (Stratasys® [5]) has been used to create neurosurgical models to train an appropriate approach to specific pathology [5, 6].

What is needed is a material that can be 3D printed with a different density or pattern to emulate the skin, muscle, fat, fascia, and peritoneum from a single material. Perhaps the answer lies in a different slicing software for 3D printers that could implement these layers from CT images. This would simplify fabrication of unique ideas and would be a boon to surgeons seeking to practice complex, and perhaps never performed, operations prior to the real thing.

New Technologies: 3D, Microprocessors, Circuit Boards, and Laser Cutting

We live in a great time for advancement of simulation technologies. There are many new, very effective devices on the market. A few will be highlighted here based on experience and use. However, excellent tutorials on the setup and use of multiple other tools are also offered on the web.

Excellent and very inexpensive 3D printers and supplies are readily available. For example, the Monoprice® Mini printer (~$220 US) and 3D Solutech® PLA (polylactic acid) 1.75 mm diameter filament, purchased in 1 kg spools (~$25 US), have been used successfully by many healthcare simulation technology specialists (HSTSs). Anyone who can draw a design on paper can use a CAD (computer-aided design) program to draft the same device. There is a free online program TinkerCad for this purpose that will produce universally acceptable files [7]. The finished CAD design can be saved as ".STL" and then changed to "G-code", the mechanical instructions for a 3D printer, by using slicing software. Free programs, such as Cura® from Ultimaker®, can be used to slice the object and produce G-code [8]. G-code then is sent to the 3D printer, and a few minutes to hours later, the design is ready to evaluate. The process is fast, easy, and allows rapid prototyping.

There also are many microprocessors available, which can be used to implement new machines and to augment old ones. Microcomputer processors such as the Arduino® and Raspberry Pi® are small and versatile devices. The base device cost for these two products is ~$20–$35, respectively, and they can be easily programmed using programming languages such as C, C++, and Python. There are many

examples of their use on the internet, and they are readily interfaced to sensors and radio transceivers.

An Arduino® and some home-brew electronics can make a number of interesting simulation devices. One of these is a simulated radiation detector (Figs. 20.2 and 20.3) [9]. Current radiation training uses actual low-level radioactive materials to give students something to find. This simulated detector uses RFID tags and an RFID tag reader to spoof radiation at levels from background

Fig. 20.2 This cold war Victoreen CDV-715 radiation survey meter has been converted to read RFID tags and then to simulate a predetermined amount of radiation with each tag. Similar RFID tags are used in corporate ID badges and can be read through a manikin skin or moulaged wounds. RFID tags also can be placed safely on a standardized patient (actor), since no actual ionizing radiation is present

Fig. 20.3 The bottom of the simulated radiation detector, displaying the RFID reader, and associated home-brew circuitry

up to completely lethal levels, without the use of any dangerous ionizing radiation. This is a much better solution to the principal of ALARA (as low as reasonably achievable) [10].

Many simulations use live actors instead of manikins for authentic learner reactions. Taking advantage of this interaction, a device that can mimic a pulse that is either sinus rhythm or atrial fibrillation, with a variable rate of 0–300 beats per minute, was created using an Arduino® board. This solution uses miniature speakers to generate the pulse and can be placed at any pulse point, including the radial, femoral, posterior tibial, or carotid (Figs. 20.4 and 20.5) [11]. Future improvements

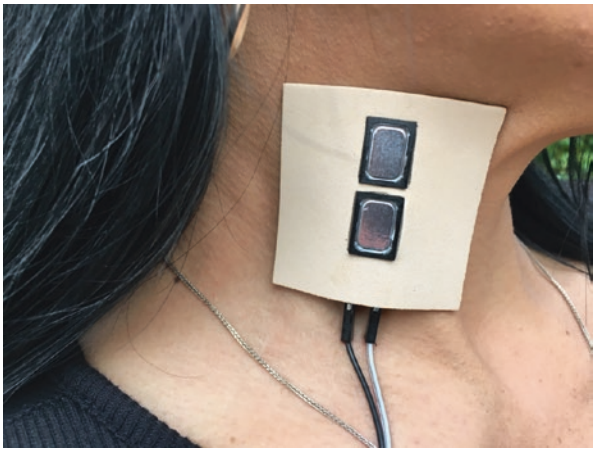


Fig. 20.4 A simulated pulse can be placed over a standardized patient's own pulse, in this case at the carotid artery. Associated circuitry provides a simulated pulse from 0–300 beats per minute, with either a regular or irregular rhythm

Fig. 20.5 A simulated pulse-generating speaker is placed over the standardized patient's radial pulse

in this device could allow pulses to be controlled at multiple body locations, with differing intensity and arrival times, allowing simulation of complex medical conditions like aortic dissection and coarctation on a standardized patient, not just a manikin.

A remote-controlled neonatal resuscitation manikin has also been created using an Arduino®-like Adafruit Feather 32u4® microprocessor [12], a pair of nRF24L01 2.4 GHz transceivers, and a "La Newborn First Yawn 15-Inch Real Boy" child's doll [13]. This innovation uses an RGB LED in the head of this doll, allowing a mimic of cyanosis by changing the color of the LED to blue. A well perfused baby can be similarly mimicked by changing the color of the LED to pink or red. All of these functions can be controlled remotely using a radio-frequency (RF) control (Figs. 20.6, 20.7, and 20.8). This innovation can be used for teaching basic bag-valve-mask techniques, but cannot be intubated with the doll described.

EAGLE, from Autodesk, is a circuit design software program to allow the creation of files to make printed circuit boards (PCB) [14]. This software is downloadable for free to educational users. This program allows easy design of circuit boards, and readily generates the "Gerber" files that are sent to the board manufacturers [15]. EAGLE has many electronic parts and devices in the native library, and many others can be installed from electronics suppliers' libraries. Many companies exist to produce boards, one such example is Gold Phoenix in China [16]. Other printed circuit board manufacturers can be found on the Adafruit website [17]. A quote from Gold Phoenix can be obtained in a few hours by emailing the

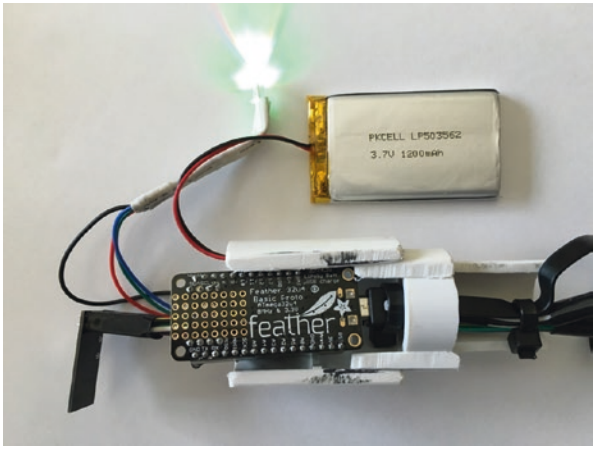


Fig. 20.6 The electronic circuitry for the receiver portion of a neonatal resuscitation trainer. Parts include a Feather® microprocessor (center), lipo battery (above), RGB (red-green-blue) LED (green light above), and nRF24L01 radio transceiver (left)

Fig. 20.7 Radio-controlled electronics assembly with LED is inserted into the doll's head

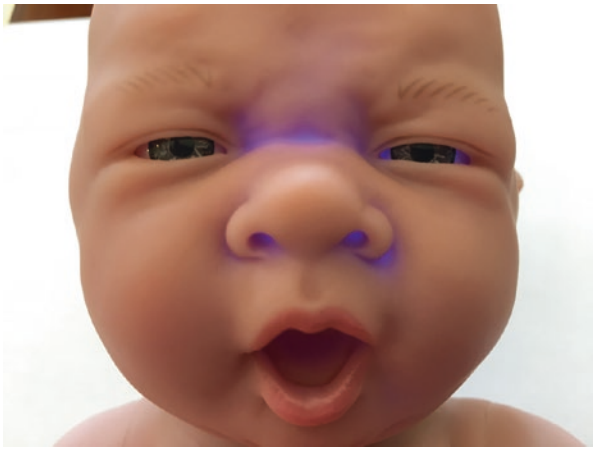


Fig. 20.8 Fully assembled neonatal trainer, with simulated cyanosis

zipped Gerber files to their sales office. Boards typically arrive within a few weeks following payment. Prototype boards can be ordered as "2 layers, 0.062", FR4-TG130, 1 oz., HAL, green solder mask, two side mask, white silk screen, two side silk." Electrical testing is offered, but is not routinely required if simply being used for prototyping.

Laser cutting is still largely out of the realm of hobbyists due its danger from high powered lasers and carcinogenic fumes, as well as the machine expense. There are, however, several internet firms which provide laser cutting of thin metals, relatively thick plastics, foams, and paper. Pololu in Las Vegas, NV is one such company [18]. Laser cutting instructions can be created and transmitted using the .SVG file format. This can be output using the CorelDRAW® program. To create the file, lines that are to be cut should be "hairlines" in CorelDRAW®, and the line thickness set to zero in TurboCAD®. Other line widths can be used to encode specific cut depths, with a design plan sent to the manufacturer for clarification. Many other design plan formats, including PDF, also are acceptable [19].

General Sources of Simformation

A valuable and expanding source of simulation knowledge can be found on Kam McCowan's "Behind the Sim Curtain" website [20]. This website contains a plethora of information including daily sim operation checklists, moulage, manikin modifications, and scenarios. It is a great example of the low-tech, low-cost movement in medical simulation.

Another valuable website with simformation is the SimTech moulage site [21]. It has downloadable moulage recipes from Jackie Langford, as well as moulage tips and tricks from Suzanne Lortie-Carlyle and Karen Paquette [22, 23]. This site includes links to various simulation manufacturers and their moulage suggestions.

TheSimTech.com also shows several videos such as those by Tim Shea, from the North Dakota STAR program. He discusses a wide range of moulage and simulation topics, and gives the clothing and shoe sizes of some manikins [24].

The "HomeGrown Simulation Solutions" website curated by the International Nursing Association for Clinical Simulation and Learning (INACSL) site publishes ideas in simulation, providing online peer-reviewed publication of simulation ideas [25].

Moulage and Body Fluids

Moulage is a very effective method for making a scenario real (Fig. 20.9). Sights, sounds, and smells drive human emotion, and the addition of these helps to immerse the learner in the moment. A modest amount of the smell of blood, a serious wound with shrapnel, and some screaming or gunshots in the background can help to stage an event.

Fig. 20.9 A standardized patient with moulage for a radioactive dirty bomb scenario, including shrapnel (white arrows)

Blood

A homemade blood product that has appeared in multiple discussions of moulage consists of Ivory® dishwashing detergent, red food coloring, starch, and iron tablets for the smell of blood [22]. It is simple to make and very effective.

Vomit

A simple recipe for emesis uses parmesan cheese, lemon juice, and crushed garbanzo beans [26]. It is quick and effective. Add a trace of flat beer for that "I might be drunk driving" effect.

Sputum/Mucus

A mixture of gel-based hand sanitizer, water-based lubricating jelly, vegetable glycerin, distilled water, and watercolor paint (yellow or green) is recommended as a method to make sputum. This combination is thick and slightly stringy and will resist mold growth due to the alcohol-based hand sanitizer component [27].

Urine

Urine can be generated from water or dilute tea, starch or milk (for sediment), and yellow food coloring [22]. A few drops of ammonia can be added for odor and red food coloring for hematuria.

Poop

A disgustingly realistic method for producing manikin defecation has been devised using a substance called "schkin" [28]. Schkin is made up of petroleum jelly and baby powder (the full recipe is described below). In this case, brown paint was added for the effect of the poop color. Some HSTSs even devised a method for remote-controlled defecation for use during a scenario. It is crude, but offers a successful way to present gastroenteritis or rectal bleeding.

Positive Guaiac Test

A guaiac test is used to test for hidden blood in feces. A positive test can be simulated using the blood from ground beef, or the juice of a squeezed apple as it reacts with the reagent used for testing.

Bruises

New bruises can be created using the Ben Nye® CK-1 bruise palette (or burgundy, black, green, and purple regular makeup) daubing the makeup in roughly equal portions over the region and then smearing it to create the final bruise [29]. Older bruises can be made by a similar technique, but use more burgundy and green [30]. A helpful hint is to start with the darker colors first and move toward lighter in subsequent layers.

Burns

Partial thickness burns can be produced by using red Saran® wrap applied to skin with Spirit Gum (a theatrical glue) [31], or with Vaseline® [32], and smoothed to eliminate any bubbles. The addition of liquid latex or Elmer's® glue at the edges, followed by red makeup, can add depth and realism. Shaved pencil lead or a small amount of powdered charcoal are added to simulate soot or third-degree burns.

A very realistic but complex method to create acid burn has been described by Goldie Starling [33]. This chemical burn uses safe antacid tablets, like Alka-Seltzer® spritzed with water to create the bubbling effect of the acid. The tablets are ground up and sprinkled over an existing moulaged wound. The resulting effect is dynamic and very convincing.

Closely tied to the making of moulage burns is a do-it-yourself (DIY) escharotomy trainer. A simple-to-build escharotomy device was made from a red foam yoga mat, saran wrap, a thin polystyrene packing foam sheet, rubber bands, and white cloth tape. These can be applied in successive layers to a trauma manikin and the outer tape layer colored to simulated burnt skin [34]. This contraption allows students to first draw proposed escharotomy incisions and then to cut them with realistic subcutaneous elasticity.

Frostbite

Moderate frostbite can be created with Ben Nye® white cream makeup, plus a small amount of black mascara [35]. More profound frostbite is made using more black mascara to simulate necrosis [36].

Lacerations

There are many methods for making realistic lacerations. It is worth noting that very few lacerations are clean. Many contain dirt, grease, sawdust, metal flakes, gunpowder, or other debris. The HSTS should feel free to improvise to match the conditions of each scenario. Below are a couple of techniques.

Wax Wounds

Apply Ben Nye® Nose and Scar Wax to the skin of a manikin or standardized patient with Spirit Gum adhesive. The wax should be pressed against the skin to assist with adhesion and to make a thin layer. Once applied, it can be tinted with makeup to make it look traumatic, and a tongue depressor, the back of a knife, and a spatula are used to create an indentation or line (the laceration). Stage blood can be added as a final effect to the indentation [37]. A nice final touch is to have a drop of blood dripping from the wound.

Silicone Wounds

Silicone wounds can be made by creating a plaster of Paris mold applied over modeling clay formed into a shape for the initial design. After the plaster is set, the clay can be removed, and the mold is cleaned using isopropyl alcohol. A silicone product, like Dragon Skin® from Smooth-On® mixed in a 1:1 ratio and colored using a silicone-based pigment (Silc Pig®), is placed in the mold. A similar process using a silicone-based mold is described in Chap. 19. When the silicone solidifies, the wound can be moved from the mold and painted. Molds are reusable and can easily make 10s to 100s of copies of a wound, although there is some degradation of detail with each copy.

An innovative technique for making silicone appliances has been created by Tim Shea at the ND STAR Simulation Center. He uses clear household silicone (GE Silicone I®, GE Silicone II®, or DAP® 100% Silicone Caulk) and then adds 5–10 drops of glycerin per ounce of silicone to make it cure faster. It also can be cured more quickly by spraying it with water. Like other silicones, these can be dyed with commercial silicone pigments or with acrylic paints. A more realistic color for blood can be obtained by adding a small amount of blue pigment to the red as it is mixed.

Schkin

"Schkin" is a versatile putty-like moulage substance that can be used for making lacerations, burns, or adding texture and detail to almost any type of skin moulage. It is even used (as discussed above) to mimic feces. It is based from a thickened petroleum jelly and colored to match the skin of the manikin or standardized patient to which it will be applied. Recipes to make schkin are listed below:

Recipe 1 (small batch) [38]
- 2 oz. petroleum jelly
- 3 oz. baby powder
- 2.5 ml Skintone (949) Folkart Acrylic Paint (for color)

or
- 2.5 ml Nutmeg Brown (20432) Apple Barrel Colors Paint (for color)

Recipe 2 (large batch) [39]
- 26 oz. petroleum jelly
- 48 oz. corn starch
- 2–6 Tbs cocoa powder (for color)

Weigh or measure the desired amount of petroleum jelly. Using a double boiler or hot plate, gently heat the petroleum jelly in a heat tolerant mixing bowl until liquid. Remove from heat and stir in coloring agent (paint or cocoa powder). Once the color is incorporated, slowly add the cornstarch until a thick dough-like consistency is formed. Once cooled, additional cornstarch can be mixed into the "dough" and kneaded until smooth. The finished material can be stored in a cool dry environment and used to make lacerations, to embed impaled objects, or even to paint on additional skin-based moulage [38, 39].

Manikin Enhancements and Task Trainers

An interesting series of modifications to a manikin dental set have been described by replacing the existing upper tooth plate using an acrylic dental model [40]. These changes allow for commonly encountered intubation hazards such as decayed teeth, loose teeth, and an overbite. In one variation of the model, pressure on a tooth with a laryngoscope generates a tooth avulsion.

Anaphylaxis is a rapidly evolving medical emergency due to allergic reaction. It is associated with rash, hypotension, and swift airway compromise. A system for creating a rash under the skin of a manikin uses remote-controlled LEDs to simulate anaphylaxis similar to the neonatal manikin discussed above [41].

A method to create a manikin ear that produces a thermal output to allow the use of tympanic thermometers has been demonstrated [42]. This device uses a 9V battery and two infrared (IR) LEDs, with fixed value and variable resistors to mimic temperatures from 34 to 41.9 °C. This allows actual tympanic thermometers to

measure a realistic temperature from the manikin. This IR source can model values from hypothermic to febrile and possibly septic.

Pneumatic otoscopy with insufflation is a valuable skill used for the diagnosis of otitis media in children. A manikin with a removable cartridge in each ear is filled with different amounts of fluid behind the tympanic membrane, allowing learners to practice the correct amount of air pressure for insufflation and to correctly diagnose otitis media [43].

Partial seizures in infants and children are a particularly frightening phenomenon for parents and healthcare providers alike. Partial seizure activity is frequently associated with serious medical conditions such as malignant, infectious, toxicological, or traumatic processes. While some manikins have the ability to demonstrate whole body tonic-clonic events, partial seizures involve isolated movements. A simple mechanical method for simulating partial seizure has been developed using the force from a bicycle brake lever and cable [44]. This system uses the bicycle brake assembly to move a single arm on a commercially available manikin, a minimal but efficient method to demonstrate a partial seizure.

Melanoma is a relatively common but deadly form of skin cancer found in all races. Once present, it can manifest in virtually any organ of the body. It can reappear years after remission making early recognition and treatment essential to management. A melanoma trainer, using prefabricated benign and malignant lesions, has been developed for training medical students [45]. This technique using lesions designed from polyurethane foam and silicone facilitates provider detection of benign and malignant skin lesions.

Bone marrow aspiration and trephine biopsy has a pivotal role in the practice of hematology and oncology. A bone biopsy requires penetration of epidermis and dermis, subcutaneous fat, muscle, periosteum, and compact bone prior to reaching the desired medullary marrow cavity. The physician feels resistance as the biopsy needle passes through the epidermis, dermis, fat, and muscle, and perceives increased resistance as the needle touches cortical bone. Penetration of cortical bone requires a twisting movement of the needle, until it pierces into the medullary bone marrow. These layers have been simulated by using an injection pad (epidermis, dermis, fat, muscle), compressed chipped wood sheet (periosteum and cortical bone), and balsa wood (medullary bone marrow). This method allows realistic practice of bone marrow biopsy on a manikin [46].

Epistaxis (“nose bleed”) is a medical complaint that requires immediate attention due to the persistence and prominence of the location for bleeding. An unfortunate few with epistaxis will have retrograde flow of blood into the eyes via the lacrimal duct, which connects the nose and the inner canthus of the eye. Bleeding from the eyes has apocryphal implications and generates excitement in the most stoic of patients. A homemade epistaxis trainer has been devised using IV tubing routed through the nares on a CPR task trainer. This model simulates bleeding through the pressure of an attached pneumatically enhanced red-colored IV bag system [47]. Treatment options such as balloon tamponade and nasal packing can be repeatedly practiced with this training apparatus.

One of the most technologically advanced notions found in the medical simulation literature details an innovative method for providing haptic feedback to providers during epidural anesthesia [48]. A magnetic tracker is used to monitor needle position, while four brushless motors provide haptic resistance mimicking each tissue layer. This method can be generalized to any needle puncture technique.

Open Surgical Techniques

One method for allowing tactile surgical procedures is demonstrated by Robert Kerner using a project box with realistic skin layers covering contained simulated anatomy [49]. The described device allowed training for the management of intrathoracic hemorrhage during a code, with a heart and bleeding vessel (i.e., leaking tubing) inside. This type of box system could be used for any surgical training with appropriately contained anatomical models.

The placement of chest tubes for pneumothorax or hemothorax is a frequently required procedure in the emergency department or operating suite. One suggested simulation of chest tube placement uses a lamb chest wall, attached to a plastic enclosure [50]. A camera is placed interior to the ribs, so that assessment of the intrathoracic portion of the procedure can be achieved.

A chest tube simulation method using no food products has been developed using designed plastic, rubber, and foam materials to emulate the dermis, subcutaneous fat, muscle, and ribs (Figs. 20.10 and 20.11) [51, 52]. This apparatus has many admirable qualities—it is durable, reusable, and readily reconfigured for each learner.

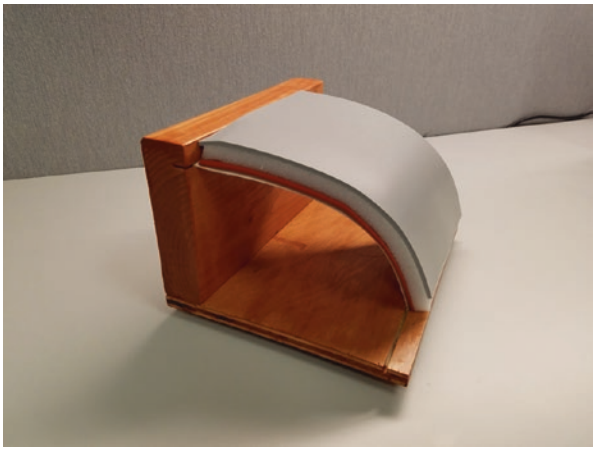


Fig. 20.10 A multilayer chest tube task trainer with dermis, subcutaneous fat, and muscle layers over the ribs

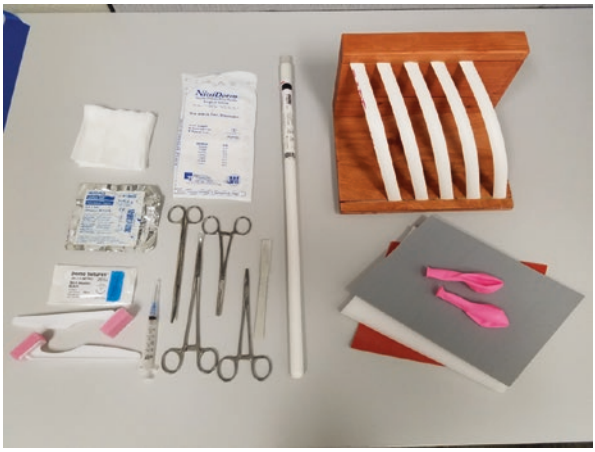


Fig. 20.11 Equipment for simulated chest tube insertion

Cervical cerclage is a surgical technique that is used to treat cervical insufficiency in pregnant patients. Cervical cerclage uses an encircling suture to keep the uterine cervix from premature dilation prior to actual labor. A trainer for this surgical technique has been constructed using PVC pipe and cow muscle (i.e., pot roast) to fashion a cervix with realistic consistency [53].

Vaginal and total abdominal hysterectomies are complex gynecologic procedures. Recent advances in robotic and laparoscopic surgery have limited resident opportunities to perform these vital procedures. A realistic simulator for vaginal hysterectomy has been fabricated from a uterus-shaped wooden part, with simulated broad ligaments, uterosacral ligaments, utero-ovarian ligaments, uterine arteries, and bladder attached to a resin pelvis on a reconfigurable frame [54]. A model for total abdominal hysterectomy has been created from foam board, an egg-shaped foam part (uterus), balloons (for ligaments, fallopian tubes, and uterine arteries), foam balls (ovaries), thin cotton batting (loose areolar tissue), and plastic wrap [55].

Several methods for modeling a second-trimester uterus have been described. One of these allows multiple cervices, with varying dilation and texture [56]. Another uses an adult pig heart and a fetal pig to create a uterine model that can be used for ultrasound and extraction of a fetus [57].

Circumcision of neonatal males can be simulated by…wait for it—cocktail wieners [58]. This scheme allows practice with a Mogen or Gomco clamp, both designed to make circumcision easier. Wieners (i.e., circumcision simulation trainers) can even be frozen in bulk for future use.

Dentists are accustomed to working in the deep, narrow territory of the mouth, but physicians typically are not. A simple training device for the drainage of peritonsillar abscesses can be constructed from a balloon filled with simulated abscess material glued to the base of a paper cup. The cup is then filled with red gelatin and cooled. Just prior to use, the gelatin is cut away to outline a uvula adjacent to the abscess for landmark identification [59].

Podiatrists use sharp dissection to remove unhealthy tissue from diabetic foot ulcers. A method for training this uses the outer skin of a grapefruit to simulate the thickened epidermis of a foot. The pith of the grapefruit skin is similar to a necrotic skin ulcer, and the inside of the fruit is viewed as viable tissue [60]. Appropriate use of this model allows rehearsal of debridement at varying depths.

A brilliant use of modern technology uses the 3D images provided by CT and MRI scans to plan and practice microsurgical clipping of brain aneurysms [61]. This method imports the CT/MRI data to OsiriX, a DICOM image processing program, and then to Blender, a 3D animation and modeling program. Digitized aneurysm clips and appliers can then be manipulated within a virtual model to find the best surgical approach.

Laparoscopic Techniques

A simple DIY laparoscopic simulation device has been shown using the camera on an Ipad® to provide visualization of the instruments inside of a laparoscopic surgical box trainer [62]. This innovation allows the operator to make the transition from real-world 3D vision to the 2D images viewed through a laparoscope. This is one of the most important student skills required to progress from beginner to expert laparoscopic surgeon. A related laparoscopic model allows practice working within the 30-degree visual field of the instrument by mounting a small camera at the expected oblique angle during visual training and tool manipulation inside of a laparoscopic surgical box trainer [63].

Cystoscopy has been trained using a boar's bladder with an 8–12 cm length of penile urethra, attached to a frame [64]. This model has been successfully used to train six skills: (1) to assemble a rigid cystoscope, (2) to assemble a resectoscope, (3) to perform a cystogram, (4) to perform cystoscopy, (5) to retrieve a foreign body, and (6) to obtain a bladder biopsy.

A fascinating method of teaching laparoscopic techniques uses a clementine (an orange and mandarin orange cross). This exercise requires that the student must remove the peel in as few fragments as possible, then to remove the albedo (the fibrous tissue between the fruit segments), and finally to return the clementine to as near the original state as possible using laparoscopic instruments. This is a truly laborious task that requires considerable planning and experience [65].

Ultrasound (US)

A fantastic resource and review of ultrasound phantoms for training recently has been summarized by the Ultrasound Training Solutions® website [66]. This compendium contains phantoms made from a wide variety of materials. Innovative phantoms made from everything from ballistic gel to tofu to Spam® are described. This site shows construction of models for US guided biopsies, IV access, nerve blocks, and many other medical procedures.

Fluoroscopy

A novel spine phantom has been demonstrated using a PVC spine model embedded in a thermoplastic polymer gel [67]. This mechanism is realistic for both fluoroscopy and CT scan. Although this model does not mimic the multiple tissue layers involved in performing a lumbar puncture (LP), it does allow practice of technique and can provide approximately 200 punctures before repair. Model restoration can be performed by reheating the gel to 110 °C for 3–4 hours.

Conclusion

There has been much progress in the field of medical simulation in the past decade, but there are many new wonderful things yet to be discovered. It is critical that fresh technical ideas are published quickly and completely. The author supports this practice without the additional requirement of human validation studies.

References

1. Owen H. Unexpected consequences of simulator use in medical education: a cautionary tale. Simul Healthc. 2014;9(3):149–52.
2. Dürer A. The Large Piece of Turf. In: Albrecht Dürer – The Large Piece of Turf -GAPj, editor. Google Art Project. [Online] https://commons.wikimedia.org/w/index.php?curid=217923921503
3. Scerbo MW. Some changes in store for the journal. Simul Healthc. 2017;12(2):67–8.
4. Merriam-Webster. Best practice. [Online] https://www.merriamwebster.com/dictionary/bestpractice.
5. Stratasys. Make modern manufacturing happen. [Online] http://www.stratasys.com/. Available from: http://www.stratasys.com/.
6. Waran V, Narayanan V, Karuppiah R, Thambynayagam HC, Muthusamy KA, Rahman ZAA, et al. Neurosurgical endoscopic training via a realistic 3-dimensional model with pathology. Simul Healthc. 2015;10(1):43–8.
7. TinkerCad. From mind to design in minutes. [Online] https://www.tinkercad.com/; 2017. Available from: https://www.tinkercad.com/
8. Ultimaker. Ultimaker Cura software. [Online] https://ultimaker.com/en/products/ultimaker-cura-software; 2017. Available from: https://ultimaker.com/en/products/ultimaker-cura-software
9. Stump RF, editor. A novel low-cost simulated radiation detector. In 3rd Asia Pacific meeting on Simulation in Healthcare; 2016 November 16, 2016; Singapore.
10. Centers for Disease Control and Prevention. ALARA-As Low As Reasonably Achievable; 2015 June 25, 2017. Available from: https://www.cdc.gov/nceh/radiation/alara.html.
11. Stump RF. A method for generating a microprocessor-controlled synthetic pulse on a standardized patient. Simul Healthc. 2016;11:442.
12. Adafruit. Adafruit Feather 32u4 Basic Proto. [Online] https://www.adafruit.com/product/2771. Available from: https://www.adafruit.com/product/2771
13. JC Toys. JC Toys 18504 La Newborn First Yawn 15-Inch Real Boy Vinyl Doll. [Online] https://www.amazon.com/gp/product/B001DNVD90/ref=oh_aui_detailpage_o05_s01?ie=UTF8&psc=1 [cited 2018 September 18th].
14. Autodesk. Eagle – PCB design made easy. [Online] https://www.autodesk.com/products/eagle/overview; 2017 [cited 2018 September 18th]. Available from: https://www.autodesk.com/products/eagle/overview

15. Spark Fun. Using EAGLE: board layout. [Online] https://learn.sparkfun.com/tutorials/using-eagle-board-layout/; 2017 [cited 2018 September 18th]. Available from: https://learn.sparkfun.com/tutorials/using-eagle-board-layout/ - generating-gerbers
16. Gold Phoenix PCB. [Online] http://www.goldphoenixpcb.com/ [cited 2018 September 18th]. Available from: http://www.goldphoenixpcb.com/
17. Ladyada.net. [Online] http://www.ladyada.net/library/pcb/manufacturers.html; 2011 May 17, 2011. [cited 2017]. Available from: http://www.ladyada.net/library/pcb/manufacturers.html
18. Pololu Robotics and Electonics. [Online] https://www.pololu.com/ [cited 2018 September 18th]. Available from: https://www.pololu.com/
19. Pololu Robotics and Electonics. Instructions for laser cutting file setup. [Online] https://www.pololu.com/docs/0J24/5; 2017 [cited 2018 September 18th]. Available from: https://www.pololu.com/docs/0J24/
20. McCowan K. Behind the Sim Curtain. [Online] https://sites.google.com/site/sshtog/home. Available from: https://sites.google.com/site/sshtog/home
21. Howes A. Moulage. [Online] http://thesimtech.com/moulage/: thesimtech; 2017. Available from: http://thesimtech.com/moulage/
22. Langford J. Moulage recipes. [Online] http://thesimtech.com/s/Art-of-Moulage-Recipes.pdf. Available from: http://thesimtech.com/s/Art-of-Moulage-Recipes.pdf
23. Lortie-Carlyle S, Paquette K. Moulage Tips and Tricks Workshop; May 25, 2017. Available from: http://thesimtech.com/s/Moulage-Tips-and-Tricks-by-Suzanne-Lortie-Carlyle-and-Karen-Paquette.pdf
24. Shea T. ND Star: Moulage. [Online] https://youtu.be/HvE4v2h-958. YouTube; 2013.
25. Simulation Innovation Resource Center. HomeGrown Simulation Solutions. [Online] https://sirc.nln.org/homegrown/. National League for Nursing; 2017.
26. Behind the Sim Curtain. Emesis. [Online] https://sites.google.com/site/sshtog/props/emesis. Available from: https://sites.google.com/site/sshtog/props/emesis
27. Avkin. AVTrach user manual. [Online] https://diamedicalusa.com/wp-content/pdf/AVTRACH_USER_MANUAL.pdf
28. Behind the Sim Curtain. Get the Bed Pan!! [Online] https://sites.google.com/site/sshtog/props/get-the-bed-pan. Available from: https://sites.google.com/site/sshtog/props/get-the-bed-pan
29. Rowland J. Behind the Sim Curtain [Internet]. McCowan K, editor. [Online] https://sites.google.com/site/sshtog/moulage/bruising. Behind the Sim Curtain. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/bruising
30. Rowland J, McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/bruising-old. Behind the Sim Curtain. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/bruising-old
31. Rowland J. McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/burn-partial-thickness-of-hand. Behind the Sim Curtain. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/burn-partial-thickness-of-hand
32. Rowland J. McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/burn. Behind the Sim Curtain. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/burn
33. Starling G. FX makeup series: acid burns. [Online] https://youtu.be/vyHQMfDDXjg. YouTube; 2013.
34. Burns E. Build your own Escharotomy man! [Online] https://sydneyhems.com/2014/08/30/build-your-own-escharotomy-man/2014. Updated August 30, 2014. Available from: https://sydneyhems.com/2014/08/30/build-your-own-escharotomy-man/
35. Rowland J, McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/frostbite-moderate. Behind the Sim Curtain. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/frostbite-moderate
36. Rowland J, McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/frostbite. Behind the Sim Curtain. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/frostbite

37. Rowland J, McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/laceration. Behind the Sim Curtain. [cited 2017]. Available from: https://sites.google.com/site/sshtog/moulage/laceration
38. Makalinaw T, Manning E, McCowan K, editors. [Online] https://sites.google.com/site/sshtog/moulage/schkin-recipe. [cited 2018]. Available from: https://sites.google.com/site/sshtog/moulage/schkin-recipe
39. Rich H. Moulage recipes. 2007 September 20, 2018: [3 p.]. Available from: http://www.cert-la.com/downloads/moulage/moulage-recipes.pdf
40. Mehta NN, Miyasaki SH, Hirsch J, Fidler RL. Easy-to-implement oral cavity modification to expand simulation-based training in airway management. Simul Healthc. 2014;9(4):260–3.
41. Hellaby MD. Anaphylaxis simulation session: seeing is believing. Simul Healthc. 2011;6(3):180–3.
42. Kelly MA, Forbes JR, Carpenter C. Extending patient simulation: a novel prototype to produce tympanic thermal output. Simul Healthc. 2012;7(3):192–5.
43. Morris E, Kesser BW, Peirce-Cottler S, Keeley M. Development and validation of a novel ear simulator to teach pneumatic otoscopy. Simul Healthc. 2012;7(1):22–6.
44. Lemke D, Feux D, Doughty C. A novel mechanism for simulation of partial seizures in an infant. Simul Healthc. 2012;7(6):359–61.
45. Macgregor CA, Donnell MK, Haley AC, Martini M, Robinson JK. Melanoma trainer using simulated back skin: an innovative design. Simul Healthc J Soc. 2012;7(4)
46. Yap ES, Koh PL, Ng CH, de Mel S, Chee YL. A bone marrow aspirate and trephine simulator. Simul Healthc. 2015;10(4):245–8.
47. Pettineo CM, Vozenilek JA, Kharasch M, Wang E, Aitchison P. Epistaxis simulator: an innovative design. Simul Healthc. 2008;3(4):239–41.
48. Magill JC, Byl MF, Hinds MF, Agassounon W, Pratt SD, Hess PE. A novel actuator for simulation of epidural anesthesia and other needle insertion procedures. Simul Healthc. 2010;5(3):179–84.
49. Kerner R. Open heart surgery on a human patient simulator. [Online] https://vimeo.com/12305465. Vimeo; 2010.
50. Ghazali A, Breque C, Léger A, Scépi M, Oriot D. Testing of a complete training model for chest tube insertion in traumatic pneumothorax. Simul Healthc. 2015;10(4):239–44.
51. Crawford S. Chest tube task trainer setup. [Online] https://www.youtube.com/watch?v=8VyrY80mC5U&feature=youtu.be. YouTube; 2016.
52. Crawford SB, Huque YI, Austin DE, Monks SM. Development and review of the Chest tube High-feedback Educational Simulation Trainer (CHEST). Simul Healthc. 2019; https://doi.org/10.1097/SIH.0000000000000361.
53. Nitsche JF, Brost BC. A cervical cerclage task trainer for maternal-fetal medicine fellows and obstetrics/gynecology residents. Simul Healthc. 2012;7(5):321–5.
54. Barrier BF, Thompson AB, McCullough MW, Occhino JA. A novel and inexpensive vaginal hysterectomy simulator. Simul Healthc. 2012;7(6):374–9.
55. Hong A, Mullin PM, Al-Marayati L, Peyre SE, Muderspach L, Macdonald H, et al. A low-fidelity total abdominal hysterectomy teaching model for obstetrics and gynecology residents. Simul Healthc. 2012;7(2):123–6.
56. York SL, Migas S, Haag J, Liu Z, Stiller R, McGaghie WC, et al. Creation and initial assessment of a second-trimester uterine model. Simul Healthc. 2014;9(3):199–202.
57. Shumard KM, Akoma UN, Street LM, Brost BC, Nitsche JF. Development of a novel task trainer for second trimester ultrasound-guided uterine evacuation. Simul Healthc. 2015;10(1):49–53.
58. Roca P, Alvarado C, Stausmire JM, Farooq S, Hill-Engstler EA. Effectiveness of a simulated training model for procedural skill demonstration in neonatal circumcision. Simul Healthc. 2012;7(6):362–73.
59. Bunting H, Wilson BM, Malloy KM, Malekzadeh S. A novel Peritonsillar abscess simulator. Simul Healthc. 2015;10(5):320–5.
60. Jackson A, Rajbhandari S. Developing a grapefruit model for assessment and training of diabetic foot ulcer debridement. Simul Healthc. 2014;9(5):331–6.

61. Marinho P, Vermandel M, Bourgeois P, Lejeune J-P, Mordon S, Thines L. Preoperative simulation for the planning of microsurgical clipping of intracranial aneurysms. Simul Healthc. 2014;9(6):370–6.
62. Lockhart E. [Online] http://blog.simsingularity.com/?p=962. SimSingularity. 2012. [cited 2018]. Available from: http://blog.simsingularity.com/?p=962
63. Daniel LE, Tapia FM, Arturo MM, Ricardo OF. Adapting to the 30-degree visual perspective by emulating the angled laparoscope: a simple and low-cost solution for basic surgical training. Simul Healthc. 2014;9(6):384–91.
64. Grimsby GM, Andrews PE, Castle EP, Wolter CE, Patel BM, Humphreys MR. Urologic surgical simulation: an endoscopic bladder model. Simul Healthc. 2011;6(6):352–5.
65. Andreatta P, Marzano DA, Curran DS, Klotz JJ, Gamble CR, Reynolds RK. Low-hanging fruit: a clementine as a simulation model for advanced laparoscopy. Simul Healthc. 2014;9(4):234–40.
66. Ultrasound Training Solutions. DIY Ultrasound Phantom Compendium. [Online] https://www.ultrasoundtraining.com.au/foamus/diy-phantom-compendium; 2018 [updated August 24, 2018]. Available from: https://www.ultrasoundtraining.com.au/foamus/diy-phantom-compendium
67. Faulkner AR, Bourgeois AC, Bradley YC, Pasciak AS. A robust and inexpensive phantom for fluoroscopically guided lumbar puncture training. Simul Healthc. 2015;10(1):54–8.

Role and Goal of Industry in Education and Patient Safety

21

Graham A. Whiteside

Abbreviations

AACOM	American Association of Colleges of Osteopathic Medicine
AAMC	Association of American Medical Colleges
AMA	American Medical Association
AOA	American Osteopathic Association
CEO	Chief Executive Officer
CFO	Chief Financial Officer
CIO	Chief Information Officer
CMO	Chief Medical Officer
CMS	Centers for Medicare & Medicaid Services
COO	Chief Operating Officer
CRADA	Combined Research and Development Agreement
CTO	Chief Technology Officer
FAQs	Frequently Asked Questions
HSTS	Healthcare Simulation Technology Specialist
IoM	Institute of Medicine
PPSA	Physician Payments Sunshine Act (2010)
RFP	Request for Proposal
RFQ	Request for Quote
SBARA	Situation, Background, Assessment, and Required Assistance
SIGs	Special Interest Groups
SVP	Senior Vice President
TT	Technology Transfer
VP	Vice President

G. A. Whiteside (✉)
Anatomic Excellence, LLC, Savannah, GA, USA
e-mail: graham@anatomicexcellence.com

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6_21

Introduction

Industry is an all-encompassing term that will be used in this chapter to describe the numerous corporations or vendors who create, market, and sell products or services related to healthcare simulation. This includes companies that manufacture manikins, task trainers, anatomical models, and moulage supplies; audio/video companies that market hardware and software debriefing tools, or integrators who combine existing hardware and software into seamlessly functioning systems; and finally education and learning management companies that design and support software packages to track simulation scenarios, learner performance, and review usage and metrics data to promote the efficient operation of simulation programs. While every company is in business to stay in business, this does not mean financial gain is their only mission. This chapter will describe how these groups can develop a relationship and synergistic existence with end users to foster a more appropriate and long-term relationship that will benefit the educators, learners, and patients to whom they provide care.

During their career, healthcare simulation technology specialists (HSTSs) will use many products and interact with industry team members both at their institutions and during conferences. These relationships are often extremely friendly, but on occasion there will be challenges due to role conflicts, policies, or product and service issues. It is important that these challenges are managed with professionalism and honesty on both sides to avoid misunderstandings and maintain the relationship over time. Challenges can be compounded by the fact that some customers do not recognize industry representatives as stakeholders in the education and patient safety arena. However, many industry team members dedicate their entire careers to improving education practice and patient outcomes, albeit outside of clinical practice or academic research.

The aim of this chapter is to outline the role and goal of the simulation industry as it relates to education and patient safety in order to promote strong relationships between HSTSs, their institutions, and their industry partners. In order to do this, the chapter will explore the varied nature of the companies that support healthcare simulation and the legal and policy environment within which they operate. It will also describe the teams that make up these companies, provide a description of web- and call-based support systems, and outline the individuals with whom HSTSs will engage at their institutions. There are potential conflicts of interest for educators, HSTSs, and their institutions regarding innovations they create when such products are brought to market. Even if a product is designed to improve education or patient care, the potential for monetary gain can call this motivation into question. When this occurs, the line between education and industry can quickly become blurred.

Throughout the chapter there are suggestions on how HSTSs and their institutions might engage with industry stakeholders and representatives from sales, customer service, and product support teams to get the most out of their products and services. Each HSTS should learn and understand how their institution's rules affect these relationships before trying out any of the strategies suggested.

Understanding the Types of Corporations in the Education and Patient Safety Market

The education and patient safety market is made up of companies that provide a wide range of practical and technology-based products and services. The goal of these offerings is to promote improved clinical management and practice through simulation focused on technical and nontechnical skills, which promote safe healthcare practice and quality improvement. The underlying aim of these products and services is to assist and support education, skill development, and teamwork to improve patient safety by promoting best practices and reducing preventable adverse incidents.

The variety of companies within the simulation industry is quite staggering, especially when one realizes that the education and patient safety markets are still often referred to as a "cottage industry." While there are several big players in this market, there are also many small businesses that serve the needs of more specific niche roles in healthcare and education. For most companies, this means that there are limited economies of scale for manufacturing and limited profits; therefore, bringing a product to market is fraught with great risk. The innate altruism of the industry stakeholders and their employees contributes to the success of education and patient safety goals, albeit with the expectation that the risk involved is offset by the potential for monetary gain. Such "return on investment" will allow for additional product "research and design," enabling further improvement to healthcare education and training practices through innovative simulation technologies. Because the risk is so great, only financial growth from successful relationships and products that improve healthcare outcomes will allow the industry to continue developing better products. During interactions with industry team members, the HSTS should consider that those in the industry share a similar drive, fascination with, and enjoyment of working within education and patient safety.

In order to assist the HSTS to further this understanding, Table 21.1 provides a summary of the key characteristics of the types of companies that exist within the industry. This information focuses on the level of specialization in the education and patient safety market and the type of company managing a product, service, or warranty issue. Each company is unique with respect to its market engagement and product or service specialization. Understanding a company and its team can help to foster an appropriate relationship based on its size, type of product or service offered, and the need it fulfills for an institution.

While companies thrive on sales, they are best served individually and collectively when they work as stakeholders within the education and patient safety realm to provide functional and highly utilized solutions. There is a tendency for some people to see the industry as an entity that must be kept at arm's length to prevent a conflict of interest. While elements of this are reasonable, companies and their representatives will try to influence purchasing decisions in a professional and reasonable manner. Many organizations have enacted policies to reduce any perceived influence on buying decisions.

Table 21.1 A broad overview of corporation types in education and patient safety

Company type	Broad description
Manufacturers	Manufacturers produce and sell products either directly to consumers or in aggregate using distributors. These companies may be single owner/employee groups that make one product or large organizations with diverse product portfolios that can form total solution bundles that reach a global market. They manage their own product warranty issues and may provide custom product development services. Larger companies can sponsor regional education conferences and support grant and budget writing assistance. Smaller companies will focus on their product(s) and product support
Manufacturer/ Distributors	Manufacturer/distributors are companies that sell other manufacturers' products to fill gaps in their own product offerings. These companies will often have a preferential relationship with suppliers and can provide products as a sole source provider. They may have in-house expertise to handle both their own, and their supplier's, product and warranty issues; or they may only be able to handle tier 1 product and warranty issues for the products that they distribute
Distributors	Distributors are companies that sell products created by others and add value through subject matter expertise and/or marketing capabilities. These groups may be solely aligned with the healthcare simulation market or may be part of a larger and more diversified product portfolio. As they are not primary producers, distributors may have limited ability to provide product support and warranty directly
Resellers	Resellers act as a storefront focusing entirely on sales at a regional/local level. Some healthcare knowledge and product inquires can be handled during sales discussions, but often non-healthcare specialists may be providing products and services. Resellers usually manage multiple product lines that may or may not be in related markets. Product and warranty issues are referred to the manufacturer
Publishers	Publishers are companies that create, print, and assemble material from content experts. This material may be in print or digital, and products commonly include websites, books, periodicals, or computer software designed for education and training. They will often solicit content from clinical, education, and industry expertise to use in generating material. They also provide marketing and sales expertise to ensure the success of their publications
Technology transfer/seed companies	Companies that grow out of an academic or clinical institution's drive to commercialize a product that was developed in-house and bring it to market, both for the greater good and commercial profit. These companies usually create products to meet a clinically or educationally identified need. Their products may evolve as they receive feedback from new customers who work with them to optimize their product/service
Consultants	Consultants are individuals or teams that have relevant knowledge and experience within the healthcare, education, and simulation industries who are brought in to assist with planning organizational level changes. They will make recommendations on future design, structure, and practice
Consolidators/ solution providers	Consolidators are companies that offer solutions by using the resources of varied contractors, experts, and product manufacturers. They assist with the sourcing of products and implementation of services that others may find difficult to integrate
501(c)(3) nonprofit organizations	Organizations described in the internal revenue code as public charities. They are organized and operated exclusively for tax-exempt purposes, and none of the earnings may pass through to a private shareholder or individual. This does not mean they cannot make a profit; the adage "no money, no mission" means that they must generate revenue to cover administrative and program costs to continue the mission of the organization over time. Additionally, a 501(c)(3) nonprofit may not attempt to influence legislation or engage in political activity

Industry stakeholders are aware of the rules around conflict of interest and understand that there are purchasing requirements that affect the ability of HSTSs and their institutions from interacting with an industry representative at specific times, e.g., during a request for proposal (RFP) or request for quote (RFQ) process. It is important that these rules do not restrict the educator or patient safety team from discussing, reviewing, and evaluating a product or service that could improve current training or enhance the educational curriculum. This communication is vital, as the industry representatives must thoroughly understand the needs of a center to be able to recommend products or strategies for implementation. This is especially true when an institution wishes to explore a significant capital investment.

Separate from institutional rules that relate to interactions with industry stakeholders, an HSTS should understand how companies are structured and how they operate. An important consideration is that many companies have a 3- to 5-year plan. These are reviewed on a regular basis and require "replanning" for each subsequent year as early as September/October of the current year. This usually means that by September/October, most companies will have identified the following year's sales revenue targets for their marketing and sales team, the national and local conferences at which they wish to exhibit, their sales strategy and processes, staffing needs, acquisition of demonstration equipment, and the budget that will enable them to meet these goals. This process is painstaking and is based on years of previous sales revenue history, market research, and the interpretation of the data provided to the company's management and leadership by their team members. Thus, the management teams will plan and maintain a focused strategy, while the frontline team members in marketing, sales, and customer support are allowed some flexibility to react to customer and market needs. All of this is done so that they can meet their sales revenue, cost management, and professional development goals.

For example, frontline sales team members are expected to plan their travel and workload 6–8 weeks in advance yet remain somewhat flexible. Consequently, they may not be able to adapt immediately to sudden requests for the loan of demonstration or consumable equipment at short notice. Within the industry there are a couple of sayings that are frequently used: "Failure to plan is planning to fail," and "Your emergency is not my urgency." Industry stakeholders will usually try to assist customers with last-minute needs even if they could have been anticipated. In fact, customer requests for products to be sent overnight to meet their course needs or bail them out of a difficult situation are frequent. In many cases the urgency is rarely the fault of a single person, and as such most industry team members are pleased to help when they can, but there are limitations to their capabilities.

For instance, many products are made using "just-in-time" and "lean" manufacturing processes, which means that they are made to order, so there is not a large volume of inventory for sales or demonstration sitting on a shelf waiting to be shipped. Lead times (the time from order placement to delivery) is frequently anywhere from 4 weeks to 12 months, depending upon the demand and specialized nature of the product. The 2-day shipping capabilities of Amazon and others have created an expectation that is rarely deliverable considering the scale of the education and patient safety industry. Demonstration equipment is also committed on a first come, first served basis, with pre-planned customer demonstrations and

pre-purchase trials taking precedence over free equipment loans for workshops and short notice requests. Except for the use of simulation to analyze a recent patient safety event, there is little in the education and patient safety world that cannot be preplanned, and there is rarely a true simulation emergency.

Industry team members travel frequently and spend long periods of time away from their home, families, and office. While the career is obviously a personal choice, there are reasonable side effects of the required work schedule. For instance, when an "emergency" hits, they may not be able to respond to your call, email, or text in the time frame that you need. They may be on another call, driving, or flying to an appointment. They may also need to confer with or refer you to an office-based colleague who will try to help you instead. It is important for the HSTS to recognize that any actions they take to put out a customer's fire can come at a significant cost. In fact, everything a company does for the HSTSs and their institutions, including demo equipment loans, consumable product giveaways, expedited shipping, marketing pieces, literature, refreshments during meetings, and entertainment at conferences, adds to the list price of their products and services.

Such an understanding is particularly important, as pricing is the most contentious issue discussed between education and patient safety teams and industry partners. There are frequent questions from buyers regarding the high-perceived cost of products in this market. It is worth remembering that the cost of an industry-developed product covers many hidden expenditures that are higher than the production costs of the products, such as human resources, product research and development, raw materials, utilities, factory equipment, marketing, and sales costs to name just a few. These costs are seldom considered when an institution creates its own version of a product. While innovation has been previously discussed in Chaps. 19 and 20, time to innovate is not a free resource, even if the HSTS designs something using easily available components to create small batches of products. Therefore, institutions often cite that they can make a product more cheaply, which in some cases is true, but in many not entirely accurate as they have not factored in the cost to produce the product at scale or cover ongoing technical support. Many institutions will only account for the cost of the raw materials, without adding any hardware, software, machinery, facilities costs, utilities costs, or the time and cost for the person who creates the product. They also may not account for "opportunity cost versus opportunity lost," which considers how much time is taken up by small batch creation versus the other things that the HSTS could have been doing for the institution's benefit during the time spent innovating.

Within the industry, price setting is as much an art form as it is a science. There are many different price mechanisms and strategies that can be employed by the marketing teams. At a basic level, an HSTS should consider the adage, "You can have it cheap, fast or good; but you can only pick two." This can be interpreted in several ways:

- If you want it cheap, it will take longer to make, or it will be of poor quality due to the use of inferior raw materials or rushing it out of the factory door.
  - Which do you prefer: cheap and fast or cheap and high quality?

- If you want it fast, it will be more expensive as the company must put more resources into manufacturing or may not have time to research good quality, inexpensive materials. Or it may be of lower quality due to the factory using whatever materials are on hand and rushing it to you.
  - Which do you prefer: fast and cheap or fast and high quality?
- If you want high quality, the factory can take the time to use refined design and manufacturing techniques to make a quality product, or the company can spend money on production facilities, processes, or supply chain systems that enable them to ship it faster.
  - Which do you prefer: higher quality and cheap or higher quality and fast?

The industry is constantly searching for ways to trim its costs and provide the education and patient safety market with easy to use, cost-effective products and services. Just-in-time and lean manufacturing are two ways in which companies prevent their cash from being tied up in wasted resources, but these can affect delivery and supply times. Therefore, industry representatives will encourage you to plan your needs as far ahead as possible to ensure that the products and services you need are provided in a timely and cost-effective manner.

Whether or not your institution resembles the above remark, the ability for HSTSs to identify and recommend cost-effective solutions will be greatly appreciated by their institutions. Understanding the total cost of ownership and applying the principles associated with it is a skill that will assist the HSTS in making long-term recommendations. This concept requires the HSTS to identify the planned use of the product being assessed, including predicting all elements of cost before the product is purchased. This allows the HSTS to compare products using balanced data, so that he or she can recommend the most appropriate and sustainable solution.

For example, when comparing two central venous catheter task trainers, Product A may have the highest initial cost, yet lower costs for consumables over time. Product A may also be ultrasoundable and have pulsatile blood flow, skin that does not show track marks, and blood vessels that self-seal. Product B may have a lower initial cost but more expensive consumables. If this model, while ultrasoundable, leaves needle track marks that distort the image and confuse the next user or has blood vessels that do not seal well, resulting in blood pooling within the trainer, the lower utility may not justify the initial cost savings. The sticker shock of the higher initial price of Product A may put the institution off; however, a thorough assessment of the proposed use model and a cost comparison might show that over 3 years, Product A will cost the institution much less and be more useful than Product B.

Table 21.2 outlines a format for performing a total cost of ownership and planned use review in relation to a request for a nursing manikin.

Finally, the industry is often asked to improve its products through research and to develop higher quality devices. Enhancements such as improved standardization between batches and increasingly realistic human tissue or physiological responses are desired in order to meet education goals and satisfy standards. This development is expensive, especially considering that few standards are universal across the

Table 21.2 Product selection and total cost of ownership assessment template

Product Selection & Total Cost of Ownership Assessment Template

Training Requirement:	**Nursing care of the bedbound patient -** Procedures will include: patient positioning, sheet changing with the patient in bed (with and without patient assistance), pressure area care, preparation of the patient for transport, eye care, oral hygiene care, tracheostomy care (including suction and trach changes), SC/IM injection technique (gluteal, thigh and arm).
Simulation Style Chosen:	Manikin-based training
Purchase Partner Programs:	Risk Management and Occupational Health Programs

Purchaser Contact:	Linda Greaves	**Department:**	Nurse Recruitment
Telephone:	900 900 9000 ext 900	**Email:**	lgreaves@abchospital.com
Program Payment Address:	Purchasing Dept, Suite 1010, ABC Hospital, Infirmary Road, Savannah, GA 31000		
Program Delivery Address:	Simulation Lab, Floor 5, Suite 5100, ABC Hospital, Infirmary Road, Savannah, GA 31000		

Identified Product / Service for Review			
Capital Product Name:	Nursing Care Manikin 101		
Capital Product Code:	NURSE101	**Price:**	$1,200.00
Consumable Product Name:	NC101 Injection Pads - arm		
Consumable Product Code:	NURSE101-AP	**Price:**	$40 each
Consumable Product Name:	NURSE101 Injection Pads - thigh and gluteal		
Consumable Product Code:	NUSRE101-T&G	**Price:**	$50 each
Bespoke Specifications to be discussed with Vendor:	None		

Vendor Name:	Nurse Manikins LLC		
Sales Contact:	David Graham	**Email:**	david.graham@nursemanikins.com
Telephone:	800 800 8007	**Fax:**	800 800 8001
Customer Service Contact:	Helen Kathryn	**Email:**	helen.kathryn@nursemanikins.com
Telephone:	800 800 8000	**Fax:**	800 800 8001
Technical Services Contact:	n/a	**Email:**	n/a
Telephone:	n/a	**Fax:**	n/a
Vendor Address:			

Alignment with User Requirements		
Notes: NURSE101 also has features that allow for NG tube insertion, nasal and oral airway care, urinary catheterization, enema and suppository insertion. Currently used for Program 10-100-01 at the Nightingale Nursing School.	**Does not meet specifications - Cannot be adapted**	
	Does not meet specifications - Can be adapted	
	Meets specifications	
	Exceeds Specifications	
	Exceeds Specifications - Adds value for multiple program requirements	**Yes**
	Excess features - These have no value to any program at the institution	

Quality Indicators						
Product History:	**Prototype**		**New (<1 Year)**	Yes	**Proven (> 1 Year)**	
Demo Performed:	**Date**	No	**Site**		**Staff Present?**	
Objective Validation:	**Date**	Yes	**How?**	X	**By whom?**	
List Reference Articles:	None identified.					
List Testimonial Sites:	Nightingale Nursing School - Simulation Lab.					
Compare Testimonial Site:	**Is the identified testimonial site comparable to your program?**				Yes	
	Testimonial site's availability of trained users?				Always	
	Testimonial site's frequency of use?				Weekly	
	Testimonial site uses product within design specifications?				Always	

Procurement Decision and Use Plan					
Product / Service Decision:	Buy	**Why (not)?**		**Delay Purchase Until Date:**	
Purchase Plan:	2 models in current budget year, replace every 3 years. Possibly buy 2 more in 1 year.				
Volume Required:	2		**Frequency Required:**		12 sessions per year
Product Life Span (Years):	3		**Replacement Frequency:**		Every 3 years
			Begin Replacement Sourcing:		
Manufacturer's Warranty:	1 Year		**Warranty Options / Cost:**		None
Product Lead Time:	4 Weeks	**Product Needed Date:**	Oct. 30th	**Order By Date:**	Sept. 4th (8 Weeks)

Initial Cost Assessment							
Initial Cost Assessment				**Ongoing Cost Assessment**			
Item	**Units**	**Price / Unit**	**Total**	**Item**	**Units**	**Price / Unit**	**Total**
Capital Item	2	$1,200.00	$2,400.00	**Consumable Item / Year**	2	$40.00	$80.00
Consumable Item / Year	2	$40.00	$80.00	**Consumable Item / Year**	2	$50.00	$100.00
Consumable Item / Year	2	$50.00	$100.00	**User / License Fees**	0	$0.00	$0.00
Installation Costs	0	$0.00	$0.00	**Extended Warranty Cost**	0	$0.00	$0.00
Product Training Costs	0	$0.00	$0.00	**Total Repeatable Costs (TRC)**			$180.00
User / License Fees	0	$0.00	$0.00	**TRC multiplied by Product Life Span**		3	$540.00
Extended Warranty Costs	0	$0.00	$0.00	**Initial Investment**			$2,580.00
Total Initial Investment			**$2,580.00**	**TOTAL COST OF OWNERSHIP**			**$3,120.00**

Procurement Details, After Sales Service and Future Recommendations			
PO Approval By & Date:		**PO Number & Date:**	
Purchase Order Placed:		**Sales Acknowledgment:**	
Product Tracking Number:			
Product Received By & Date:		**Product Checked Date:**	
Warranty Renewal:		**Software License Renewal:**	
Product / Service Issues & Resolutions (if any):			
Recommendations for Future:			

education and patient safety domains. Additionally, an institution may end up overlooking high-end features if it can produce or buy a less robust product that is "good enough." The HSTS should be mindful of the potential discord that exists when an institution's expressed needs, development requests, and final decisions do not align. It is also important to consider that industry-sponsored studies are often viewed as tainted due to an inherent conflict of interest that such findings are only to support their product or service. This may create a double standard as education and healthcare institutions demand greater rigor and backing for the products they use while simultaneously questioning the validity of the tools created to aid in the endeavor to improve patient care and safety.

Understanding the Legal Environment of the Education and Safety Markets

The variety of academic and healthcare professionals involved in education and patient safety make it difficult to identify one set of rules, standards, or legal guidelines that govern all interactions between the various stakeholders. Therefore, it is recommended that HSTSs review the internal policies at their institutions and be aware of how they affect their interactions with industry teams. Outside of local institutional policy, there are many professional and special interest group guidelines that follow a similar format. Some of these are listed in Table 21.3.

Conflict of interest is the most commonly cited concern among individuals and special interest groups in relation to education and patient safety, so it is vital that the HSTS understands this concept fully.

Definition

A conflict of interest can be discerned by using a reasonable person standard; i.e. a conflict of interest exists when a reasonable person would interpret the financial circumstances pertaining to a situation as potentially sufficient to influence the judgement of the physician in question. [11]

Although this may seem like a simple statement, the complexity of the standard is exemplified by the American Association of Medical Colleges (AAMC), which released its Conflict of Interest Statement in 2008 [12]. The Institute of Medicine (IoM) recommended changes to the system in 2012 and the Pew Charitable Trusts followed in 2013 (see Table 21.4 for a summary of recommendations) [13, 14]. Subsequently, the AAMC launched the Convey Global Disclosure System in 2016, which is designed as a "central repository where individuals can enter and maintain records of their financial interest" to reduce the workload of physicians and researchers preparing journal submissions or conference talks [15].

In relation to practicing physicians, the Patient Protection and Affordable Care Act (2010), Section 6002, also known as the Physician Payments Sunshine Act (PPSA, 2010) was designed to increase transparency around the financial

Table 21.3 Examples of standards and conflict of interest policies in education and patient safety

Professional body	Standard title
Accreditation Council for Continuing Medical Education	Standards for Commercial Support: Standards to Ensure Independence in CME Activities [1]
American Osteopathic Association	Accreditation Requirements for Category 1 CME Sponsors [2]
American Medical Association	Conflict of Interest Policy [3]
American Nurses Association	Conflict of Interest Policy [4]
American Nurses Credentialing Center	Volunteers Conflict of Interest Disclosure [5]
Association of American Medical Colleges	Conflicts of Interest and Transparency Initiatives [6]
Association of American Medical Society Executives	Conflict of Interest Policy and Disclosure [7]
Council of Medical Specialty Societies	Code for Interactions & Code Signers [8]
Institute for Healthcare Improvement	IHI/NPSF Patient Safety Coalition: Partnership Compact [9]
US Preventive Services Task Force	Conflict of Interest Disclosures [10]

Table 21.4 Recommendations on medical conflicts of interest from the Pew Task Force [14]. (Copyright © 2019 The Pew Charitable Trusts. All Rights Reserved. Reproduced with permission. Any use without the express written consent of The Pew Charitable Trusts is prohibited)

Acceptance of gifts and meals	No gifts or meals of any value should be accepted by clinical faculty members and staff, medical students, residents, clinical fellows, or other clinical trainees from the pharmaceutical, biotechnology, medical device, or medical diagnostics industries or their sales representatives.
Disclosing conflicts of interest	Faculty should be required to disclose to their institutions all industry relationships that relate to their academic activities in teaching, research, patient care, and institutional service.
Industry-funded speaking	Faculty should not accept industry funding for speaking engagements directed toward other faculty, medical students, trainees, patients, community physicians, health professionals, or the public.
Continuing medical education	In general, continuing medical education should not be supported by industry.
Attendance at industry-sponsored lectures and meetings	Faculty, students, and trainees should not attend promotional or educational events that are supported directly by industry.
Pharmaceutical sales representative presence in academic medical centers	Pharmaceutical sales representatives should not be allowed access to any faculty, students, or trainees in academic medical centers or affiliated entities.
Medical device representative presence in academic medical centers	The access of medical device representatives to patient care areas should be limited to in-service training and technical assistance on devices and other equipment already purchased and then only by appointment and with disclosure to and consent from the patients who would be involved.
Curriculum on conflict of interest	Conflict-of-interest education should be required for all medical students, residents, clinical fellows, and teaching faculty
Extension of institutional conflict-of-interest policies to community educational settings	Conflict of interest policies established by academic medical centers should apply to all faculty members regardless of the nature of their relationship to the institution – paid or voluntary, full time or part time, on-site or off-site – and to affiliated institutions participating in the academic medical center's educational and training programs.

Table 21.4 (continued)

Industry-supported clinical fellowships	In general, clinical fellows, residents, and medical students may not accept industry-sponsored fellowships earmarked specifically for clinical training but may compete for industry fellowships awarded for scientific training.
Ghostwriting and honorary authorship	Academic medical faculty and trainees should follow the International Committee of Medical Journal Editors standards for authorship and contributorship. Ghostwriting and honorary authorship are strictly prohibited.
Consulting relationships for research and scientific activities	Faculty and trainees should be permitted to engage in consulting relationships with pharmaceutical and device companies about research and scientific matters.
Consulting relationships for marketing (excluding scientific research and speaking)	Academic medical faculty and trainees should be prohibited from engaging in consulting relationships that are solely or primarily for commercial marketing purposes.
Pharmaceutical samples	An academic medical center should not accept samples unless it determines that there are compelling circumstances to do so. In these cases, it should implement mechanisms for accepting samples that prevent their use as marketing tools.
Pharmacy and therapeutics committee	Ideally, voting members of these committees should not have a financial relationship with industry. In circumstances when this standard cannot be achieved, members with such relationships should be recused from any discussion of, or voting on, a related product, whether the product is manufactured by the company, is a competitor of that product, or is in the same class as that product. All committee members should disclose financial relationships with pharmaceutical and medical device companies, as should practitioners requesting changes or additions to the institution's formulary.

relationships between physicians, teaching hospitals, and manufacturers of drugs, medical devices, and biologics [16]. The Open Payments Program managed by the Centers for Medicare and Medicaid Services (CMS) fulfills the law's mandate and requires manufacturers to submit annual data on payment and transfers of value made to covered recipients. Physicians themselves have 45 days to review their Open Payments data and dispute errors before public release.

Interestingly, this rule defines a "physician" as an MD, DO, a dentist, a podiatrist, an optometrist, or a chiropractor who is legally authorized to practice by the state in which he or she works. However, advance practice nurses, registered nurses, physician assistants, residents, and pharmacists are not covered. Any payments made to them are expected to be passed through to a doctor and are considered indirect payments to the physician, which must be reported under the name of the doctor.

The PPSA's final rule defines affected manufacturers, covered drugs, devices, biological, or medical supply, and payment or transfer of value [16]. In general, a manufacturer is required to report information if its prescription drugs, biologics, devices, or medical supplies require premarket approval/clearance or notification to the Food and Drug Administration and if payment is available for them under Medicare, Medicaid, or the Children's Health Insurance Program. These definitions

are definitively aimed at medical device and pharmaceutical manufacturers and seek to prevent them from influencing patient care. It may be argued then that these rules do not apply to most products and services supplied by the education and patient safety industry stakeholders. However, if an HSTS follows the spirit of these recommendations and the rules of their institution, there is less risk of them being accused of having a conflict interest [17].

The Role and Goal of Corporations in Education and Patient Safety

As mentioned above, many companies within education and patient safety possess a degree of altruism and personal connection with the mission for better patient care. This may be driven from company founders or directly from employees who are truly engaged in the effort to further the evidence and research around education, simulation, and patient safety. Many members of the industry have had healthcare and life experiences that drove them to build their company or to choose their career within the industry. While driven to this goal, realistically no company or group can help to support this mission if the company is not sustainable; and so a balance between profitability and educational philanthropy must be achieved. It is important for the HSTS to appreciate that most companies in the education and patient safety space are small businesses compared to many others in the corporate world. If the net result of products and services sold is not sustainable (i.e., profitable), the company will cease to exist. Remember: No money…no mission…no company…no products or services!

Consequently, the role of the corporation in this field may be broken down as follows:

1. Sell products and services to hit monthly, quarterly, and yearly sales revenue goals that contribute to the company profit in a financially responsible manner.
2. Drive innovation through empirical research and development (R&D), combined research and development agreements (CRADA), and technology transfer (TT) from education and healthcare institutions that encourage improvement in education and patient safety outcomes through their products and services.
3. Support education and patient safety practitioners and special interest groups at an international, national, regional, and local level when practical. For example, there are industrial partnerships with the Gathering of Healthcare Simulation Technology Specialists, Global Network for Simulation in Healthcare, International Nursing Association for Clinical Simulation and Learning, and the Society for Simulation in Healthcare.

In order to have a positive impact on education and patient safety, every activity in which a company engages requires increasing sales, protecting sales relationships, growing market share, and improving profit margins. Without profit a company would not be able to support the development of innovation and integration of

modern evidence-based education and patient safety measures. There are far too many education and healthcare institutions; conferences; and international, national, and local special interest groups for any company to support them all. These constraints also limit the availability of "free" demonstration materials and test equipment for product review or workshops.

The Role and Goals of Individual Corporate Team Members in Education and Safety

As well as understanding the different types of companies with which they are interacting, it is also crucial that the HSTS understand the role and limitations of the industry team members with whom they interact. It is difficult to provide absolutes for this section; while job titles often tell you the major role of an industry team member, they rarely provide the full picture of what their job entails or how busy they may be. Even with the same job title, a role in one company may be significantly different than in another. This is often a reflection of the size of the company and the level of specialization that team member has within their company. Table 21.5 provides the HSTS with an understanding of the administrative and management needs of a corporation. It also lists some of the titles that may describe each role.

An HSTS is most likely to interact with the frontline sales team or customer service and product support teams on a regular basis. The roles of these teams and some tips to promote mutually beneficial relationships are discussed next.

Frontline Sales Representatives

As with corporations, it is important to remember that the goals of the frontline sales team are oriented to profit and costs management. Arguably, they can be broken down as follows:

1. Sell products and services that enable and support the educational aims of the institutional customer while meeting sales revenue and cost management goals set by his or her leadership and management team.
2. Provide pre-purchase information (e.g., sales literature, evidence, presentations, and discussion), product demonstrations, quote, and pre-purchase support.
3. Offer post-purchase support and continued relationship building.

The best salespeople seek to build long-term relationships with you, your team, and your institution. They strive to be viewed as a resource for the benefit of all parties. Naturally, they are expected to use appropriate sales techniques to achieve this goal. Salespeople will likely exhibit product features, report product claims, and describe product benefits; use the technique of sales funneling; and utilize professional selling skills (PSS) training [18, 19]. These techniques are indications of a

Table 21.5 A broad overview of corporate teams and titles across the education and safety industry

Broad need	Various roles and titles
Provider of corporate mission, vision, values, and leadership	Owner, Founder, Chief Executive Officer (CEO), President, Vice President (VP), Chief Operating Officer (COO)
Administration and day-to-day management	COO, General Manager (GM), Administration Manager, Administrative Assistant
Financial responsibility and stability	Chief Financial Officer (CFO), Vice President of Finance, Accountant, Comptroller, Controller, Accounts Receiving, Accounts Payable
Product, service, and technology development team	Chief Medical Officer (CMO), Chief Technology Officer (CTO), Vice President of Technology Development, Vice President of Research & Development (R&D), Director of R&D, R&D Manager, Medical Manager, Design Engineer, Software Engineer, Imagineers, Quality Assurance
IT infrastructure	Chief Technology Officer (CTO), Chief Information Officer (CIO)
Marketing leadership: Conferences, advertising, promotions, and giveaways	Senior Vice President of Marketing, Vice President of Marketing, Director of Marketing, Marketing Manager, Senior Strategic Marketing Manager, Event Manager, Communications Specialist
Corporate sales leadership: Interpreting the mission, vision, and values to drive income	Senior Vice President of Sales, Vice President of Sales, Vice President of International Sales, Vice President of Business Development, Director of Sales, Director of Business Development, Director of Strategic Initiatives
Frontline sales leadership: Managing and driving the sales activities, policies, and teams	National Accounts Manager, National Sales Manager, Business Development Manager, Business Manager
Frontline sales management: Middle tier of management led by experienced sales team members who influence those above and below them	Regional Sales Manager, Regional Account Manager, Senior Program Account Executive
Frontline sales representative: These individuals are often the "face" of a company and the person an HSTS is most likely to meet frequently	Senior Territory Sales Manager, Regional Sales Manager, Regional Account Manager, Sales Executive, Sales Representative, Sales Specialist, Product Specialist, Territory Manager
In-house sales team: A lower cost sales driver	Inside Sales, Inside Sales Specialist, Sales Support Supervisor, Sales Support, Telesales
Customer service: Pre- and post-sales support, depending upon the size of the corporation	Customer Service, Customer Support
Education team: Internal education of all team members and/or external education of customers	Global Education Services Manager, Senior Educational Services Specialist, Educational Services Specialist, Education Specialist, Senior Program Development Manager, Program Manager, Simulation Specialist
Product support team: Technical support of products for pre- and post-sales needs	Group Leader Field Service, Field Engineer, Service Engineer, Technical Support, Director of Customer Support, Manager of Customer Service, Customer Service, Customer Support

process-orientated, responsible, and trained representative. Be aware that "Sell now, sell soon, sell something eventually" is the basis for your relationship as every representative must, at some point, justify their interactions with you and your institution through purchasing activity. Try not to be put off by sales techniques, assuming of course, that the sales representative does not become pushy or manipulative.

It is important to remember that the sales team is restricted by the same national and local rules around conflict of interest as you. In fact, the moment a representative steps foot in your institution to provide you with a product or service, they are bound by the rules of your organization, including those around patient confidentiality. Be clear in identifying any rules that will influence your discussions with them early on. Remember that service is driven by a mutual understanding that any restrictions imposed by the institution are to be followed by both parties [17]. Sales teams are also still subject to corporate expectations around the number of telephone calls, webinars, and visits they must perform per day, per week, or per month. These expectations vary depending on the size of their territory, the availability of demonstration and marketing materials, the cost of the sales process, and the resulting profitability of the products or services provided.

The HSTS should look out for experienced representatives with a body of tacit knowledge gained from years of education, healthcare experience, or sales expertise in the market. Sales representatives have visited numerous institutions and have seen many interventions and models of education for simulation and patient safety. Of course, even the best sales representatives are generally only product experts, not clinical, educational, or procedural experts. Although, many companies are now building their sales teams using people with extensive education and healthcare backgrounds, although even these individuals can lose sight of evolving practices in the clinical environment over time.

Overall, it is reasonable to expect that corporations take the time to train their representatives to understand their product, the evidence behind its need and use, and the how it was designed to meet an education or training goal. While they are trained in specific areas of terminology and product use, some may require gentle correction or education when discussing certain medical procedures or clinical care guidelines. Helping the representative understand the application and need for a product/service will enable them to make better product or use recommendations.

Developing Mutually Beneficial Sales Team Interactions

As in every other partnership, there are implied social expectations that will lead to a strong and mutually beneficial client-sales relationship. Specifically, being polite, informative, and sharing the limitations of your institutions will promote a positive and trusting relationship with your industry partners. Most industry representatives will be willing and happy to manage your account and needs with courtesy and professionalism. However, if you are aggressive, evasive, unresponsive, aloof, indirect, or disrespectful in any way, you may get a response that reflects your contribution to the conversation. Industry representatives will always try to remain

professional and polite, but they are people too, and should be treated with the same respect we all hope to experience ourselves.

Sales team members are driven by targets set by their managers, and sometimes their options to respond to your needs are constrained by organizational and managerial decisions. Corporate working policies and practices can also be a limiting factor for a sales person. For instance, they may have to make a significant number of telephone or face-to-face calls each day that are linked to strict sales revenue targets. These demands and the skill set required to meet them tends to attract people who are competitive by nature, but his or her focus should always be on your needs, in addition to corporate expectations. A good sales representative should only sell you the product(s) you need, rather than the newest gadget, even though they will be under pressure to promote the newest products and services by their leadership. Therefore, when an HSTS or educator is involved in purchasing products or services, they must be prepared to explain the organization's needs and situation clearly and concisely. Table 21.6 lists a range of questions that each should be willing and prepared to answer when speaking with a sales team.

Finally, education and patient safety industry representatives often have a vast territory. This may mean that a single representative covers 10 or more states, and so their ability to respond immediately to your needs may not always be realistic. Sales travel is usually booked four to six weeks in advance, as this allows the representative to make cost-effective travel plans and to make appointments with others in your area.

Customer Service and Product Support Team Members

The overriding goals of the customer service and product support teams are drawn around one simple goal: to promote the appropriate use of the company's products and services by assisting the HSTS and others to plan, integrate, and manage them appropriately. This includes assisting each individual or institution with issues related to the performance of the product or service and warranty claims should they arise. These team members must listen to your concerns and issues in order to handle them in a timely manner, find the best solution to meet your need, and ensure that follow-up takes place.

The company representative will also want to help you in a cost- and time-efficient, mutually advantageous way. Everyone in these roles anticipates the potential for a customer to express their frustrations firmly, assertively and sometimes aggressively. Obviously, the person you talk to is rarely directly responsible for the issues that arise with a product, so be firm yet gentle with them. The HSTS should bear in mind that there are different types of customer service and product support systems; all of which have varying levels of representative experience and skills, issue resolution authority, managerial and technical ability. The first point of contact is likely to be a broadly trained individual that can identify the appropriate level of support needed using a "support matrix." This matrix will allow the company representative to guide you in a stepwise troubleshooting algorithm to assist in determining the cause for the problem encountered or the best department to address the concern.

Table 21.6 Discussing a product or service need with a frontline sales team member

What are your goals – what are you trying to fix … improve … reduce?
What is the current situation?
What do you want things to look like after you implement the solution?
Why is your organization interested in identifying a (new) education or patient safety solution?:
To identify or address identified risks within the clinical environment
Reduce risk of harm to patients through targeted initiatives
Improve individual competence
Improve clinical management and teamwork
Improve education management and teamwork
Improve individual engagement to promote improvements in learning outcomes
To perform formative and summative assessments +/– high stakes testing
Assess, improve and audit institutional systems and processes
Address the limited availability and/or current inefficiency of clinical training sites, faculty availability and/or administrative workload
Meet a regulatory requirement – what is this exactly and can you provide the representative with any reference material?
Other – please explain
Who are the internal and external education and patient safety program customers and what are their needs?
Who are the education, clinical and institutional stakeholders and what are their expectations?
How does education/patient safety fit into the overall organizational strategy and goals?
What is your organizational culture and is it ready to adopt a new product or service in the education/patient safety arena?
What are the technical requirements of the solution?
What is the scope of the project?
Big picture overview?
Timeline?
Constraints or restrictions?
Is the project funded or do you need information to seek funding via an internal process or external grant?
How will purchasing decisions be made and by whom?
Will the organization solicit competitive bids or sole-source the solution?
How will you assess and compare the "Total Cost of Ownership" of a product or service between companies?
What is the amount budgeted for capital expenditure?
What is the amount budgeted for disposable and consumable supplies?
Do you have an ongoing budget identified for ongoing disposable and consumable supplies related to the product or service?

Adapted from LaCombe and Whiteside (2015) – p. 340 – Questions vendors may ask during the initial meeting

Prior to calling or emailing a customer service or product support team, an HSTS should explore the company, product, or service provider's website to see if there are existing resources or guides to help. These resources are usually designed to assist you with managing all issues related to the general use of a product or service. The support and management of product performance and warranty-related issues often vary widely between companies, depending upon their size and the technical nature of their product or service.

Web-based customer support systems are built around some form of trouble-shooting guide or frequently asked questions (FAQs) page on the company's

website. A website may also offer an online customer support technician that can answer queries in real time via text responses. Product manuals and online guides are available for managing the most common questions and issues. There has also been an increase in the use of customer discussion boards or user networks that contain searchable histories in which you will find resolution suggestions from others that have posed the same question. These may also be found on the discussion boards of special interest groups (SIGs); many of these are available through membership with professional societies related to education and patient safety.

Many issues can be resolved without involving customer service by looking through available resources first. From the HSTS perspective, these guides may help in identifying whether there has been an element of "user error" behind an issue that can be easily resolved. It may also prevent multiple postings of a familiar issue in the user forum. Occasionally, it may be discovered that there are issues that are ongoing or need focused attention from the company. Posting and reporting similar problems as others that do not yet have a solution may help to bring attention to a problem and expedite a large-scale solution.

When an HSTS contacts a company, they will notice two basic types of support systems: a one-tier whole service system or a multi-tier system, whereby requests for help go through a series of escalations until the issue is resolved. One-tier customer support systems are manned by experienced, decision-makers, and technically adept individuals who can help you with all aspects of your issues. They are most often found in smaller companies with limited resources, so you may find yourself talking directly to the owner or the chief technical officer of the company. This system can sometimes also be present in larger companies with especially technical equipment that demands expert level support from the beginning.

Three-tier customer support systems are very common and are designed to manage a wide variety of issues and match the company's resources to a time and cost-effective resolution. This type of system is designed to identify the level of each issue reported and escalate the problem to the minimal technical level required to resolve it. Most of the simpler issues will be solved by the first-line support team – tier one – while the fewer but more complex issues that require more sophisticated or in-depth knowledge are reserved for tier three [20]. Support calls are escalated through the system depending upon several factors. For example:

- Tier one – Usually staffed by a trained support staff or a technician who will try to answer the most frequently asked questions and might be able to help with simple setup issues or "how do I do this" questions. Their knowledge may be very broad but superficial, as they are expected to be the primary sorting house for the customer's level of need. Calls will be escalated to tier two when the issue is outside the scope of their ability or if the customer feels that their expectations are not being met at this level.
- Tier two – Usually staffed by an experienced technician who can deal with more technical issues, use of advanced features, or the ability to troubleshoot potential

bugs in a system. Tier two staff will have more experience dealing with difficult issues, as well as upset or angry customers. They usually have more discretion in making decisions about problem resolution and what can be offered to make a customer happy. Most calls should end at this level.

- Tier three – Usually staffed by expert technicians, programmers, and quality assurance staff who can provide in-depth research and investigation to difficult to fix issues or previously unheard-of issues that require examination of source code or mechanical engineering review. In some larger companies, there may even be an escalation team beyond this level that manages public (social media) issues or complaints.

How to Engage with Your Customer Service and Product Support Team

If a problem is encountered with a product or service, be sure to take up that concern or failure directly with the company, their sales representative, or customer service team. Respect the company and do not post your complaint or issue to a community board before it is first discussed with a representative. There is always a possibility for, and in many instances, a component of user error in the setup and configuration of a product or in some cases an unrealistic expectation around the performance of a product. Please remember that negative reports stick in the mind of others, even when they are proven to be inaccurate or based on incomplete data. This may lead to a good product being unfairly viewed as a bad one in the minds of others. Also, please bear in mind that an inaccurate or hurriedly written negative review may paint a negative image of you as an individual or your institution, and can detract from the body of evidence that is being built to support the field of healthcare simulation.

Remember that while the industry takes time to test its products and services, they cannot suit all users and all potential arenas within which a product is used. This can mean that there are some procedures, or approaches to a procedure, which cannot be performed on a specific product. It may also mean that a user can identify and innovate other ways of using a product to meet the needs of an organization or offering suggestions on how to improve a product or service. Careful research and planning will ensure that a purchased product will meet a need and if it doesn't meet your needs, don’t buy it. Users should not plan on modifying a product unless no other option exists for their training needs; but be careful about deciding to use a product outside of the manufacturers recommendations, as this may invalidate the warranty.

Finally, share your frustration and concerns firmly and thoroughly with a customer service or product support team member, but understand that a single call may not fully resolve all the issues. Plan your handling of an issue with a product or service carefully by allowing adequate time to discuss the issue with the company. Describe the issue using facts and first-hand information. A new HSTS may find it useful to use a modification of the SBAR [Situation, Background, Assessment, and

Request (instead of Response)] format to present the information with the company in a concise yet detailed manner [21]. See below for an example of SBAR presentation of a product issue to a customer service or product support team member:

1. *Situation:*
   (a) Provide your name, direct telephone number, and email address.
   (b) Name of your institution and the account number with the company.
   (c) The product name, product code, and serial number for the item with the issue.
   (d) A brief overview of the context in which the issue was experienced.
   (e) A brief overview of the timeline for getting this fixed.

   Example: "Good morning, this is Jane Taylor, an HSTS calling from the simulation lab, at University Medical Center of Savannah in Georgia. We have the Pediatric Manikin Model 5, its product number is 103050709. This morning when we were setting up for an emergency department trauma scenario we noticed that there was no rise and fall of the chest and we couldn't identify why it wasn't working. We were able to complete the training with our second pediatric manikin, but we need to get this resolved ASAP as we have a course on Friday that requires both to be fully functional."
2. *Background:*
   (a) Give a brief overview of the product/service history, including its use and any other issues you have had with it or similar products.
   (b) What was the manikin being used for at the time the issue happened? Be sure to describe who was working with it, any relevant experience they have with the product, and whether the use of the product is within their normal scope of work.
   (c) What was done to resolve the issue so far, including reviewing the manufacturers troubleshooting guide or any other suggestions you have heard about from online forums?

   Example: "We purchased this manikin in June 2017 and received training in July 2017 prior to the new emergency medicine residents starting in August. We have used it weekly since then without any issues and we have the same team working on it now as when it was purchased. I personally set it up and was testing the manikin prior to the course. I attended the on-site HSTS training and went back to the product manual and followed the set-up guide to the letter. When it still didn't work I reviewed the product using the trouble-shooting guide in the product manual."
3. *Assessment:*
   (a) What is working as you would expect on the product?
   (b) What you did or didn't find during the troubleshooting process?

   Example: "The power supply is connected correctly. All the other components including vital signs, pulses and lung sounds appear to be working properly. I cannot see any loose connections; any obviously broken components and I am baffled why this has happened when it was working perfectly well last Wednesday."

4. *Request:*
   (a) What would you like to happen immediately?
   (b) What response would you desire if the issue cannot be resolved over the telephone?
   (c) When will team members be available to assist a field engineer to review the product on location?
   (d) What administrative or operational constraints exist for resolving the issue?

   Example: "If possible I'd like you to guide me through any other trouble shooting protocols you have while we're on the telephone. Although, I only have a maximum of 30 min right now. I can make the product available to a field engineer anytime between now and Thursday morning. In all honesty, I really need this fixed for a dry run at 2 pm on Thursday, as all of the faculty for Friday's simulation will be there."

This strategy will help to remove any frustration from the discussion so that you can get a prompt and acceptable resolution. If it is felt that this is not forthcoming, politely ask for the call to be escalated to another level until it is resolved to your satisfaction.

Conclusion

The education and patient safety arenas are fraught with the potential for misunderstandings led by a lack of knowledge about how both sides of the industry operate. This chapter sought to provide the HSTS with information that supports the role of their industry contacts as stakeholders in the education and patient safety environment. It also aimed to provide suggestions on how to maximize the benefits of their industry interactions.

Industry stakeholders are generally altruistic and well intentioned, even when their actions are driven by the need to maximize profits and reduce the costs of doing business. Following the simple steps identified in the chapter for pre-purchase information sharing, partnership engagement strategies and product/service management will promote timely and cost-effective resolutions to most issues. Every HSTS should recognize and encourage positive industry relationships that are bound by their institutional rules and common sense. This will enable industry partners to provide products and services for the HSTS and their institution to reach and exceed their goals.

References

1. Accreditation Council for Continuing Medical Education. Standards for commercial support. [Online] http://www.accme.org/accreditation-rules/standards-for-commercial-support. Available from: http://www.accme.org/accreditation-rules/standards-for-commercial-support
2. Council on Osteopathic Continuing Medical Education. Accreditation requirements for category 1 CME sponsors. [Online] https://osteopathic.org/wp-content/uploads/2018/03/cme-accreditation-requirements.pdf. American Osteopathic Association; 2018.

3. American Medical Association. AMA conflict of interest policy. [Online] https://www.ama-assn.org/ama-conflict-interest-policy; 1999.
4. American Nurses Association. Conflict of interest policy. [Online] https://www.nursingworld.org/~497a1a/globalassets/ana/leadership%2D%2Dgovernance/conflict-of-interest-policy-and-financial-disclosure-form-2018.pdf; 2017.
5. American Nurses Credentialling Center. Volunteers' Conflict of Interest Disclosure. [Online] https://www.nursingworld.org/~4a18b2/globalassets/certification/ancc-vol-opportunities/ancc-volunteer-conflict-of-interest-and-financial-disclosure.pdf; 2012.
6. Association of American Medical Colleges. Conflicts of Interest and Transparency Initiatives. [Online] https://www.aamc.org/initiatives/research/coi/; 2018. Available from: https://www.aamc.org/initiatives/research/coi/
7. Association of American medical Society Executives. AAMSE conflict of interest policy and procedure. [Online] https://www.aamse.org/page/conflict_of_interest. Available from: https://www.aamse.org/page/conflict_of_interest
8. Council of Medical Specialty Societies. Code for interactions & code signers. [Online] https://www.aamse.org/page/conflict_of_interest. Available from: https://www.aamse.org/page/conflict_of_interest
9. Institute for Healthcare Improvement. Partnership compact. [Online] http://www.ihi.org/Engage/Memberships/Patient-Safety-Coalition/Pages/background.aspx. Available from: http://www.ihi.org/Engage/Memberships/Patient-Safety-Coalition/Pages/background.aspx
10. U.S. Preventive Services Task Force. Conflict of interest disclosures. [Online] https://www.uspreventiveservicestaskforce.org/Page/Name/conflict-of-interest-disclosures; 2018. Available from: https://www.uspreventiveservicestaskforce.org/Page/Name/conflict-of-interest-disclosures
11. Fineberg HV. Conflict of interest: why does it matter? JAMA. 2017;317(17):1717–8.
12. Colleges AoAM. Industry funding of medical education: report of an AAMC task force. [Online] https://www.aamc.org/download/482220/data/industryfundingofmedicaleducation.pdf. AAMC, Washington, DC; 2008.
13. Lichter A, McKinney R, Anderson T, Breese E, Brennan N, Butler D, et al. Harmonizing reporting on potential conflicts of interest: a common disclosure process for health care and life sciences. Washington, DC: National Academy of Medicine; 2012. https://nam.edu/perspectives-2012-harmonizing-reporting-on-potential-conflicts-of-interest-a-common-disclosureprocess-for-health-care-and-life-sciences/
14. Pew Charitable Trusts. Conflicts-of-interest policies for academic medical centers: recommendations for best practices. [Online] https://www.pewtrusts.org/en/research-and-analysis/reports/0001/01/01/conflictsofinterest-policies-for-academic-medical-centers; 18 Dec 2013.
15. Convey.org. Convey global disclosure system. [Online] http://www.convey.org/. Available from: http://www.convey.org/
16. Transparency and Program Integrity – transparency reports and reporting of physician ownership or investment interests. S 301. Sect. 6002; 2010.
17. Pizzo PA, Lawley TJ, Rubenstein AHJJ. Role of leaders in fostering meaningful collaborations between academic medical centers and industry while also managing individual and institutional conflicts of interest. JAMA. 2017;317(17):1729–30.
18. Adams R. What is a sales funnel? The guide to building an automated selling machine. [Online] https://www.entrepreneur.com/article/296526. Entrepreneur.com. 2017. Available from: https://www.entrepreneur.com/article/296526
19. Miller Heiman Group. Professional selling skills. [Online] https://www.millerheimangroup.com/uk/training/foundational-selling/professional-selling-skills/. Available from: https://www.millerheimangroup.com/uk/training/foundational-selling/professional-selling-skills/.

20. Walker G. IT problem management (Harris Kern's enterprise computing institute series). Upper Saddle River: Prentice Hall; 2001.
21. Haig KM, Sutton S, Whittington J. SBAR: a shared mental model for improving communication between clinicians. Jt Comm J Qual Patient Saf. 2006;32(3):167–75.

Additional Recommended Readings

Doyle T, Carovano RG, Anton J. Successful simulation center operations: an industry perspective. In: Kyle RR, Murray WB, editors. Clinical simulation: operations, engineering and management. Boston: Elsevier; 2008. p. 479–88.

LaCombe DM, Whiteside GA. Working with vendors. In: Palaganas JC, Maxworthy JC, Epps CA, Mancini ME, editors. Defining excellence in simulation programs. Philadelphia: Wolters Kluwer; 2015. p. 343–4.

Lewandowksi W. Success with clinical simulation = assessment + planning + implementation. In: Kyle RR, Murray WB, editors. Clinical simulation: operations, engineering and management. Boston: Elsevier; 2008. p. 471–8.

Index

S. B. Crawford et al. (eds.), *Comprehensive Healthcare Simulation: Operations, Technology, and Innovative Practice*, Comprehensive Healthcare Simulation,
https://doi.org/10.1007/978-3-030-15378-6