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Healthcare Simulation Standards of Best Practice™ Simulation Design

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As the science of simulation continues to evolve, so does the need for additions and revisions to the Healthcare Simulation Standards of Best Practice. Therefore, the Healthcare Simulation Standards of Best Practice™ are living documents.

Standard

Simulation-based experiences are purposefully designed to meet identified objectives and optimize the achievement of expected outcomes.

Background

Standardized simulation design provides a framework for developing effective simulation-based experiences for participants. The method of simulation-based experiences incorporates best practices from adult learning[1], educa-

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tion,[2,3] instructional design,[4,5] clinical standards of care,[6,7] and simulation pedagogy.[8-11], and simulation pedagogy[12-16] Purposeful simulation design promotes essential structure, process, and outcomes consistent with programmatic goals and institutional mission and strengthens their overall value in all settings. All simulation-based experiences require purposeful and systematic yet flexible and cyclical planning. To achieve expected outcomes, their design and development should consider criteria that facilitate their effectiveness. Following this standard supports development of relevant/ educationally sound simulation-based experiences.

Criteria Necessary to Meet this Standard

1 Simulation-based experiences (SBE) should be designed in consultation with content experts and simulationists knowledgeable in best practices in simulation education, pedagogy, and practice.
2 Perform a needs assessment to provide the foundational evidence of the need for a well-designed simulation-based experience.
3 Construct measurable objectives that build upon the learner's foundational knowledge.
4 Build the simulation-based experience to align the modality with the objectives.
5 Design a scenario, case, or activity to provide the context for the simulation-based experience.
6 Use various types of fidelity to create the required perception of realism.
7 Plan a learner-centered facilitative approach driven by the objectives, learners' knowledge and level of experience, and the expected outcomes.
8 Create a prebriefing plan that includes preparation materials and briefing to guide participant success in the simulation-based experience.
9 Create a debriefing or feedback session and/or a guided reflection exercise to follow the simulation-based experience.
10 Develop a plan for evaluation of the learner and of the simulation- based experience.
11 Pilot test simulation-based experiences before full implementation.

Criterion 1: Simulation experiences should be designed in consultation with content experts as well as simulationists who are knowledgeable and competent in best practices in simulation education, pedagogy, and practice.

Required Elements:

- Simulation designers should have formal or informal training in simulation pedagogy and practices.
- Suggested methods for developing competency include (but are not limited to):
  - Joining professional simulation organizations.
  - Incorporating the Healthcare Simulation Standards of Best Practice™ (HSSOBP™).
  - Literature survey and review.
  - Mentorship and networking.[17,18]
  - Formal coursework or certification.[18,19]
  - Simulation conference attendance or workshops.[17,18]
  - Continuing education offerings focusing on pedagogy or andragogy.
- Be knowledgeable of ethical standards of simulation-based experiences and adhere to the Healthcare Simulationist Code of Ethics[19] (Follow the HSSOBP™ Professional Integrity).
- Content experts should have a general knowledge of simulation and scenario design principles, debriefing methods, and evaluation approaches.[18]
- Follow the HSSOBP™ Professional Development.

Criterion 2: Perform a needs assessment to provide the foundational evidence of the need for a well-designed simulation-based experience.

Required Elements:

- The needs assessment may include analysis of:
  - Underlying causes of concern (e.g., root cause or gap analysis).
  - Organizational analysis (e.g., Strengths, Weaknesses, Opportunities and Threats analysis).
  - Surveys of stakeholders, learners, clinicians, and/ or educators.
  - Outcome data (e.g., from pilot testing; certification or licensure exams, previous simulation-based experiences; aggregate health care data; patient safety data).
  - Standards (e.g., certifying bodies, rules and regulations, practice guidelines).
- The needs assessment includes examining knowledge, skills, attitudes, and/or behaviors of individuals; organizational initiatives; systems analysis; clinical practice guidelines; quality improvement programs; and/or patient safety goals.
- Use the needs assessment results to guide the development of an overarching goal or broad objective for the simulation, which directs the designer(s) in the development of simulation-specific objectives (Follow the HSSOBP™ Objectives and Outcomes).
- Use the results of the needs assessment to create relevant, innovative, and interactive simulation-based experiences that aim to:
  - Enhance curriculum in the classroom and/or clinical areas.
  - Provide just-in time training in the clinical practice setting.
  - Provide opportunities for standardized clinical experiences.
  - Address relevant and identified competencies.
  - Improve the quality of care and patient safety.
  - Promote readiness for clinical practice.

Criterion 3: Construct measurable objectives that build upon the learner's foundational knowledge.

Required Elements:

- Develop broad and specific objectives to address identified needs and optimize the achievement of expected outcomes. These objectives provide a blueprint for the design of a simulation-based experience.
- Use broad objectives to reflect the purpose of the simulation-based experience and are related to organizational goals.
- Create specific objectives for learner performance measures.
- During the design phase, determine which objectives will or will not be available to the learner(s) before the experience. For example, it may be appropriate to disclose general information and context for the learner (care of a postoperative patient), but specific critical actions (interventions for sepsis) may not be disclosed until the debriefing session. Objective disclosure will be determined by the overall purpose of the simulation-based experience.
- Follow the HSSOBP™ Objectives and Outcomes.

Criterion 4: Build the simulation-based experience to align the modality with the objectives.

Required Elements:

- Develop the simulation-based experience format based on the needs assessment, resources available, learning objectives, the targeted learners, and the type of assessment or evaluation method.
- Choose a theoretical and/or conceptual framework[20-22] based on the identified purpose and the targeted learners (e.g., adult learning, inter-professional teams.[23]
- Select the appropriate modality for the simulation-based experience. The modality is the platform for the experience and includes simulated clinical immersion, in situ simulation, computer-assisted simulation, virtual reality, procedural simulation, and/ or hybrid simulation. These modalities may incorporate, but are not limited to the following: standardized patients, manikins, haptic devices, avatars, partial task trainers, and so forth.[24]
- Develop all simulation-based experiences to include a starting point, structured learner activities, and an endpoint.
  - The starting point represents the patient's initial circumstances or situation when the learners start their engagement in the simulation-based experience.
  - Structured activities are designed for learner engagement (e.g., a simulated case or an unfolding scenario, and/or psychomotor skill teaching/evaluation).
  - The endpoint is the stage at which the simulation-based experience is expected to end; usually, when desired learning outcomes have been demonstrated, time is exhausted, or the scenario can proceed no further.

Criterion 5: Design a scenario, case, or activity to provide the context for the simulation-based experience.

Use a process to design a scenario, case, or activity that ensures the content's quality and validity and supports the objectives and expected outcomes.[25-27]

Required Elements:

- Design the scenario, case, or activity to include:
- A situation and backstory to provide a realistic starting point from which the structured activity begins.
  - The complete picture of this context may be given verbally to the learners, found in the patient's file, or be revealed if requested through adequate inquiry.
- A script for a scenario or case is developed for consistency and standardization to increase scenario repeatability/reliability.
  - Variation from the planned dialogue may add distractions that could interfere with the objectives and affect the validity and/or reliability of the scenario or case, especially when the activity is expected to be run with consecutive groups of learners.
- Clinical progression and cues provide a framework for the advancing of the clinical case or scenario in response to learner actions, including standardization of cues to guide the learner(s).
  - Cues, if used, should be linked to performance measures and used to refocus learners when they stray from the intended objectives.[28]
  - Cues can be delivered to learners in a variety of ways, including verbally (e.g., through the patient, provider, or embedded participant, visually (e.g., through changes in vital signs on a monitor), through additional data (e.g., new laboratory results), and so forth (Follow the HSSOBP™ Facilitation).
  - Planned time frames serve to facilitate the progression of the scenario and ensure that there is a reasonable time to achieve the objectives.[12]
- Identification of critical actions/performance measures that are required to evaluate achievement of scenario objectives.[29]
  - Each measure should be evidence-based. Use content experts to strengthen validity of the simulation scenario and the critical performance measures.

In the case of a purely procedural or psychomotor activity:

- A clear and concise scripted explanation provides the context for the activity to be undertaken.
- A setting represents the clinical environment so the learner(s) can practice or undertake the task in an ergonomics matching the experience in the actual clinical setting.[30]

- Identification of critical actions/performance measures that are required to evaluate achievement of the activity objectives.[31]

Criterion 6: Use various types of fidelity to create the required perception of realism.

Required Elements:

- Design the simulation through attention to physical, conceptual, and psychological aspects of fidelity that can contribute to the attaining objectives. Specifically, this is less about specific "reality" and should instead focus on representing stimuli and cues that would typically be present to drive decision-making and action.[32] These aspects of fidelity must be considered from the perspective of the learners.[33-37]
  - Physical (or environmental) fidelity relates to how realistically the physical context of the simulation-based activity compares to[38] the actual environment in which the situation would occur in real life. Physical fidelity includes such factors as the patient(s), simulator/manikin, standardized patient, environment, equipment, embedded actors, and related props.[39-41]
  - Conceptual fidelity ensures that all elements of the scenario or case realistically relate to each other so that the patient makes sense as a whole to the learner(s) (e.g., vital signs are consistent with the diagnosis). To maximize conceptual fidelity, cases or scenarios should be reviewed by the content expert(s), and pilot tested before use with learners.[39,40]
  - Psychological fidelity maximizes the simulation environment by mimicking the contextual elements found in clinical environments. Some examples include 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 learner engagement.[39,40]
  - Develop the simulation using the appropriate types of fidelity that create the required perception of realism that will allow learners to engage in a relevant manner.[33,36,37,39,42-45]
  - Fidelity should also be broken down to focus on patient, facility, and scenario. This framework would be used in conjunction with the concepts of physical, conceptual, and psychological fidelity to create the highest possible fidelity in each element of the simulation.
- As appropriate, use moulage to replicate features or characteristics of the patient situation and when possible, select manikins that respectfully represents the race and culture of the patients in the scenario to promote the sensory perceptions of learners and support the fidelity of the scenario.[44-46]
- It is important to reiterate the distinction between fidelity and modality or technology. These terms are independent of one another and need to remain so.[32,39] High-technology does not necessarily equate to high-fidelity, and any single modality (manikin, task trainer, etc.) may or may not be high-fidelity without caveat. Not every simulation requires the highest fidelity of realism. Determinations about the degree of fidelity and the implementation of this fidelity need to be determined through the examination of several factors.[33,36,37,39,42-45] These factors may include, but are not limited to:
  - Learner level
  - Learning objectives
  - Available time and resources
  - Available equipment
  - Desired learning outcomes
  - Clinical significance

Criterion 7: Plan a learner-centered facilitative approach driven by the objectives, learners' knowledge and level of experience, and the expected outcomes.

Required Elements:

- Facilitators who have formal training in simulation-based pedagogy.
- Determine the planned facilitative approach during the simulation in the design phase and include preparatory activities.[48]
- If the plan is to have more than one facilitator, applying a structured approach to preplan certain aspects of the prebriefing and debriefing session.[49]
- Facilitators should incorporate evidence-based components of cultural diversity within the simulation design or scenarios.
- Use a level of facilitator involvement that is appropriate to the learner's knowledge, competency and experience.[50,51]
- Predetermine the delivery of cues as part of the facilitation planning to be delivered during the simulation activity.[52]
- Facilitators should be aware and mindful of the learners' diverse cultural differences, values and responsibilities and consider that during the simulation design phase.[53]
- Facilitators should refer to the Healthcare Simulationist Code of Ethics with respect to confidentiality, mutual respect, and creating a safe educational environment.[19]
- Follow the HSSOBP™ Facilitation[47] and Professional Integrity.

Criterion 8: Create a prebriefing plan that includes preparation materials and briefing to guide participant success in the simulation-based experience.[54-58]

Prebriefing activities are intended to establish a psychologically safe learning environment by:

1) Situating the learners into a shared mental model and preparing participants for the simulation-based experience's educational content (preparation).
2) Conveying important ground rules for the simulation-based experience (briefing).

Required Elements:

- Prebriefing should be developed according to the purpose and learning objectives of the simulation-based experience.[54–58]
- Consider the experience and knowledge level of the simulation participant when planning the prebriefing.[54-59]
- Develop preparation materials to assure that participants are prepared for the experience and can meet the scenario or procedural objectives based on the experience's needs assessment and purpose.[54-58,60,61]
- Convey important information to participants regarding expectations, agendas, and logistics before beginning the simulation-based experience.[54-57,59,60]
- Conduct a structured orientation to the simulation-based learning environment including the modality.[55,56,60]
- Establish a psychologically safe learning environment during the prebriefing.[55,57-59]
- Follow the HSSOBP™ Prebriefing: Preparation and Briefing.

Criterion 9: Create a debriefing or feedback session and/or a guided reflection exercise to follow the simulation-based experience.

Required Elements:

Identify the most appropriate debriefing, feedback, or reflective method for the simulation-based experience during the design phase.[62,63]

- Use a planned debriefing, feedback session, or a guided reflection exercise to enrich learning and contribute to the consistency of the simulation-based experiences for learners and facilitators.[64]
- Debriefing and feedback are different, but both are critical elements that should be structured using best practices. In the case of a skills-based or testing simulation activity, debriefing may be replaced by feedback, so the learners are guided to improve further or confirm their practice.[65,66]
- Guided reflection is an intellectual and affective activity that explores the critical elements to gain understanding and insight. It can be integrated with debriefing or accomplished after the event through journaling or open discussions.[65]
- Debriefing facilitators should have formal training in debriefing techniques.[65,67]
- Follow the HSSOBP™ The Debriefing Process

Criterion 10: Develop a plan for evaluation of the learner and of the simulation-based experience.

Required Elements:

- Determine the assessment and evaluation processes in the design phase to ensure quality and effectiveness of simulation-based experiences.[27]
- Consider an assessment framework to guide the selection and/ or development of a valid and reliable tool to measure expected learner outcomes.[68]
- Ensure that participants understand the method of assessment (formative, summative, and/or high stakes) before or at the onset of the simulation.
- Follow the HSSOBP™ Evaluation of Learning and Performance.
- Plan an evaluation process to determine the quality or effectiveness of the simulation- based experience Use evaluation data for continuous quality improvement. Include feedback from participants, peer clinicians and educators, stakeholders, and simulation program faculty and staff[68–70] in the evaluation process.

Criterion 11: Pilot test simulation-based experiences before full implementation.

Required Elements:

- After the design is complete, pilot test the entire simulation-based experience to ensure that it accomplishes its intended purpose, provides opportunity to achieve objectives, and is effective when used with learners.
- Select a participant similar to the target learner group for the optimal test environment.
- Select any tool(s), checklists, or other measures to assess for validity and to ensure consistency and reliability (i.e., content validity, expert review, inter-rater reliability).
- During pilot implementation, identify any confusing, missing, or underdeveloped elements of the simulation-based experience.
- Make improvements based upon the pilot and revise before the full implementation of the simulation-based experience.
- Recognize that it may not always be possible to pilot test simulation-based experiences prior to facilitation (For example, just in time training or with limits to time and resources).

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Original INACSL Standard

Lioce, L., Meakim, C. H., Fey, M. K., Chmil, J. V., Mariani, B., & Alinier, G. (2015). Standards of best practice: Simulation standard IX: Simulation design. *Clinical Simulation in Nursing, 11*(6), 309-315. http://dx.doi.org/10/1016/j.ecns.2015.03.005.

Subsequent INACSL Standard

INACSL Standards Committee (2016, December). INACSL standards of best practice: Simulation℠: Simulation design. *Clinical Simulation in Nursing, 12*(S), S5-S12. http://dx.doi.org/10.1016/j.ecns.2016.09.005.

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INNOVATION

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Development of a simulation technical competence curriculum for medical simulation fellows

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Abstract

Background and needs: Medical educators with simulation fellowship training have a unique skill set. Simulation fellowship graduates have the ability to handle basic and common troubleshooting issues with simulation software, hardware, and equipment setup. Outside of formal training programs such as this, simulation skills are inconsistently taught and organically learned. This is important to address because there are high expectations of medical educators who complete simulation fellowships. To fill the gap, we offer one way of teaching and assessing simulation technical skills within a fellowship curriculum and reflect on lessons learned throughout the process. This report describes the instructional designs, implementation, and program evaluation of an educational intervention: a simulation technology curriculum for simulation fellows.

Curriculum design: The current iteration of the simulation technical skill curriculum was introduced in 2018 and took approximately 8 months to develop under the guidance of expert simulation technology specialists, simulation fellowship-trained faculty, and simulation center administrators. Kern's six steps to curriculum development was used as the guiding conceptual framework. The curriculum was categorized into four domains, which emerged from the outcome of a qualitative needs assessment. Instructional sessions occurred on 5 days spanning a 2-week block. The final session concluded with summative testing.

Program evaluation: Fellows were administered summative objective structured exams at three stations. The performance was rated by instructors using station-specific checklists. Scores approached 100% accuracy/completion for all stations.

Conclusions: The development of an evidence-based educational intervention, a simulation technical skill curriculum, was highly regarded by participants and demonstrated effective training of the simulation fellows. This curriculum serves as a template for other simulationists to implement formal training in simulation technical skills.

Keywords: Simulation fellow, Simulation technical competence, CHSOS, Sim tech, Simulation technology specialist, Summative assessment, Curriculum

Main text

Medical simulation fellowship trained faculty have a unique skill set from other medical educators [1–3]. As a result of their expert training in debriefing, simulation curriculum development, educational theory, simulation technical skills, and administration, they

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are frequently recruited and tasked with leading simulation programs and simulation centers [4]. In an effort to deliver consistent education and meet new accreditation standards, there is a need to standardize simulation fellowship training [5, 6]. Currently, few simulation fellowships include simulation technical skill training and assessment as a formal part of the curriculum and instead focus heavily on the development of expertise in debriefing, case design, and curriculum development [6]. At present these, technical skills are inconsistently taught and organically learned.

Simulation fellowship graduates (hereby called fellowship graduates) acquire the ability to handle basic and common troubleshooting issues with simulation software, hardware, and equipment setup. This is only one skill set that distinguishes fellowship graduates from clinical faculty who utilize simulation with no formal training [7, 8]. This training quickly puts fellowship graduates at the same ability of those simulation pioneers who acquired their skills through experiential, on-the-job learning, and often by trial and error before formal training was available. This combination of skills, frequently called "sim tech skills," are typically mastered and executed in simulation centers by simulation technology specialists [9]. Simulation technology specialists, or "sim techs," provide expertise in the setup, execution, and troubleshooting of high-quality simulation training events, which permits the faculty to focus on case-flow, learner assessment, and debriefing [10]. Fellowship graduates are expected to have an advanced skill set to concordantly manage the education, run simulators, and address common equipment issues [5–7, 11].

Fellows typically learn these technical skills in an apprenticeship-style approach through informal training and guidance by experienced simulation technology specialists. Importantly, many established centers with fellowships are staffed with certified simulation experts—CHSOS® (Certified Healthcare Simulation Operations Specialist) and CHSE® (Certified Healthcare Simulation Educator)—who are qualified to teach this skill set [12–16].

Our simulation fellowship curriculum includes formal simulation technical skills training with summative assessments. There is longitudinal exposure to key concepts and training in common simulation technical skills expected of an entry level simulation technology specialist. The educational goal of this training is to provide fellows with a basic skillset to troubleshoot and repair common simulation equipment malfunctions and failures, so as to function independently without sim techs.

Rationale

We developed this curriculum as a mandatory, formal component of our simulation fellowship. In this report, we describe the design, development, and implementation of the simulation technical skills curriculum between 2018 and 2021, learner assessment and outcomes, and lessons learned regarding iterative modifications. We anticipate that others may adopt and adapt this curriculum component for their specific program needs.

Educational setting

The program was implemented in 2018 and administered over 3 years. A total of eight simulation fellows joined after completing residency or fellowships in either emergency medicine, pediatric emergency medicine, or pediatric critical care. The Simulation Center at Fairbanks Hall is a collaborative partnership among the Indiana University (IU) School of Medicine, IU School of Nursing, and IU Health System. The Sim Center is over 30,000 square feet (to include inpatient, acute care, and clinic settings) and delivers over 1200 events and 50,000 learner hours of education annually. The Sim Center has 22 full- and part-time staff, including 10 simulation staff with CHSOS® or CHSE® certification, and three with advanced certification (CHSE-A or CHSOS-A) (CHSE-A Certified Health Simulation Educator-Advanced; Certified Health Simulation Operations Specialist-Advanced). The IU School of Medicine is the largest allopathic medical school in the USA, the IU School of Nursing is the largest nursing school in the state, and IU Health System is the largest employer in the state.

Curriculum design

The initial simulation technical skill curriculum was introduced in 2018 and took approximately 8 months to design and develop by a committee of experts:

- Two simulation faculty members (emergency medicine)
- Three certified simulation operation specialists (2 CHSOS-A; 1 CHSOS)
- One nurse administrator/educator (doctorate in nursing practice, DNP and CHSE-A)
- One simulation educator/administrator (anesthesiology, doctorate in education, EdD)
- One simulation faculty member/administrator (anesthesiology, physician).

Our current fellowship program director previously (2013) executed a comparable basic sim tech-ops program for a simulation fellowship program at a prior institution with a total of 10 fellows from three specialties:

emergency medicine, pediatric emergency medicine, and obstetrics and gynecology.

The fellowship program director assembled the committee of simulation faculty and staff and reviewed sources of information regarding simulation technical skill training: the CHSOS content domains and examination blueprint, several simulation tech textbooks, the very limited number of peer-reviewed journal articles on technical skills and training, and written feedback from previous fellows. These resources were evaluated for common overlapping themes. This was further scrutinized through the lens of what would be most practical and beneficial to fellows within the capability of our simulation center.

Kern's six steps to curriculum development was used as the guiding conceptual framework:

Kern's six steps [17]

Step 1: problem identification

Current simulation fellows and recent graduates serving as program faculty lack basic technical skills to operate simulation equipment (i.e., hardware and software), troubleshooting when issues occur (i.e., identification and anticipation of problems), repair/fixing the issues (i.e., problem solving), and finding helpful resources (i.e., website, user manuals, how-to videos). Thus, fellows and faculty were dependent on the presence of simulation technology specialists to ensure a successful learning experience. Fellows/faculty frequently contacted simulation technology specialists to consult on technical problems (i.e., disruption to learners) via email, text messaging, and phone calls who were assigned to other simulation events or work duties (i.e., disruption to others, interrupted sim tech attention), and while off work (i.e., disruption of personal time, violation of non-exempt worker employment statutes). The simulation techs voiced to leadership their concerns and frustrations that fellows/faculty required consultation for routine operation of equipment, commonly encountered technical issues, and high-frequency workflow problems, which appeared to be basic skills that could be easily taught and learned. The leadership team acknowledged a curricular gap may exist, which could be filled via an educational intervention.

Step 2: needs assessment

Simulation fellows need structured, organized, technical skills training, akin to those basic skills held by simulation technology specialists, to function independently and correct common equipment issues when running simulation sessions for learners. Focused discussions were had by the authors with fellow graduates and simulation technology specialists to identify (a) the desired skills for simulation faculty and (b) the basic skills that technology specialists think simulation faculty should possess. From this qualitative investigation, the outcome of four major themes/categories emerged as knowledge gaps:

1. Hardware/software content and mannequins
2. Technical skills and troubleshooting content
3. Learning management system
4. Task trainer setup, proper care, and handling.

Step 3: goals and objectives

This is to enhance the competency of simulation fellowship graduates by including a technical skill curriculum.

Step 4: educational strategies

Educational strategies should be applied in person immersive training (the intervention of experiential learning on the hardware, software, and mannequins), asynchronous reading (pre-intervention of user manuals, "how to" guides, manufacturer websites), longitudinal skill utilization (microlearning throughout the year-long fellowship as embedded activities during highly technical simulation sessions), summative competency testing (post-intervention of the immersive training).

Step 5: implementation

The curriculum was designed and implemented using a scaffolding framework such that foundational information was taught first and repeated when new, related topics were presented. For example, how to perform a pre-use check on the mannequins preceded troubleshooting common problems that occur during use. Also, content was grouped to address high fidelity mannequins separate from low-fidelity task trainers. Asynchronous pre-reading prepared fellows for the experiential learning sessions. Summative testing allowed fellows to demonstrate achievement, receive feedback from faculty, correct misunderstandings/errors, and reflect on the curriculum. Additionally, the overall design served as a hidden curriculum since fellows were training to become sim educators while serving as learners in a sim session complete with pre-work, scenarios, and summative testing stations.

Resources/inputs: simulation technology specialist expertise, simulation faculty expertise, leadership support, simulation center resources, simulation tech textbook review, simulation technical training literature review, educational courses, and certification review. Deliverables/outputs: lesson plans, time allotment/scheduling, resources list, and grading checklists. Iterative improvement based on faculty and fellow feedback.

Step 6: evaluation

Programmatic evaluation of outcomes are as follows: internally developed checklists, summative testing stations, faculty feedback, and fellow feedback. High scores on the summative stations and positive feedback from faculty and fellows support that the educational intervention was successful and that the learning goal was achieved to enhance the competency of simulation fellowship graduates by including a technical skills curriculum.

As a result of the above analysis, the developed curriculum was organized into 4 main themes. These themes are further explained and illuminated below using a combination of text, tables, and figures.

Fig. 1 Medical simulation fellow participating in immersive formative training on high-fidelity simulator connectivity and troubleshooting common issues

Fig. 2 Simulation technology specialist providing formative training to simulation fellows and staff on hardware, technical skills, and troubleshooting common issues

1. ***Hardware/software content and mannequins***

   The content related to mannequin-based skills was designed as a broad exposure to various mannequins to provide an optimal foundation for the fellows. The training included an overview of high-fidelity mannequins, including adult, adolescent, newborn, and birthing mannequins The simulation center primarily uses Laerdal® high-fidelity mannequins, except for birthing mannequins which are from CAE® (Canadian Aviation Electronics) and Gaumard®. Almost exclusively using simulators from one manufacturer allows the center to run one software program across all computer control stations and simulated patient monitors. This facilitates quicker onboarding for simulation technology specialists and faculty and for these operators to have a consistent experience when running sessions. Also, a single-software system allows for easier and less time-consuming tasks of updating and networking.

   Introductory content for the mannequins followed the content outline in Domain II (sections A & B) of the CHSOS® examination blueprint [13]. This included basic software and user interface training, including turning on the simulator's software system, manipulation of vital signs, physical exam findings, utilization of audio-representing the mannequin's voice, and display of medical images (i.e., ECGs (electrocardiogram), X-rays, CT (computed tomography) scans) on simulated patient monitors. After the fellows were introduced to these topics and provided time to perform all functions, they were given a demonstration on the external hardware/parts of the high-fidelity mannequins for how to do a pre-use check: head-to-toe assessment; inspection of the skin for damage, moisture, or left over moulage; ECG and defibrillation posts; and loose or exposed wiring. The next topic focused on the various internal parts that need to be inspected pre-use: batteries, defibrillation wiring, ECG wiring, lung bladders, fluid reservoirs, pneumatic connections, and limb connections. The inspection process culminated in a demonstration on how to replace/repair the items mentioned above. The fellows were then each given the opportunity to perform repairs or replacement (see Figs. 1 and 2). A question-and-answer session followed to assess knowledge retention, provide clarification, and revisit mannequin inspection steps. This provided a transition to the next section of the curriculum.

2. ***Technical skills and troubleshooting content***

   This portion of the curriculum provides an opportunity to review and demonstrate the previous foundational lessons while building a deeper understanding of common troubleshooting situations. In many simulation centers, simulation educators do not have the support for hiring a simulation technology specialist. Therefore, it is crucial that sim educators possess certain technical skills and perform troubleshooting techniques at a basic level as written in user manuals from the original equipment manufacturer (OEM). Fellows and simulation technology specialists review the OEM user manuals. Subsequently, a few additional steps that experienced simulation technology specialists complete are reviewed to promote efficiency and success when fellows may be working autonomously or with limited tech support.

Based on principles in Domain II (section C) of the CHSOS® examination blueprint, the fellows were shown how to work through troubleshooting and then practiced these skills. This portion of the curriculum started with common network connectivity issues. While this portion is specific to our sim center Internet options and mannequins, we recognize and emphasize to the fellows that alternative technologies (i.e., hardwire computer to mannequins with ethernet) may be used and that mannequin-specific connectivity differs among and within manufacturers. Also, we recognize that highly technical terminology and hardware components may differ among countries and suggest referring to the country of use in the OEM manuals.

The mannequins at our center rely on a WLAN (wireless local area network) or wired LAN (local area network). Some mannequins (i.e., pediatric, baby, and neonate) rely on a CAN BUS (controller area network omnibus) computing system. We use an internal network, or intranet, to ensure mannequins and control computers are linked only to each other. Having functional knowledge of these networking differences and how the mannequins and computers connect are key responsibilities of simulation technology specialists. A knowledge gap in this area leads to a high number of mistakes and ultimately a high incidence of failure when using these mannequins. Mistakes can often be avoided by following the OEM user manual. The fellows were shown how to connect to an internal network and how to configure a mannequin to that respective network. Once shown, they practiced multiple times. Next, fellows were taught common issues with physical disconnection of the simulators, how to manage this, how to address it mid-simulation, and how to re-establish the connection.

The high-fidelity birthing mannequins from CAE® and Gaumard® utilize a WLAN connection and an operating system that is web-based (software that runs via an Internet browser). Of note, Internet access is not needed to operate these mannequins. They run via offline functionality built into the software architecture in programs such as Google Chrome® or Mozilla Firefox®. Fellow training with the birthing mannequins included common internal hardware setup and troubleshooting. The session focused heavily on the OEM instructions written in the manuals that were demonstrated during hands on practice.

While a hardwired system is most reliable and stable, we also covered wireless connections to address mannequins that only connect wirelessly. Additionally, the benefit of mobility was emphasized. For instance, in situ events where the mannequins are blocked from joining the hospital network via ethernet and WIFI (wireless fidelity), which requires knowledge of a stand-alone network.

3. ***Learning management system***

The learning management system training was designed to provide the fellow directives on how to sign into the system, record playback, and collect data needed for learner performance assessment and simulation-based research. Fellows were previously introduced to video playback during debriefing both as learners and instructors. Here, we covered the control room aspects to ensure that events are recorded and available for playback, assessment, and research. Again, we used the OEM as an instructional guide and practiced the steps repeatedly with other fellows/faculty/staff serving as learners in a mock simulation scenario.

Although many sim centers may lack this robust educational technology, it is important to recognize the potential impact on teaching and learning. Learner debriefing is enriched by incorporating video playback, which aids in accurate depiction of the scenario events and drives discussion [18]. Also, learner self-reflection as an instructional method is enhanced by having learners watch and annotate their own recordings. To emphasize this point, fellows took turns acting as the learner and the instructor in sequential scenarios, reviewed their learner performance playback, and reviewed their instructor debriefing playback. A group discussion and debrief of the debrief included fellow self-reflection, faculty observations, and sim tech feedback. We then discussed alternative, low-budget, portable recording devices (i.e., tablets, smart phones, laptop with external camera, external microphones) that may be used in lieu of an installed, permanent event capture system, and still meet minimum requirements for recording and playback. The self-reported knowledge base and confidence level of the fellows on use of

Table 1 Task trainers reviewed

Trainer	Setup	Teardown
Central line trainer	Inspection of insert and priming of fluids for insert	Inspection of insert and priming of fluids for insert. Clean and disinfect all surfaces per OEM manual. Placed in appropriate storage case and stowed in appropriate position (per OEM manual)
Arterial line trainer	Filling fluid reservoir, installing new artery tubing, inspecting, and installing arm tissue, priming fluid system	Draining of fluid reservoir, remove arm tissue, install new artery, add mixture of sterile water and 1–2cc isopropyl alcohol, prime system, repeat until system plumbing is clear, drain system. Clean and disinfect all surfaces per OEM manual. Place trainer in appropriate case for storage
Lumbar/epidural trainer	Inspection of tissue insert, priming, and or removal of air depending on LP or EP usage	Inspection of insert, prime fluid, or remove air. Place in appropriate storage case and stowed in appropriate position (per OEM manual)
Airway/intubation heads	Inspection of overall appearance, tears in tongue, broken teeth, holes/tears in lung bladders, lubricate airway with OEM-approved airway lubricant	Inspection of overall appearance, tears in tongue, broken teeth, holes/tears in lung bladders, wipe away excess airway lubricant, Clean and disinfect all surfaces per OEM manual. Place in appropriate storage case
Trauma man	Inspection of simulator skin, selection and installation of appropriate tissue insert	Inspection of simulator skin, removal of used tissue inserts. Clean and disinfect all surfaces per OEM manual. Place in appropriate storage case

OEM original equipment manufacturer

these devices was high, and thus, we did not practice these skills.

4. ***Task trainer setup, proper care, and handling***
The task trainer portion of the curriculum was developed to ensure the fellows were able to demonstrate proficiency in setting up, maintaining, cleaning, breaking down, and troubleshooting the most common issues of frequently used medical task trainers (see Table 1). This session included a review of task trainer user manuals, an overview of the internal mechanics/parts, setup instructions, how to keep task trainers free of mold and leaks, how to drain fluids, and proper storage. Once these basics were addressed, common troubleshooting issues were discussed for each step. Fellows then practiced with the task trainers. This hands-on practice is essential for discovering "what is under the skin" of the task trainers since sim educators may be uncomfortable disassembling a costly piece of equipment and unfamiliar with setup, maintenance, and storage.

Implementation and assessment of learning

This program consisted of 4 days of 3-h formative sessions and a fifth day for 3 h of summative testing (12 h formative, 3 h summative, 15 h total) spread over a 2-week period (see Table 2). The fourth 3-h session was a review period where fellows engaged in discussion, asked questions, and practiced technical skills. The course concluded with a 3-h testing session that covered three stations. Each station was staffed with 1 to 2 faculty or simulation technology specialists to assess the fellows' performance (see Figs. 3, 4, and 5). No formal rater training was incorporated into this curriculum.

Checklists were used to rate the fellows in real time. The checklists were developed from established best practices in a variety of simulation skill areas, the user manuals for the products, and expert guidance from simulation technology specialists (see Additional file 1). A score of 80% was predetermined to be the minimum passing score.

Program evaluation

Assessment of learning results

Fellows were tested on three of the four summative checklists. All fellows scored nearly 100% on all stations, and none scored below the benchmark of 80%.

Course feedback summary

Fellows provided open response feedback regarding the strengths and weakness of the curriculum. The first iteration of the course was executed over 8 weeks. The fellow's major feedback that there was too much time between training sessions. The course was compressed so that the formal training sessions were all completed within 1 week. The final review and test session were held the following week. We received positive feedback on the compressed schedule the following year. Overwhelmingly positive feedback was received for the final review session as it ensured their ability to demonstrate skills, review troubleshooting approaches, and answer final questions.

Overall, the fellows reported appreciating the immersive environment that focused heavily on hands on skills (deliberate practice with expert coaching) with minimal lecture/didactics.

Discussion

The authors report the development, implementation, lessons learned, and feedback on an innovative curriculum for medical simulation fellows focused on technical skill development (aka "sim tech skills"). The immersive approach to the utilization of a variety of simulators, task trainers, and troubleshooting common issues with software and hardware delivered in a deliberate practice/mastery learning instructional method [19] over several sessions proved to be a successful approach with our fellows. This success was partially a result of using experts/coaches providing immediate, real-time feedback with sessions that were executed in a timeframe that facilitated progressive learning within the fellow's zone of proximal development [20]. This immersive approach, in combination with reducing the time gap between formative training sessions and summative testing sessions, likely explains the high scores demonstrated by the fellows in our program.

Many fellowship programs preach deliberate practice and mastery learning to their learners that come through their labs yet continue to train their fellows in an apprenticeship model where the fellows inconsistently participate, get haphazard formative feedback, are infrequently formally trained, and rarely administered summative tests [6, 7]. As a result, the simulation literature regarding curriculum development and research in this particular area of simulation is very limited. Overall, fellows strongly valued the time spent getting hands-on experience, receiving real-time feedback, and working through specific tasks and stations. Curricula like this could lead to further standardization of training for simulation fellows globally and potentially prepare fellows to take the CHSOS® exam. Furthermore, after completion of the course, the fellows intermittently worked in the role of sim tech to setup, run scenarios, and breakdown skill stations for various groups of learners. This was done intentionally to minimize skill decay [21, 22] and ensure maintenance of training prior to fellowship graduation. We continually emphasized the utility of OEM manuals

Table 2 Outline of simulation technical curriculum for fellows

	Description	Outcome
Day 1:		
OBJECTIVES	° Discuss simulator selection process depending on simulation scenario objectives/needs ° Setup and prepare Laerdal® simulator hardware & software ° Setup & shutdown of router-based mannequins ° Setup & shutdown of link box-based mannequins ° Navigate and apply knowledge in order to troubleshoot simulator connectivity issues ° Review and discuss features specific to each high-fidelity patient simulator ° Discuss and demonstrate proper care and handling of each high-fidelity patient simulator	
INFORMATION	Laerdal® LLEAP guide/manual Laerdal® SimMan 3G manual Laerdal® SimBaby manual Laerdal® SimNewB manual	Student will be given specific pages of each manual in order to reference steps taught during this lesson
ACTIVITY	Break into equal sized groups and have each student run through the following: ° Simulator selection and setup procedures ° Simulator start up and shut down procedures ° Simulator inspection and prep for usage ° Troubleshooting of hardware, software, networking ° Care and handling before and after simulator usage	Each student will have the opportunity to practice and complete a full setup and shutdown of each Laerdal® high-fidelity simulator
DAY 2		
OBJECTIVES	° Operation of Laerdal® LLEAP software ° Basic scenario building/programming within LLEAP ° Setup and operation of birthing simulator ° Operation of CAE® Muse software	
INFORMATION	Laerdal® SimMan 3G manual Laerdal® SimBaby manual Laerdal® SimNewB manual Laerdal® SimJr manual CAE® Lucina manual	Student will be given user guides for each simulator in order to reference steps taught during this lesson
ACTIVITY	Break into equal sized groups and have each student run through the following: ° Navigating and understanding important functions within LLEAP user interface ° Basic programming within LLEAP SimDesigner ° Operation and navigation of the Muse platform	Students will be able to operate and navigate the LLEAP and CAE® software to successfully run a Laerdal® or CAE® simulator for a sim scenario
DAY 3		
OBJECTIVES	° Operation of B-Line® SimCapture Learning Management System ° Setup, operation, maintenance, and troubleshooting of various task trainers	Student will be able to demonstrate the ability to successfully setup the SimCapture recording system in order to record a sim session Students will be able to choose, setup, troubleshoot, and tear down various task trainers
INFORMATION	Simulab® A-Line Arm manual Simulab® LP/EP manual Simulab® central line man manual Simulab® TraumaMan manual CAE® Blue Phantom CVL manual Laerdal® & 3B Scientific ®airway trainer manual	Student will be given user guides for each simulator in order to reference steps taught during this lesson
ACTIVITY	Break into equal sized groups and have each student run through the following: ° Navigating and understanding important functions within B-Line's® SimCapture software ° Selection, setup, troubleshooting, maintenance, and clean up for each of the task trainers	Each student will be able to demonstrate proficiency in setting up, maintaining, cleaning, breaking down, and troubleshooting the most common issues from commonly used medical task trainers
DAY 4		
OBJECTIVES	° Review each of the previous day's activities	Students can go over any of the course's activities they feel they need more practice on

Table 2 (continued)

	Description	Outcome
DAY 5		
OBJECTIVES	° Exam day ° Test station 1 ° Test station 2 ° Test station 3	

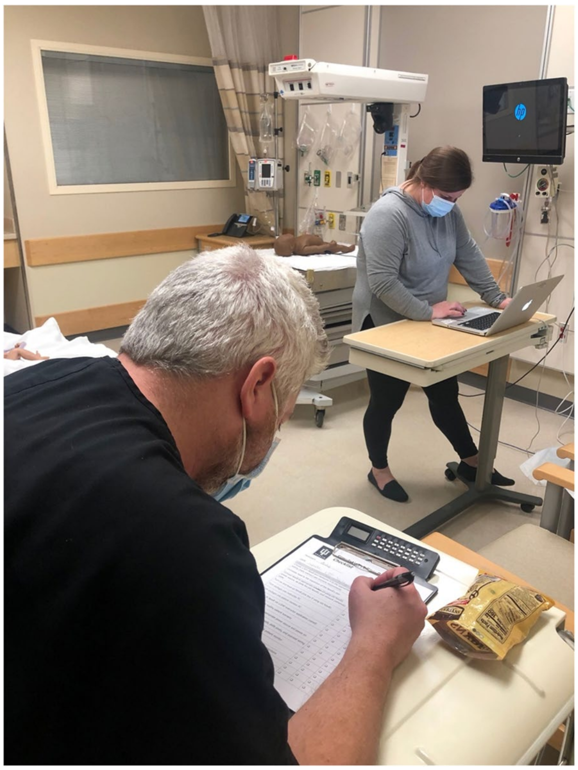

Fig. 3 Simulation fellow undergoing summative testing on simulator software and troubleshooting

Fig. 4 Simulation fellow undergoing summative testing on simulator software and troubleshooting

Fig. 5 Simulation fellow undergoing summative testing on task trainer setup and maintenance

and that the process of learning would be transferable to new environments, equipment, and systems.

Lessons learned and recommendations

The scheduling of this curriculum has been through several iterations. In its first year, fellows were asked to attend a total of four half-days of training, spread over 2 months, with a cumulative test in month 9 of a 12-month fellowship. Based on fellow feedback, this large time gap between sessions resulted in significant skill decay, anxiety, and reiteration of previous lessons before getting to the goals and objectives of the scheduled training for the day. As a result, the course was then altered to be a 1-week intensive curriculum with four half-days of education culminating in a comprehensive exam on a fifth day the following week. Additionally, the fellows provided the feedback that they wanted some overlap or review from the previous day of training as a part of the lesson plan for each day of the curriculum, concluding with a formative review day that provided an opportunity to revisit the entire curriculum.

In the second year, we included non-fellows in the training session, such as ancillary (non-sim tech) simulation staff, faculty/staff from other departments who infrequently utilized simulation, and entry level simulation technology specialists. Fellows reported that this took away from their experience and gave them less personalized attention. They suggested a homogenous cohort to ensure the training focused on their needs as future faculty members and simulation educators. We subsequently changed this curriculum to only train simulation fellows, which garnered positive feedback and an increased comfort level with the material before proceeding to the summative testing period.

Our institution may be unique in its ability to employ multiple simulation faculty and certified simulation staff to host this curriculum. We were able to educate and assess three fellows in the first year and four fellows in the second year of this program. However, not all institutions will have the expertise or resources to implement this simulation technical competence curriculum. We recommend advanced planning to ensure adequate support. Additionally, we recommend summative assessment stations be run in parallel when testing multiple learners for quick turn-around and set-up. An alternative is to run stations sequentially where all examinees complete Station 1 and then move on to Station 2. Smaller institutions may utilize the expertise and availability of mannequin sale representatives to provide exposure to equipment not available at the institution.

Next steps

The faculty continue to refine the curriculum based off current fellow and graduate feedback on the content and delivery of this training. Future research could assess the impact of this curriculum on fellow confidence and performance during simulation education events and post-fellowship, in their leadership roles. Long-term impact may be measured by graduate scholarship published works, grants awarded, simulation center certification attainment, personnel certification attainment, new centers designed, and opened.

Conclusion

The development of a novel simulation technical skills curriculum was highly regarded and effective for the training of simulation fellows. This curriculum provides a template for other fellowships to provide formal training in simulation technical skills to future simulation faculty leaders.

Abbreviations

CHSOS®: Certified Healthcare Simulation Operations Specialist; CHSE®: Certified Healthcare Simulation Educator; IU: Indiana University; CHSE-A: Certified Healthcare Simulation Educator-Advanced; CHSOS-A: Certified Healthcare Simulation Operations Specialist-Advanced; CAE: Canadian Aviation Electronics; ECGs: Electrocardiograms; CT: Computed tomography; OEM: The original equipment manufacturer; WLAN: Wireless local area network; LAN: Local area network; CAN BUS: Controller Area Network Omnibus; WIFI: Wireless fidelity.

Supplementary Information

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Additional file 1. Sim tech skills fellow exam.

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Authors' contributions

All authors (RA, DC, CM, CW, JP, AB, LF, MM, SM, TB, SA, JC) meet all the below criteria: Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work. Drafting the work or revising it critically for important intellectual content. Final approval of the version to be published. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Declarations

Ethics approval and consent to participate

This manuscript describes a curricular narrative and was deemed unnecessary for exempt status from IRB review at Indiana University.

Consent for publication

Consent for publication of the photos has been uploaded.

Competing interests

The authors declare that they have no competing interests.

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