Published in final edited form as:

J Contin Educ Health Prof. 2012 ; 32(4): 255–260. doi:10.1002/chp.21153.

Judicious Use of Simulation Technology in Continuing Medical Education

Michael T. Curtis, PhD [Research Scientist],

University of Central Florida, Institute for Simulation and Training, Team Performance Laboratory

Deborah DiazGranados, PhD [Assistant Professor], and

Virginia Commonwealth University, School of Medicine

Moshe Feldman, PhD [Assistant Professor]

Virginia Commonwealth University, School of Medicine

Abstract

Use of simulation-based training is fast becoming a vital source of experiential learning in medical education. Although simulation is a common tool for undergraduate and graduate medical education curricula, the utilization of simulation in continuing medical education (CME) is still an area of growth. As more CME programs turn to simulation to address their training needs, it is important to highlight concepts of simulation technology that can help to optimize learning outcomes. This article discusses the role of fidelity in medical simulation. It provides support from a cross section of simulation training domains for determining the appropriate levels of fidelity, and it offers guidelines for creating an optimal balance of skill practice and realism for efficient training outcomes. After defining fidelity, 3 dimensions of fidelity, drawn from the human factors literature, are discussed in terms of their relevance to medical simulation. From this, research-based guidelines are provided to inform CME providers regarding the use of simulation in CME training.

Keywords

simulation; continuing medical education; physical fidelity; functional fidelity; psychological fidelity; guidelines; fidelity

The practice of using anatomical models built out of available rudimentary materials for training was common in ancient health care settings.¹ Despite historical evidence that simulation has been used for medical training for centuries,^{2,3} the systematic use of simulation for medical education has emerged only in the past couple of decades. The increased use of simulation in medical education is largely due to technological advances that have enhanced the ability to reliably model real-world clinical tasks, thus providing increased opportunities for experiential learning. Simulation refers to any system that replicates real-world processes, actions, or behaviors. This broad definition of simulation includes devices, technologies, computer programs, scenarios, standardized patients, and a host of other methods of imitating real-world systems.

Use of simulation provides health profession educators with increased control over the educational environment while at the same time decreasing the risks associated with on-the-job training. This is especially important in domains where errors can have life-or-death consequences. Simulations can be designed to replicate whole systems, target isolated skills using part-task trainers, or generate conditions in which cognitive skills that generalize to task performance can be practiced.

The argument for expanding the use of simulation-based training as a viable alternative to more traditional didactic modes of education appears to be gaining traction in the continuing medical education (CME) community. In 2010, nearly 60% of all US and Canadian medical schools, teaching hospitals in the United States, and clinical academic societies participating in the American Association of Medical Colleges' and Society for Academic CME's Harrison survey reported at least occasional use of simulation (eg, standardized patients, audio, video resources, simulators) in their continuing education activities.⁴ Ten percent of the respondents reported using simulation on a regular basis, up from 5% in 2008.

Advances in simulator technology have made it possible to provide highly realistic immersive educational environments. Naturally, practitioners and policy makers alike are drawn to recognizable instances of high-fidelity replication, due to the parallels that can easily be drawn to real-world application. However, in some situations, high-fidelity simulation may not be the best option. Although recent reviews suggest that the quality of published research on the effectiveness of simulation is weak,^{5,6} available evidence does suggest that high-fidelity simulation is effective, but only under specific conditions.⁶ Simply providing high-fidelity simulation does not necessarily produce optimal learning outcomes.⁷⁻¹⁰ In addition, some studies have shown that low-fidelity simulations, such as part-task trainers, can sometimes lead to training gains.^{7,8}

The decision about the degree of fidelity appropriate for achieving the desired result in simulation is a critically important one. The high cost and limited availability of high-fidelity simulation in the face of growing demand for more effective approaches to CME presents a challenge to CME providers. For example, high cost was cited as a major barrier to the widespread adoption of the first computerized anesthesiology simulator, Sim One.^{11,12} A recent survey revealed a combined operating deficit of roughly \$27 million at responding CME institutions.⁴ As such, CME providers may be confined by budget restrictions impacting the amount of resources that can be allocated to implementation of simulation technology. With the estimated cost for setup of a simulation center approaching \$1 million and additional fixed costs of at least \$350k annually,¹³ CME providers have to be judicious in the use of simulation-based training programs.

By virtue of the fact that simulation cannot produce an exact replica of the operational environment, it is important to understand the benefits and limitations of simulation technology. Simulation technology is only an effective training medium in respect to how the skill(s) targeted transfer into real-world performance goals. When considering the training effectiveness of simulation technology, one should be careful not to misconstrue user acceptance as a valid measure of effectiveness. Although generally easier to obtain and interpret than more objective simulation and transfer task performance measures, there is no evidence that user acceptance provides an acceptable gauge of learning outcomes from simulation training.^{14,15} User acceptance ratings generally skew higher on high-fidelity devices, because the "bells and whistles" of high-fidelity simulation are generally viewed more favorably.¹¹ As such, subjective acceptance ratings are still a useful gauge of buy-in simulation training, but should not be used to determine training efficacy.

This article discusses fidelity in medical simulation. It summarizes the simulation literature on how to determine the appropriate level of fidelity and offers guidelines for creating an optimal balance of skill practice and realism for efficient training outcomes. The discussion addresses a definition for the broad concept of fidelity, issues associated with implementing different levels of fidelity, and the multiple dimensions of fidelity for medical simulation. A set of research-based guidelines to inform CME providers' decisions, regarding the use of simulation as an educational tool, is also given. Ours is a multidisciplinary approach. The relevant literature was identified using publication databases such as PsychInfo and PubMed, in addition to more general search engines (ie, Google Scholar). Included were works addressing simulation training and fidelity in a variety of medical disciplines (eg, anesthesiology, nursing, obstetrics-gynecology) as well as seminal works from aviation and military simulation research.

Conceptualizing Fidelity for CME

The resemblance of a simulation to the intended real-world context it is replicating is known as fidelity.¹⁶ It is not uncommon for practitioners to simplify fidelity into a 1-dimensional construct that results in categorizations on a continuum from low to high.^{7,17,18} However, a 1-dimensional conceptualization of fidelity can be misleading when trying to select appropriate simulations for a given training need. A simulation that has the look of the real world is often considered high fidelity, when in fact only 1 dimension of fidelity is high. A simulation can replicate the outward appearance of the operational environment (eg, an operating room) quite effectively, yet still be ineffective at helping learners meet the training goals.

Fidelity is better understood as a multidimensional construct (FIGURE 1). To effectively utilize simulation technology, understanding these dimensions of fidelity and how they impact the entire training system is vital. This can help CME leaders to approach simulation training from a more informed perspective. However, there is no consensus on how to conceptualize the various dimensions of fidelity. CME planners and medical researchers have utilized a cadre of conceptualizations of fidelity when implementing simulations in their training and when determining simulation effectiveness.^{19,20} In this section, we draw primarily on the human factors literature to identify 3 primary dimensions of fidelity (ie, physical, functional, and psychological) that we believe are readily applied to simulation in medical education. For each dimension of fidelity, we also discuss the evidence bearing on when and how simulations with these characteristics are best used.

Physical Fidelity

The extent to which the physical properties of the operational task environment are recreated in a simulation is known as physical fidelity.^{2,21,22} Specifically, this involves the degree to which a simulation recreates the sensory characteristics (eg, look, feel, sound, smell), personnel (eg, patients, nurses, technicians, doctors), and equipment (eg, EKG, IV) of the operational task environment.^{23,24} High levels of physical fidelity can result in very close replications of the task environment. Due to the readily observable sensory nature of physical fidelity, it is the most easily recognized of the 3 dimensions of fidelity.

In CME, high physical fidelity simulation can be useful for development of skills that require coordinated action in response to specific observable cues in the environment, such as laparoscopic surgery and advanced airway management.²⁵ Human patient simulators continue to improve the level of physical fidelity, but accurately modeling human anatomical structures such as the airway remains a challenge.²⁶ Although there is a tendency for users to rate high physical fidelity devices better than their lower-fidelity counterparts, there is evidence that overtraining on simulators with high physical fidelity can produce

negative transfer effects.²⁷ Even the most advanced simulations will have differences from the real world. If physical fidelity is high, but functional and psychological fidelity are low, there is a risk that repeated exposure could lead to development of “simulation specific” behaviors that do not transfer to the clinical environment.

The research evidence suggests that high physical fidelity is necessary only for cues that are integral to completing the task being trained.²⁸ For example, cues such as environmental lighting have been shown to effect transfer in development of fine motor skill movement.²⁹ However, any increase in physical fidelity on cues that are not central to the training goal can result in added cost with minimal training benefit. When used for training, low-physical-fidelity devices have been found to hold up remarkably well in terms of skill transfer. Low-fidelity devices, such as the shoulder dystocia trainer,³⁰ have been shown to provide transferable psychomotor skills, and software-based trainers have been successfully used for developing cognitive skills (eg, decision making, situation awareness, problem solving, diagnostics).³¹ Low physical fidelity has been found to be especially useful for training unfamiliar tasks where the focus is on developing basic skills that will apply into a more complex integrated task environment upon mastery.³²

Functional Fidelity

The second overarching dimension of fidelity is functional fidelity. Functional fidelity is the degree to which the action the simulation system initiates matches its real-world counterpart.³³ Functional fidelity can be applied to equipment (eg, EKG readings), patient simulations (eg, mannequin, actors), or complex organizational simulations (eg, code team simulations). The accuracy of readings from a simulated medical device (eg, blood pressure, heart rate)² and the stimulus-response aspects of a system (eg, haptic responses, symptom accuracy) are examples of system features that influence the functional fidelity of a simulator.

Functional fidelity rests heavily on the quality of feedback that results from user input. Functional fidelity can be impacted by whether or not a simulation is passive, active, or interactive.¹ A passive simulation element can enhance fidelity by providing a realistic functional replication within a simulated health care environment but cannot be manipulated by the user. Active and interactive elements are dependent on user actions and changes to the simulated environment. Hence, active and interactive elements may have a larger impact on the training effectiveness of the system than passive elements. In CME patient simulations, an example of functional fidelity is the responsiveness of the virtual patient.³⁴ Due to the wide range of between-patient variation that occurs in real settings, higher functional fidelity would result from having a larger variation of realistic reactions or responses to trainee action in the simulation. Functional fidelity can be achieved using computer-based simulation, which reduces physical similarities but retains the functional properties of the trained task.³⁵ For cognitive tasks, high functional fidelity can have greater training impacts than high physical fidelity.^{10,33} When training goals are more focused on development of cognitive skills, this can result in the potential for using a lower-cost means of practice with tasks like patient diagnosis or clinical skills training.

Psychological Fidelity

The third overarching dimension of fidelity, psychological fidelity, involves the extent to which trainees engage in tasks that generate experience, action, and processing demands that are similar to the operational environment.^{2,36} Accurately reproducing stressful conditions is a prime example. Recreating the stress associated with real world environments in simulated environments can be difficult. In task domains where life and death are at stake, it is hard to replicate the pressure of these situations in a simulation where the stakes cannot possibly be

the same. Although it is difficult to accurately replicate stress, higher degrees of psychological fidelity can help to achieve a level of stress closer to what would actually be experienced in the operational environment.³⁵

Psychological fidelity can generally be achieved at a fraction of the cost associated with attaining high physical or functional fidelity. Low-cost techniques for increasing psychological fidelity include adding complexity to the scenario, scripting patient complications, or increasing the level of environmental cues (eg, phone ringing, audible warning on patient monitors). Achieving psychological fidelity can be accomplished through a cognitive task analysis, which informs the thorough development of realistic scenarios,⁸ providing trainees with realistic time restrictions, and using immersive environments. Immersion is characterized by a feeling of “being there” in an environment. One psychological goal of simulation is to help individuals suspend belief that they are operating in a replicated environment, in favor of feeling like they are engaged in the real-world task.³⁷

Summary

Although there are numerous conceptualizations of the dimensions of fidelity, this article outlines 3 dimensions (ie, physical, functional, psychological), which provide a broad enough categorization to capture the variety of more specific conceptualizations. At the same time, presenting fidelity in terms of physical, functional, and psychological dimensions illustrates it as a multidimensional concept. There is slight overlap among the 3 concepts, but understanding their differences helps demonstrate how manipulating simulation fidelity along these dimensions can result in different training outcomes.

Guidelines for Selecting Appropriate Fidelity Level in CME

In CME, training goals depend on the expected outcomes of the individuals engaging in the training. One expectation of the pursuit of CME is for maintenance of current skill and certification levels. If this is the case, the training will most effectively be geared toward a population that has already obtained basic skills and instead are better served by practice integrating these skills. However, some pursue CME to seek training with new tools, unfamiliar techniques, or to explore new fields of medical practice altogether. Unlike skill maintenance training, pursuit of unfamiliar skill sets may require more focus on basic skill development. These two expectations are only two examples of a range of expectations for pursuing CME training. As such, there is no single proscribed recommendation for what level and in what combination of dimensions of fidelity is appropriate for training needs. Planners must be attentive to several factors when selecting simulation technology for CME. Using a systematic approach to understanding the learner and the knowledge, skills, and attitudes that are targeted will inform how to utilize and incorporate fidelity. In simulations for CME, this will help to facilitate skill acquisition and retention.

Influenced by classic texts in literatures such as training^{38,39} and education,⁴⁰ most researchers consider needs analysis and objective identification as critical components to successful implementation of training programs. Drawing from these classic models of planning, we provide the following 4 guidelines for judicious use of simulation technology.

1. *Know who you are training.* In CME, the only sure bet about the pool of individuals participating is that they have had some type of medical training previously. The number of years of experience in their discipline, number of different fields of medicine they have practiced in, and the motivations for choosing a particular CME training program are all variable. By identifying the types of trainees that pursue specific training interventions, one can better tailor the

training to the audience. This will help eliminate unnecessary repetition with basic skills for experienced practitioners and unnecessary complexity of a simulation task for individuals who are transitioning to a new area of practice.

2. *Clearly identify training objectives.* It is no secret that awareness of training objectives is important for optimal use of training tools. The simplicity of this statement can be deceiving. There is no mystery to identifying the overarching task (eg, surgical procedure, clinical skills training) that is targeted for training; however, the underlying skills and how they interact is less distinct. Conducting a thorough task analysis can provide a more detailed picture of the basic skill sets that comprise a more complex overarching training objective.
3. *Understand budget constraints.* The utopian dream of a system built without concern for cost or time constraint is not the world within which we operate. In most respects, cost is viewed as the primary barrier to providing effective simulation training. However, this does not have to be the case. Low-cost alternatives have been effective in skill development as long as CME planners understand which skills and to what degree decrements in fidelity may limit training effectiveness. In the event that monetary budget constraints are less restrictive, it is still paramount to consider the availability of other resources. Running a complex intensive care unit simulation may be attainable from a cost standpoint, but there may be limits to the number of learners, availability of trained faculty to provide effective feedback, and scheduling conflicts with the simulation center where the CME activity occurs.
4. *Treat simulation fidelity as a multidimensional concept.* By going beyond a simple high-versus-low fidelity perspective and understanding the multiple dimensions of fidelity, practitioners will be better prepared to adapt to the varying demands that impact training systems. Armed with knowledge of the overarching dimension categories of physical, functional, and psychological fidelity, practitioners can take a more objective view of simulation technology. By suppressing the tendency to rely too heavily on simulation appearance, training value can be better assessed, leading to more efficient decisions on simulation technology.

Conclusion

Simulation training is a growing area of interest to CME practitioners. Despite the widespread evidence of the positive potential for simulation as a training tool, uninformed adoption of simulation technology can result in training programs that are ineffective. Understanding how simulation fidelity can impact training outcomes is important to achieving training goals. To fully understand the implication of simulation to CME training program effectiveness, more research is needed that measures the relationship of simulator fidelity to the intended outcomes of CME interventions. For example, understanding how simulation fidelity influences the change in behavior by health care professionals in their clinical practice would be critical in understanding the potential cost-benefit to patient and community health outcomes.⁴¹ If CME practitioners arm themselves with a better understanding of intended training objectives, their target training audience, and their budget constraints, in combination with understanding the multidimensional construct of simulation fidelity, simulation can be effectively integrated into CME training programs.

Acknowledgments

Disclosures: Deborah DiazGranados and Moshe Feldman are partially funded by a grant award (UL1TR000058) from the NIH.

References

1. Meller G. A typology of simulators for medical education. *J Digit Imaging*. 1997; 10(suppl1):194–196. [PubMed: 9268881]
2. Khan K, Pattison T, Sherwood M. Simulation in medical education. *Med Teach*. 2011; 33:1–3. [PubMed: 21182376]
3. Owen H. Early use of simulation in medical education. *Simul Healthc*. 2012; 7:102–116. [PubMed: 22374231]
4. Davis, D.; Fordis, M.; Colburn, L., et al. Academic CME in the U.S. and Canada: The 2010 AAMC/SACME Harrison Survey. Society for Academic Continuing Medical Education. Washington, DC: Association of American Medical Colleges; 2011.
5. Issenberg BS, McGaghie WC, Petrusa ER, Gordon DL, 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. [PubMed: 16147767]
6. McGaghie WC, Siddall VJ, Mazmanian PE, Myers J. Lessons for continuing medical education from simulation research in undergraduate and graduate medical education. *Chest*. 2009; 135:62S–68S. [PubMed: 19265078]
7. De Giovanni D, Roberts T, Norman G. Relative effectiveness of high versus low-fidelity simulation in learning heart sounds. *Med Educ*. 2009; 43(7):661–668. [PubMed: 19573189]
8. Beaubien JM, Baker DP. The use of simulation for training teamwork skills in health care: how low can you go? *Qual Saf Health Care*. 2004; 13(S1):51–56.
9. Salas E, Bowers CA, Rhodenizer L. It is not how much you have but how you use it: toward a rational use of simulation to support aviation training. *Int J Aviat Psychol*. 1998; 8(3):197–208. [PubMed: 11541532]
10. Salas E, Wilson KA, Burke CS, Priest HA. Using simulation-based training to improve patient safety: what does it take? *Jt Comm J Qual Patient Saf*. 2005; 31(7):363–371. [PubMed: 16130979]
11. Denson JS, Abrahamson S. A computer-controlled patient simulator. *JAMA*. 1969; 208:504–508. [PubMed: 5818529]
12. Abrahamson S. Sim One—a patient simulator ahead of its time. *Caduceus*. 1997; 13:29–41. [PubMed: 9509635]
13. McIntosh C, Macario A, Flanagan B, Gaba DM. Simulation: what does it really cost? *Simul Healthc*. 2006; 1(2):109.
14. Rehmann, AJ. *A Handbook of Flight Simulation Fidelity Requirements for Human Factors Research*. Atlantic City, NJ: Federal Aviation Administration; 1995.
15. Kraiger, K.; Jung, KM. Linking training objectives to evaluation criteria. In: Quinones, MA.; Ehrenstein, A., editors. *Training for a Rapidly Changing Workplace: Applications of Psychological Research*. Washington, DC: American Psychological Association; 1997. p. 151–175.
16. Hays, RT.; Singer, MJ. *Simulation Fidelity in Training System Design: Bridging the Gap Between Reality and Training*. New York, NY: Springer-Verlag; 1989.
17. Cant RP, Cooper SJ. Simulation-based learning in nurse education: systematic review. *J Adv Nurs*. 2009; 66(1):3–15. [PubMed: 20423432]
18. Littlewood KE. High fidelity simulation as a research tool. *Best Pract Res Clin Anaesthesiol*. 2011; 25:473–487. [PubMed: 22099914]
19. Broussard L. Simulation-based learning: how simulators help nurses improve clinical skills and preserve patient safety. *Nurs Womens Health*. 2009; 12(6):521–524.
20. Scerbo MW, Dawson S. High fidelity, high performance? *Simul Healthc*. 2007; 2(4):224–230. [PubMed: 19088626]
21. Bowers, C.; Jentsch, F. Use of commercial-off-the-shelf, simulations for team research. In: Salas, E., editor. *Advances in Human Performance and Cognitive Engineering Research*. New York, NY: Elsevier Science Ltd; 2001. p. 293–317.
22. Freda, JS.; Ozkaptan, H. *An Approach to Fidelity in Training Simulation*. Alexandria, VA: Army Research Institute for Behavioral and Social Sciences; 1980.

23. Kinkade, R.; Wheaton, G. Training device design. In: Vancoff, H.; Kinkade, R., editors. *Human Engineering Guide to Equipment Design*. Washington, DC: American Institutes for Research; 1972.
24. Hays, RT. *Simulator Fidelity: A Concept Paper*. Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences; 1980.
25. Lucisano KE, Talbot LA. Simulation training for advanced airway management for anesthesia and other healthcare providers: a systematic review. *AANA J*. 2012; 80(1):25–31. [PubMed: 22474801]
26. Schebesta K, Hpfl M, Rössler B, Ringl H, Mller MP, Kimberger O. 2012. Degrees of reality: airway anatomy of high-fidelity human patient simulators and airway trainers. *Anesthesiology*. 2012; 116(6):1–6. [PubMed: 22185869]
27. Weitz J, Adler S. The optimal use of simulation. *J Appl Psychol*. 1973; 58(2):219–224.
28. Kozlowski, SW.; DeShon, RP. A psychological fidelity approach to simulation-based training: theory, research and principles. In: Schiflett, SG.; Elliot, LR.; Salas, E.; Covert, MD., editors. *Scaled Worlds: Development, Validation and Applications*. Burlington, VT: Ashgate; 2004. p. 75-99.
29. Gawron V, Bailey R, Lehman E. Lessons learned in applying simulators to crewstation evaluation. *Int J Aviat Psychol*. 1995; 5(3):277–290.
30. Draycott TJ, Crofts JF, Ash JP, et al. Improving neonatal outcome through practical shoulder dystocia training. *Obstet Gynecol*. 2008; 112(1):14–20. [PubMed: 18591302]
31. Issenberg SB, McGaghie WC, Hart IR, et al. Simulation technology for health care professional skills training and assessment. *JAMA*. 1999; 282(9):861–866. [PubMed: 10478693]
32. Maran NJ, Glavin RJ. Low- to high-fidelity simulation—a continuum of medical education? *Med Educ*. 2003; 37(suppl 1):22–28. [PubMed: 14641635]
33. Alexander, AL.; Brunye, T.; Sidman, J.; Weil, SA. *From Gaming to Training: A Review of Studies on Fidelity, Immersion, Presence, and Buy-in and Their Effects on Transfer in PC-Based Simulations and Games*. Woburn, MA: DARWARS Training Impact Group; 2005.
34. Kenny, P.; Parsons, TD.; Gratch, J.; Rizzo, AA. *Intelligent Virtual Agents: Lecture Notes in Computer Science*. Vol. 5208. Springer; 2008. Evaluation of Justina: a virtual patient with PTSD; p. 394-408.
35. Wilson, GF.; Skelly, J.; Purvis, B. *Proceeding of the Aerospace Medical Panel Symposium*. The Hague, Netherlands: AGARD; 1989. Reactions to emergency situations in actual and simulated flight; p. 1-13.
36. Stoffregen, TA.; Bardy, BG.; Smart, LJ.; Pagulayan, RJ. On the nature and evaluation of fidelity in virtual environments. In: Hettinger, LJ.; Haas, MW., editors. *Virtual and Adaptive Environments: Application, Implications, and Human Performance Issues*. Mahwah, NJ: Lawrence Erlbaum; 2003. p. 111-128.
37. Patterson R, Pierce B, Bell HH, Andrews D, Winterbottom M. Training robust decision making immersive environments. *J Cogn Eng Decis Making*. 2009; 3(4):331–361.
38. Goldstein IL. Training in work organizations. *Annu Rev Psychol*. 1980; 31:229–272.
39. Goldstein, IL.; Ford, JK. *Training in organizations: needs assessment, development, and evaluation*. Belmont, CA: Wadsworth; 2002.
40. Altschuld, JW.; Witkin, BR. *From needs assesment to action: transforming needs into solution strategies*. Thousand Oaks, CA: Sage; 2000.
41. Moore DE, Green JS, Gallis HA. Achieving the desired results and improved outcomes: integrating planning and assessment throughout learning activities. *J Contin Educ Health Prof*. 2009; 29(1):1–15. [PubMed: 19288562]

Lessons for Practice

- Simulation fidelity is a complex multidimensional construct, composed of physical, functional, and psychological characteristics.
- Budget should not be a barrier to integrating effective simulation-based CME training because increased cost does not always equal increased benefits.
- Optimal transfer of training does not require maximum fidelity on all dimensions.
- Subjective user ratings can be misleading metrics of simulation effectiveness.
- Judicious use of simulation technology should include assessment of training objectives, intended audience, and budget in combination with an understanding of the dimensions of simulation fidelity.

FIGURE 1.
Structural Depiction of Dimensions of Fidelity