ELSEVIER

SEMINARS IN PERINATOLOGY

Theoretical Foundations of Learning Through Simulation

Jason J. Zigmont, PhD,* Liana J. Kappus, MEd,* and Stephanie N. Sudikoff, MD*,†

Health care simulation is a powerful educational tool to help facilitate learning for clinicians and change their practice to improve patient outcomes and safety. To promote effective life-long learning through simulation, the educator needs to consider individuals, their experiences, and their environments. Effective education of adults through simulation requires a sound understanding of both adult learning theory and experiential learning. This review article provides a framework for developing and facilitating simulation courses, founded upon empiric and theoretic research in adult and experiential learning. Specifically, this article provides a theoretic foundation for using simulation to change practice to improve patient outcomes and safety.
Semin Perinatol 35:47-51 © 2011 Elsevier Inc. All rights reserved.

KEYWORDS simulation, debriefing, experiential learning, adult learning, practice based learning

High-fidelity health care simulation is a costly and time intensive educational process that allows practitioners to learn, practice, and gain experience in a safe and structured environment without risk to patients. Health care education has traditionally relied on the apprenticeship model, where practitioners train with real patients in actual clinical settings. Although the power of this type of experience and hands-on learning is substantial, the recent pressure to decrease orientation times, work-hour restrictions for residents, and an increased awareness and commitment to patient safety provides the basis for a strong argument to invest in simulation as an educational tool. However, to justify the costs of health care simulation, educators need to ensure that simulation is used effectively to achieve desired outcomes and changes in practice. Effective education of adults through simulation requires a sound understanding of both adult learning theory and experiential learning. This review article provides a framework for developing and facilitating simulation courses, founded upon empiric and theoretic research in adult and experiential learning. Specifically, this article provides a theoretic foundation for using simulation to change practice to improve patient outcomes and safety.

*SYN:APSE Simulation Center, Yale New Haven Health System, New Haven, CT.

†Department of Pediatrics, Yale University School of Medicine, New Haven, CT.

Address reprint requests to Jason Zigmont, PhD, SYN:APSE Simulation Center, Yale New Haven Health System, 730 Howard Ave, New Haven, CT 06519. E-mail: jason.zigmont@ynhh.org

For simulation-enhanced education to be sustainable and promote healthcare professionals to change their daily practice, educators need to demonstrate results, such as improved patient outcomes. Outcomes, however, are often measured by tests or number of training hours completed. For example, multiple-choice examinations may be used to assess competency but, in reality, can only test basic knowledge and comprehension. According to Blooms Taxonomy (Fig. 1)[1] of learning, knowledge, and comprehension are the simplest levels of learning. The ability of a learner to apply and analyze knowledge is a better indicator of competence. Simulation, when used with the goal of improving practice, can allow the learner to move from knowledge or comprehension to application, analysis and even synthesis.[1]

In addition, educational interventions focused solely on increasing knowledge (ie, lectures) reflect an educational practice that envisions the mind as a computer.[2] In this way, the educator "pours" information into the learner, hoping that it is retained and can be used in future situations. Near-term retention can be improved in this way, but transfer to practice, both in the short term and long term, is limited. A focus on improving knowledge, even if achieved, may not improve practice, as subject matter knowledge is often secondary in practice to the individual's mental model, biases or assumptions which guide behavior.[3,4]

Similarly, "seat time," hours of training, or number of simulations completed, has been used as a substitute measure to substantiate the "success" of simulation. Such data have been useful for reporting purposes as short-term measures of success but, in reality, only demonstrate that the learner was physically

0146-0005/11/$-see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1053/j.semperi.2011.01.002

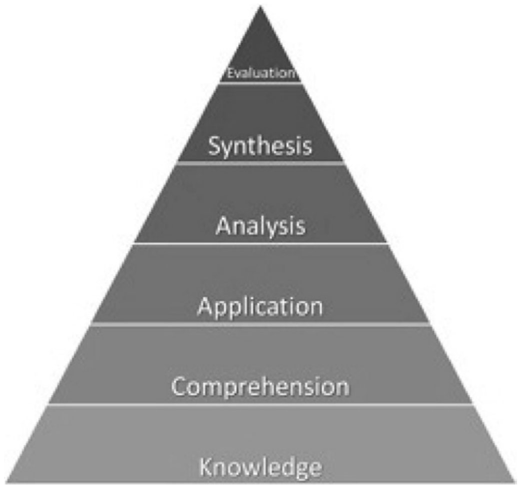

Figure 1 Bloom's taxonomy.[1]

present. When substitute measures, such as test scores, or course completion are used to assess the impact of an educational intervention, then the focus on improving practice is often lost.

Changing practice requires focus upon 3 issues: the individual, her/his experiences and the overall learning environment. Based upon the Trio Model of Professional Learning, the Learning Outcomes Model (Fig. 2) highlights the immersive relationship that exists between learning and these 3 factors.[5-9]

Often, education in the professional setting focuses solely on training or creating meaningful educational experiences for the individual, and rarely on creating a supportive learning environment. For example, simulation-based training can very quickly devolve into "experience only," without promoting assimilation of knowledge. Although one cannot extricate individuals from their experiences and environments, this article is broken into these 3 components for clarity. As educators, we need to consider all 3 components when crafting simulation exercises.

Individual

The motto for pediatric medicine is 'children are not small adults,' but rather, children have unique anatomic, physiological, immunologic, and developmental differences. Similarly, 'adult education is not the same as childhood education.' The differences have led to 2 distinct educational approaches to teaching and learning: pedagogy, the teaching of children and andragogy, the teaching of adults.[10] Andragogy is not simply working with learners older than 18 years of age; it requires an understanding of best practices to facilitate adult learning. Sound adult learning theory is premised on several crucial assumptions about the characteristics of adult learners in contrast to child learners, including: (1) adult learners are self-directed and self-regulated[10]; (2) adult learners are intrinsically motivated to learn[10,11]; (3) adult learners have previous knowledge and experience that are an increasing resource for learning[5,6,12]; (4) through this experience, adult learners form mental models which guide their behavior,[5,6,12-14]; and (5) adults use analogical reasoning in learning and practice.[3,5,6,11,13,14]

As self-regulated learners, adults learn what they want to learn, when they want and need to learn. Readiness to learn is triggered by a need to know how to perform more effectively in some aspect of one's life. Self-regulated learners require a student-centered approach, which puts the learning objectives most important and relevant to the learner at the forefront. This is often in conflict with a teacher-centered approach in which the instructor assumes full responsibility for what is taught. As educators in health care, we cannot force practitioners to learn, but rather, we must explain the relevance the learning has to their work and help them make decisions about how, when and why to learn. In this way, the educator serves as a facilitator of learning rather than a "teacher." As adults control their learning, they end up providing their own motivation.

For adults, learning is not its own reward; adult learners are intrinsically, rather than extrinsically motivated,[10] meaning they must believe that the learning outcome is practical, concrete, and immediately usable. If adults feel competent, are given autonomy, and feel as if they are part of an environment in which they are respected and connected to one another, then their self-efficacy is enhanced.[11] Self-efficacy, or belief in one's ability to complete a task contributes to one's motivation to learn.[15] Simulation-based education, because it allows hands-on practice of skills and promotes community while increasing competency and autonomy, has the power to motivate adults to learn.[11]

Educators in simulation must take care to use specific strategies to create a respectful and supportive environment, which protects the confidentiality of individual performance to maintain this motivation. Unlike lecture-based learning, confidentiality is a unique consideration for simulation-

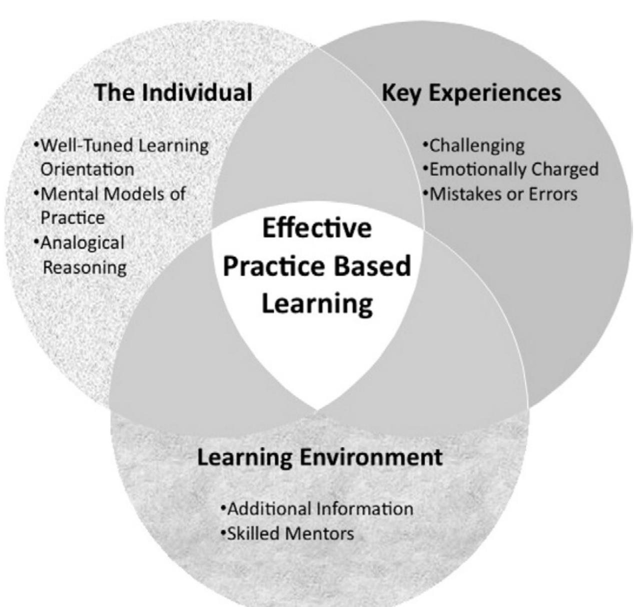

Figure 2 Learning Outcomes Model.[6]

based learning because all levels of individual performance are observed by the whole group. Some strategies to create trust, rapport, respect and support include (1) define the goals (ie, assessment or learning) for participants before the course; (2) introduce all facilitators and participants; (3) outline expectations for the course, including ground rules for participating in the scenarios and postsimulation debriefing; (4) prepare a confidentiality agreement to protect individual performance and issues raised during group discussions; (5) provide an orientation to the manikins and the simulation environment; and (6) disclose how videos are secured and archived.

In addition, adult learners bring previous knowledge, life experience, and perspective to every learning experience.[5,6,10,13] In this way, adults become a rich resource of knowledge and experience for each other. They need to connect learning to this knowledge and experience base.[13] The challenge for educators is to activate this relevant prior knowledge and elicit participants' experiences, to allow the learner to explore new and old side by side. This can be achieved through prompted or guided reflection, ie, asking participants to recall a similar situation encountered in the past and to remember the strategies they used to handle it. For example, if the learning objective is conflict management in the clinical setting, before offering tools and strategies for conflict resolutions, educators can prompt participants to recall a past experience during which conflict was present and how it was handled. Then, the adult learner is ready to compare the new strategies and tools offered by the educator with the previous strategies.

Past experience allows adults to form mental models, which govern behavior and guide learning and practice.[3,5,6,13,14,16] These mental models, also called frames, represent the decision-making processes, assumptions, standards, or protocols that dictate cognitive processing of information. In health care, mental models form the basis for clinical decision-making. For example, one may use a protocol to treat a disease process and make decisions based on past experiences.[5,13,14]

Mental models based on experience may be so entrenched that the individual will rely on them even in the presence of contradictory evidence.[3,6,13] Flawed mental models can form when providers treat symptoms rather than their underlying cause. Often this is done by intuition or tacit knowledge, even in light of contrary explicit knowledge. For example, when providers have successfully diagnosed and treated a patient, their existing mental model is reinforced regardless if the treatment plan was correct. As providers rely on their tacit mental model (intuition), adding additional explicit knowledge will not necessarily change practice unless it is attached to the provider's mental model or decision-making process. More effective learning should therefore target changing or enhancing mental models.[6,14]

Adults use analogical reasoning to adapt or connect their existing mental models to new information or a target or preferred mental model. Analogical reasoning is the process of identifying the structural similarities between a specific, novel experience and related past experiences to make inferences from prior events.[16] These inferences can then be used to respond to and understand a novel event. When the connection proves successful—the analogy between the prior and current situation is viable—the new experience is often integrated into a mental model the learner uses to guide practice in related situations.[17] The ability to reason via analogy to integrate new experiences into mental models enables individuals to transfer knowledge from their past experiences to use in novel situations.[6,13,14] In addition, the process of using analogical reasoning provides efficiency because information from previous experiences can be used to reduce the time and effort required to accomplish the new task.[18] For example, the heart is analogous to a pump. If a learner understands the way a pump operates, this mental model of pump functionality can foster learning of heart functionality.[19] Faulty analogical reasoning, by contrast, is at the core of diagnostic errors: the learner may have connected a surface feature rather than a structural feature.

For example, consider a case of a child intubated after a traumatic brain injury being monitored in the intensive care unit. During the course of care, that patient's blood pressure begins to increase, the respiratory pattern changes, and heart rate begins to decrease. This Cushing's triad physiology leads the care team to assume impending brain herniation and treat the increased intracranial pressure. They elevate the head of the bed, adjust the ventricular drain, sedate, and administer hypertonic saline. The patient does not improve. The actual etiology for the clinical changes was an obstructed endotracheal tube. The team made a surface connection: Cushing's triad = brain herniation, but overlooked the new information available and structural cause of the condition, ie, increased pressures on the ventilator and increased end tidal CO_2.

Unlike lecture-based or teacher centered-learning, simulation requires learners to apply their current mental models during an experience; it provides a great opportunity for individuals to control their learning to improve or refine their mental models. Educators can design simulations that stress existing mental models, helping the individual to identify areas where they need and want to learn. In this way, the educator facilitates the education process, while allowing adults to self-regulate their learning and focus on their own learning objectives.

Experiences

Experiences, either real or simulated, are simply catalysts for learning: the actual learning does not occur during the experience itself, but rather during the debriefing that follows. A debriefing is a discussion that occurs immediately following the simulation experience during which educators and learners can reflect together to analyze individual and group performance. Experiences provide an opportunity for this reflection during which individuals can evaluate, refine and enhance the mental models that guided behavior. Skilled debriefers facilitate reflection and analogical reasoning after an experience for each individual. The learner must then "test," or experiment with revised mental models created by

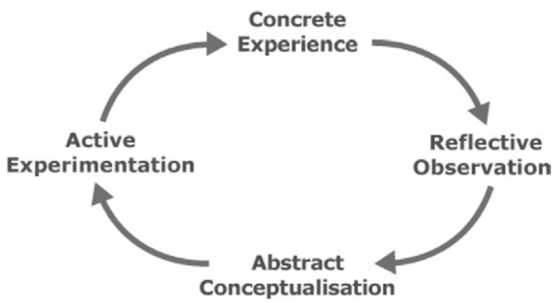

Figure 3 Kolb's Experiential Learning Cycle.[13]

this reflection, leading to permanent change. The process of having an experience (concrete experience), reflecting on that experience (reflective observation), developing mental models (abstract conceptualization) and then testing that mental model (active experimentation) is based on Kolb's Experiential Learning Cycle (Fig. 3).[12]

Concrete Experience

Simulations provide concrete experiences during which learners can identify knowledge gaps upon which they can reflect. The most profound educational experiences are those that are emotionally charged, challenging, and stresses the learner, causing a change of body state.[20] Optimally, designed simulations cause a significant change of body state to foster meaningful reflection, yet are not so stressful as to impede learning.

Reflective Observation

Debriefing provides an opportunity for learners to reflect on the simulation and their own performance. This reflective process allows the learner to identify gaps in mental models and to prepare for learning. Educators can facilitate reflective observation by providing an objective view of the learner's performance. Video-enhanced debriefings are useful to promote reflection, but should be used as an adjunct to the process not as a replacement for the individual's reflective process. The learner must reflect on the rationale for the behavior if they are going to change their mental model.

Abstract Conceptualization

Experience and reflection allow the learner to make sense of what happened, while abstract conceptualization facilitates bridging to future experiences. After reflection, the learner is ready to adapt their mental model. During abstract conceptualization, the educator has an opportunity to help shape the learner's new mental model through analogical reasoning. At this point, learners are ready to consider outside information from the educator and other resources.

Active Experimentation

Once the learner has developed a new mental model, they need to test it. In actual practice a learner must wait for this opportunity to arise. When substantial time elapses before the opportunity to practice occurs, it may result in loss of change and reversion to old mental models. Simulation provides a perfect opportunity for active experimentation by allowing the learner to try out new ideas immediately. Such active experimentation promotes "cementing" of new knowledge and long-term changes in practice.

Environment

Educators must consider the learning environment and the larger clinical environment in which students regularly practice to promote sustained change. The environment for learning can either support or undermine the ability to apply new knowledge in daily practice.[5,9] For learning to be effective, the environment must include skilled mentors to provide effective feedback and support change for life-long learning. Learners need mentors to help make sense of their experiences. Mentors are both formal and informal. The challenge for the mentor is to focus on guiding the individual through the experiential learning cycle rather than trying to "lecture" the learner after an experience. The mentor needs to shift their focus from presentation of material to facilitation of reflective observation and abstract conceptualization. Mentors help the learner through experiential learning by providing feedback. In simulation, this occurs during the debriefing. Learners first need the opportunity to have the experience (ie, simulation) without feedback or guidance even if they have difficulty. Once they have the experience and have reflected upon it, they are ready for feedback.

To help the learning process, feedback should be aimed at enhancing the learner's reflective observation and should be both positive and negative. The learner needs to make sense of the experience and understand correct interventions and areas for improvement. Positive feedback for appropriate behaviors will strengthen existing mental models, whereas incorrect behaviors or areas for improvement will be changed during abstract conceptualization.

For the individuals to change their daily practice, their working environments must support the change. As educators, we often overlook the environment in which learning will be applied. However, the actual clinical environment will make or break any change in practice. Learners must be able to use their new knowledge and mental model in daily practice as part of a lifelong experiential learning cycle. The Accreditation Council for Gradual Medical Education lists this as a core competency of practice-based learning and improvement. Environmental issues affecting practice change include both the work culture and the work processes.

If the work environment has a culture resistant to change or improvement, the learner is going to have to overcome barriers embedded within the system to use their new knowledge and mental model. If the learners go against the group and change their practice, they risk being labeled outsiders and losing their sense of relatedness.[12] For example, the processes within the environment must support the change. If as educators we help the learners with a new technique or process while the environment does not support change, the individual will not be able to use their new mental model. For example, the student learns how to use a new piece of equipment in simulation, but it will not be available on the unit until next quarter. Educators need to be aware of barriers that may currently exist in the work environment and consider solutions to overcome these barriers when choosing learning objectives.

Conclusions

Healthcare simulation is a powerful educational tool to help facilitate learning for clinicians and change in practice to improve patient outcomes and safety. To promote effective life-long learning through simulation, the educator needs to consider individuals, their experiences and their environments. Effective education must be delivered along a continuum, from simulation to the bedside, where each experience is seen as a problem to be solved or an opportunity to learn. Simulations should not only provide an opportunity for experience, but also one for reflection and refinement of mental models. Simulation adheres to the 2 most important tenets of experiential adult learning by allowing hands-on experience in a safe environment, and subsequently providing guided reflection. The educator must then facilitate discovery of mental models and provide the substrate for learners to change and improve them. When provided in the context of best practices of adult learning theory, simulation can have a positive impact on not only the learners, but also the patients they serve.

References

1. Bloom BS. (ed): Taxonomy of Educational Objectives. Vol. 1: Cognitive Domain. New York: McKay, 1956
2. Sheckley BG: Experience enhances learning: A tribute to the Ideas of Morris T Keeton: Paper Presented at the Council for Adult and Experiential Learning 2003 International Conference, San Diego, CA, Effective Adult Learning Strategies, 2003
3. Eckert E, Bell A: Invisible force: Farmers' mental models and how they influence learning and actions. J Extension 43, 2005. Available at: http://www.joe.org/joe/2005june/a2.shtml. Accessed: January 10, 2009
4. Strauss S, Ravid D, Magen N, et al: Relations between teachers' subject matter knowledge, teaching experience and their mental models of children's minds and learning. Teach Teach Educ 14:579-595, 1998
5. Sheckley BG, Kehrhahn M, Bell AA, et al: Trio Model of Adult Learning. Storrs, CT, Department of Educational Leadership, University of Connecticut, 2007
6. Zigmont JJ: How Paramedics Learn: the Relationship of Experience, Mental Models and Analogical Reasoning. Storrs, CT, Department of Educational Leadership, University of Connecticut, 2010
7. Sheckley BG, Keeton MT: Improving Employee Development: Perspectives From Research and Practice. Bloomington, IN, Author House, 2001
8. Ericsson KA, Charness N: Cognitive and developmental factors in expert performance, in Feltovich PJ, Ford KM, Hoffman RR (eds): Expertise in Context: Human and Machine. Cambridge, MA, MIT Press, 1997
9. Gully SM, Beaubien JM, Incalcaterra KA, et al: A meta-analytic investigation of the relationship between team efficacy, potency, and performance. J Appl Psychol 87:819-832, 2002
10. Knowles M: Andragogy in Action London, Jossey-Bass, 1985
11. Ryan R, Deci E: Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol 55:68-78, 2000
12. Kolb DAExperiential Learning. Upper Saddle River, NJ, Prentice Hall, 1984
13. Bakken LL: Role of experience and context in learning to diagnose Lyme disease. J Contin Educ 22:131-141, 2002
14. Lowe MMContinuing medical education for physicians: Key factors contributing to learning and change. Doctoral Dissertation, University of Connecticut, 2007. (Publication No. AAT 3265783)
15. Bandura A: Perceived self-efficacy in cognitive development and functioning. Educational Psychol 28:117-148, 1993
16. Gentner D, Markman AB: Structure mapping in analogy and similarity. Am Psychol 52:45-56, 1997
17. Seel NM: Mental models and complex problem solving: Instructional effects, in Elen J, Clark RE (eds): Handling Complexity in Learning Environments: Theory and Research. New York, Emerald Group Publishing Limited, 2006
18. Thompson L, Gentner D, Loewenstein J: Avoiding missed opportunities in managerial life: Analogical training more powerful than individual case training. Organ Behav Hum Dec Process 82:60-75, 2000
19. Norman G, Dore K, Krebs J, et al: The power of the plural: Effect of conceptual analogies on successful transfer. Acad Med 82:S16-S18, 2007
20. Damasio AThe Feeling of What Happens: Body, Emotion and the Making of Consciousness. London, Heinman, 1997