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Instructional design dogma: Creating planned learning experiences in simulation

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Abstract Human lives depend on the performance of our trainees; thus, the educational methodology used to transform our learners into experts are of paramount importance. Effective use of simulation requires educators explore and apply educational theory as they discover who the learner is, how the learner learns, what the learning needs are, and which planned learning experiences are best suited to meet the learner's specialized needs. The purpose of this article is to portray simulation as an educational strategy in the context of a curriculum, to explore emerging theories from educational psychology, and to provide concrete examples of their application in simulation-based education.

1. Introduction

> "Scholars of teaching and learning are prepared to mess with the world even more boldly than their colleagues who are satisfied to teach well and leave it at that. They mess with their student's minds and hearts as they instruct, and then they mess again as they examine the quality of those practices and ask how they could have been even more effective. Scholars of teaching and learning are prepared to confront the ethical as well as intellectual and pedagogical challenges of their work. They are not prepared to be drive-by educators. They insist on stopping at the scene to see what more they can do" [1] (p viii).

As medical educators, we are responsible for creating transformative learning experiences; we should be held accountable for the outcomes of our interventions. The effectiveness of our instruction will impact human life; therefore, the methodology must be grounded in germane educational theory and evidence-based strategies. Many educators have proposed the use of simulation as an instructional strategy in which this transformation can occur. The purpose of this article is to portray simulation as an educational strategy in the context of a curriculum, to describe experiential learning theory, deliberate practice, and reflective practice as they apply in simulation-based training, and to explore additional educational theories useful in improving and refining our educational processes in simulation.

1.1. Simulation-based training as an educational strategy

1.1.1. Comprehensive simulation-based training

Simulation is sexy. The trainee enters a room designed to replicate a real operating room, trauma bay, or delivery suite; the patient is groaning, her pupils are dilated and fixed; the bedside patient monitor is alarming as the oxygen saturation plummets below 80%. Disbelief is suspended;

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the trainee responds to this perceived crisis with authentic emotion and learned skill. The performance is videotaped and reviewed using facilitated debriefing techniques. The trainee emerges with new cognitive, technical, and behavioral skills; transfer of these skills to the real environment is seamless. This technology is so extraordinary that we expect improved patient safety, improved provider and team competence, and, ultimately, improved patient outcomes. One might conclude that superior technology results in superior educational experiences. Technology, in this sense, is a product; greater financial investments result in better technology, and better technology allows for greater learning experiences. Unfortunately, simulation is not a technology. Simulation is an educational strategy or "technique used to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner" [2]. As such, educational strategies provide the means by which a curriculum's specific measurable learning objectives are achieved. For the purpose of this discussion, simulation-based training will be defined as an experiential learning strategy that invokes reflective practice. The learner is immersed in a realistic situation (scenario) created within a physical space (simulator) that replicates the real environment with fidelity sufficient to achieve suspension of disbelief on the part of the trainee [3]. The trainee reviews the performance with a skilled instructor who facilitates learner discovery as various domains of the performance are examined.

1.1.2. Curriculum design

Curriculum can be defined as a planned learning experience. Curriculum development follows a simple 4-step approach. Step 1 involves discovering a problem, identifying the targeted learner, and determining the learning needs. Step 2 requires developing overarching educational goals and specific measurable learning objectives. Curriculum content is then selected, and the educational strategies needed to achieve these objectives are identified. The final step entails assessment of learning outcomes, curriculum evaluation, and revision. Curricula, therefore, provide a means for measuring learning.

Simulation is an educational strategy within curriculum design. Educational strategies describe the methods by which the educational content will be delivered. The content of the curriculum is derived from the specific measurable learning objectives. The educational strategies should be chosen based on how well they can meet the objectives. Simulation, as an educational strategy, can be used to effectively meet the following types of learning objectives: cognitive (knowledge and problem solving), affective (attitudinal), and psychomotor (technical skills, behavioral skills, and performance) [4]. The evidence supporting the use of simulation to meet these various learning objectives will be discussed in the section on educational theory.

1.2. Applying the principles of curriculum design in neonatal resuscitation training

The following is a prototype curriculum design process for neonatal resuscitation training; it serves as an example of methodology that can be used to craft curricula for numerous medical domains.

1.2.1. Step 1: problem identification, learning needs, and targeted learners

Each year in the United States alone, 400 000 newborns will require assistance with breathing, and approximately 40 000 of these will require extensive cardiopulmonary resuscitation [5]. The Neonatal Resuscitation Program (NRP) was developed by the American Academy of Pediatrics in conjunction with the American Heart Association in 1987 "to provide training to hospital delivery room personnel to standardize knowledge and skills in an attempt to reduce neonatal morbidity and mortality and increase successful resuscitation during the first few critical minutes after birth" [5]. This training consists of 7 lessons in which the skills necessary for temperature management, ventilation, endotracheal intubation, administration of emergency medications, cardiopulmonary resuscitation, and management of special circumstances (eg, ethical and viability issues) are described. Typically, trainees complete a cognitive knowledge examination, practice skills on task trainers, and undergo a mock code scenario. Certification depends on successful completion of the examinations and the subjective opinion of the instructor.

Research demonstrates that NRP has improved neonatal outcomes. Ryan et al [6] evaluated newborn resuscitation practices before and after the introduction of the NRP and found significant improvements in delivery room preparation, evaluation of the newborn, and thermal protection at birth. Patel et al [7] performed a retrospective evaluation of the impact of NRP instruction in Illinois hospitals by examining Apgar scores among high-risk infants. Logistic regression analysis revealed that, as the number of NRP instructors increased, high-risk neonates with low 1-minute Apgar scores were more likely to have higher 5-minute Apgar scores. Implementation of NRP has decreased the incidence of meconium aspiration syndrome [8,9], reduced neonatal hypothermia (a very serious condition) after birth [6], and significantly reduced mortality [10].

Data suggest that NRP favorably impacts neonatal outcome, but birth asphyxia still accounts for approximately 20% of the 5 million neonatal deaths that occur globally each year. For this reason, it is important to know how well practitioners adhere to the NRP guidelines during actual resuscitations so that we can identify areas of improvement. Carbine et al [11] analyzed video footage from 100 newborn resuscitations to evaluate compliance with the NRP guidelines in their institution. Although all members of the resuscitation teams were NRP certified, 54% of the resuscitations had visible deviations from the guidelines, including poor suctioning technique, incorrect use of oxygen, poor bag mask ventilation technique, and inadequate reevaluation.

Evidence from studies evaluating skill retention suggests these deviations may, in part, result from skill degradation. Currently, NRP providers are required to recertify their provider status (by taking another NRP course) every 2 years. Kaczorowski et al [12] studied skill degradation in trainees undergoing NRP training and documented a significant decline in both cognitive knowledge and technical skills after 6 months. There are similar reports from the resuscitation literature citing significant degradation of learned resuscitation skills; some degrade as early as 2 weeks after initial training [13,14].

Neonatal Resuscitation Program training, as demonstrated above, focuses on technical skills and cognitive knowledge acquisition. Root cause analyses suggest that a likely source of medical error resides in what skills we are not teaching our resuscitation teams: behavioral skills (communication, leadership, and teamwork) and critical thinking skills. The Institute of Medicine estimates that 44 000 to 98 000 deaths occur each year in the medical field as a result of human error [15]; inexpert decision making has been identified as a major contributor to these errors. In July of 2004, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) published a sentinel event report, where they investigated 71 cases of newborns with poor outcomes [16]. There were 10 cases of permanent disability and 61 cases of infant death. The primary root cause analysis identified 3 major areas that potentially led to these outcomes: problems with effective communication and teamwork (70%), problems with staff competency (47%), and problems with the training process (40%). JCAHO went on to recommend team training, mock emergency drills, and debriefings aimed at evaluating team performance to address these problems.

Problem identification. Our current training in resuscitation is not transferring to the real environment as seamlessly as it could; this failure in translation decreases patient safety and increases patient harm. Skills acquired in the current paradigm are limited to cognitive knowledge and technical domains; they are poorly retained after the training, and they are improperly applied in the real environment. How can we improve the training process itself to better prepare providers to manage newborn emergencies?

1.2.2. Step 2: overarching educational goals and specific measurable learning objectives

The answer may lie in application of sound educational theory; it is argued that learner-centered techniques are required to address complex learning needs [17,18]. For adult learners, the most significant learning experiences occur in the context of real life, for example, during immersion in authentic activity via hands on training [19]. Most NRP training programs focus on cognitive skills with passive learning activities. There is little emphasis on interdisciplinary team training and behavioral skills (communication, leadership); the mock codes are not authentic to the real delivery room situation; the learners are not encouraged to reflect on their performance; and expert critical thinking skills are not identified, taught, or evaluated.

The overarching educational goal. Neonatal resuscitation providers will develop the knowledge, attitudes, and skills necessary to effectively resuscitate newborns in distress.

A specific measurable behavioral skill objective of the curriculum. At the conclusion of a training course, the provider will demonstrate closed-loop communication skills when interacting with others on the resuscitation team during a mock code.

A specific measurable technical skill objective of the curriculum. At the conclusion of the training course, the provider will demonstrate proper technique for providing assisted ventilation.

A specific measurable cognitive skill objective of the curriculum. Six months after the training course, the provider will recite the correct initial dose for endotracheal epinephrine.

1.2.3. Step 3: select curriculum content and the educational strategies

The content flows from the learning objectives and, in this example, involves the acquisition of the skills requisite to successful resuscitation: technical skills (chest compressions, endotracheal intubation), behavioral skills (teamwork, communication, leadership), and cognitive skills (problem-solving skills, critical thinking skills). Simulation is an effective strategy for developing each of these categories of skill. Evidence emerging from carefully constructed validation studies demonstrates that simulation-based training reliably results in acquisition and transfer of technical skills into the real domain [20,21]. Critical thinking and problem-solving skills are encouraged and developed using realistic simulated learning environments [22]. Simulation-based training improves recall in authentic clinical situations [23], as well as familiarization with medications, instruments, and medical equipment during simulations, which enhances trainee performance [24]. Simulation promotes teamwork skills [25] and improves communication skills [26].

1.2.4. Step 4: assessment of learning outcomes, curriculum evaluation, and revision

As discussed above, simulation-based training is an effective instructional strategy for achieving (and documenting) technical, cognitive, and behavioral objectives. Assessment of learning outcomes and evaluation of the curriculum can take many forms. In neonatal resuscitation training, technical and behavioral checklists and performance rating scales are often used to assess immediate achievement of learning objectives [27]. Self-efficacy assessments provide insight into learner confidence in newly learned skills [28]. The motivation for designing a curriculum to improve neonatal resuscitation skills is ultimately to improve neonatal outcomes. When simulation is used as an educational strategy (within a curriculum) for teaching providers to manage fetal and neonatal emergencies, improved neonatal outcomes (less neurologic injury and higher Apgar scores) are observed [29]. Linking educational interventions to patient outcome is considered the Holy Grail in medical education. Yet, according to the curriculum design dogma, the curriculum can be improved through evaluation and revision. A thorough understanding of the educational psychology supporting the use of simulation as an educational strategy may provide insight into methods for further revising and improving simulation-based curricula.

1.3. Educational psychology

Educational psychology is concerned with manipulating the instructional environment and understanding the characteristics of the learner to create growth in the learner. The learning environment itself is idealized when support and challenge are well balanced [30]. In simulated experiences, the educator must first identify the learner and the learning needs, and then construct simulations that provide balanced challenge and support in order for the greatest learning to occur (Fig. 1).

1.4. Experiential learning

Experiential learning is "the cyclical process wherein people view their experiences as opportunities to learn, integrate those experiences into their education, and engage in subsequent action based on the integration" [31]. In other words, learning as a cycle that begins with experience continues with reflection and later leads to action. The action itself becomes a concrete experience for reflection. Experiential learning theory and its application in simulation is based on the following propositions [32]:

1. Learning is best thought of as a process, not an outcome. In simulation, this process involves repetitive practice and feedback on the effectiveness of the trainees learning efforts.
2. All learning is relearning. Learning in the simulator is best facilitated by a process that encourages the student to identify what they have previously learned and to build upon and refine that knowledge.
3. Conflict drives the learning process. Often in medical simulation, learning requires the learners to face the differences that exist between novice and expert performance. These differences can be used to develop the learning goals and objectives.
4. Learning involves a holistic process of adaptation. Learning in the simulator involves attending to the feelings associated with the experiences (stress, fear), as well as the thoughts and perceptions emerging during the simulation.
5. Learning involves creating knowledge; ideas are not transmitted to the learner. In simulated learning experiences, learners discover new methods for solving problems and create new knowledge based on these discoveries.

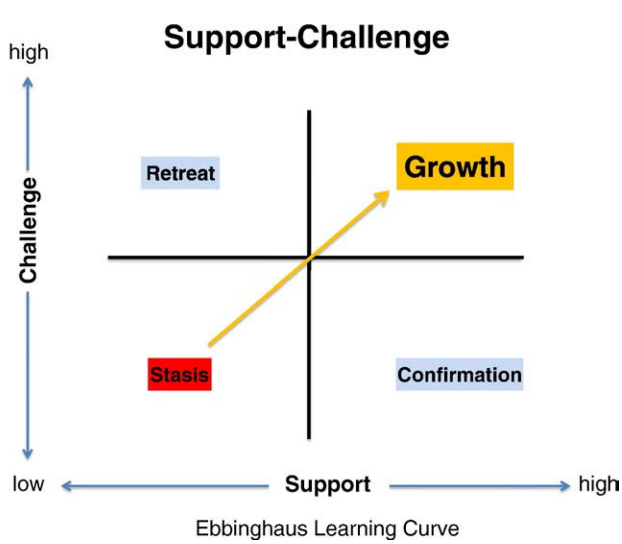

Fig. 1 Support challenge.

In simulation, the focus is learner centered. The manner in which the information is packaged is important; experiential learning requires educators to facilitate the interaction between the learner and the experience [33]. Experiential learning techniques, such as simulation-based training, address the cognitive, technical, and behavioral domains of learning, resulting in deeper learning and better retention [34-36]. Paramount to understanding ELT is the concept of individual learning styles. Individuals have different approaches to learning; some learners grasp knowledge best from concrete experiences, others from abstract conceptualization. Learners then transform these experiences into learning through reflective observation or active experimentation. Reflection is a central component of experiential learning because it provides a means of thinking about practice.

1.5. Reflection

Simulation-based training is an effective educational strategy for improving performance through developing reflective thought processes. Reflective practice refers to the process of analyzing cognitive and affective aspects of experiences to gain understanding that will lead to improved performance. Donald Schön [37]–defined reflection is an active process that turns a person's experience into learning. He recognized 3 categories of reflection:

1. Knowing-in-action: ability to complete tasks without consciously thinking through each step of the process.
2. Reflection-in-action: the process of reflecting on a given action while performing the action.
3. Refection-on-action, which he detailed as "thinking back on what we have done in order to discover how

our knowing-in-action may have contributed to an unexpected outcome" [37] (p 28).

Boud et al [38] argued that effective reflection-on-action must attend to 3 key elements: returning to the experience, attending to the feelings associated with the experience (the emotional component), and reevaluating the experience.

As an educational strategy, simulation offers opportunities to develop and explore reflection-on-action skills. Reflection-on-action occurs during facilitated debriefings with video review; the trainees are encouraged to reflect on their experiences, explain their thought processes, and discover new methods. Self-discovery and feedback involving the learner have independently been shown to improve trainee performance [39,40]. Reflective practice offers a mechanism by which to decrease cognitive diagnostic errors [41]. The ability to critically reflect upon one's performance has been identified as a skill required for developing and maintaining medical expertise [41]. Schön's concepts of knowing-in-action and reflection-in-action involve expert thought processes and highlight an area where simulation needs further investigation as an educational strategy.

1.6. Expertise

Although trainees can "reflect-on-action" during the facilitated debriefing with video review, we have yet to address ways to assess and teach "reflection-in-action." "Reflection-in-action" allows the participant to respond to cues in the environment and make critical decisions based on those cues, thereby separating the novice from the expert [42]. In medical education, often, our goal is to move our learners along the continuum from novice to expert [43]. Higgs and Jones [44] outline 8 characteristics that experts exhibit when compared with novices:

1. "Experts excel mainly in their own domains.
2. Experts perceive large meaningful patterns in their domain.
3. Experts are fast: they are faster than novices at performing the skills of their domain, and they quickly solve problems with little error."
4. Experts have superior short-term and long-term memory.
5. Experts see and represent a problem in their domain at a deeper (more principled) level than novices; novices tend to represent a problem at a superficial level.
6. Experts spend a great deal of time analyzing a problem qualitatively.
7. Experts have strong self-monitoring skills.
8. Experts have a depth of understanding of the clinical problem, which includes the client's perspective" [44] (pp 16-18).

Most of the research on medical expertise has focused on the clinical and diagnostic decision making. Critical thinking skills are developed by examining the expert's reflection-in-action. Facilitating the development of expert critical thinking skills (the expert reflecting-in-action) in the simulator may result in greatest transfer of skill from the practice domain to the real domain. Patel et al [45] described the transition from novice thinking-in-action to expert thinking-in-action. As clinical experience increases, practitioners change their mental strategies to approach clinical problems. A novice first creates a differential diagnosis then rules out each component (backward reasoning). An expert assesses the clinical situation and rapidly forms a preliminary diagnosis; they then create an algorithm that uses a few factors to rule in or out their provisional diagnosis as they move on to treatment (forward reasoning). Expertise requires effectively learning not only factual knowledge, but also the organization of these facts and ideas in a conceptual framework for application and transfer to different contexts [46]. Learning transfer refers to the learner's ability to use knowledge from a previous experience to help learn something new. Problem-solving transfer occurs when the learner uses knowledge from a previous experience to formulate a solution to a new problem. Such deep learning is facilitated by deliberate recursive practice on areas that are related to the learner's goals [32].

1.7. Deliberate practice

Simulation as an educational strategy provides an opportunity for deliberate practice [47]. The maximum level of performance for individuals is not attained automatically as a function of extended experience; mere repetition does not automatically lead to improvement. Deliberate practice refers to the individualized training activities designed to improve the current level of an individual's performance through repetition and successive refinement. The explicit goal is to improve performance.

1.8. Modeling

Simulation educators and researchers are often tempted to study the effects exposure to simulation has on learning, rather than investigating simulation as a means to deliver instruction. There is sound evidence that simulation can be used to assess novice-expert differences in medical simulation performance. Yet, researchers examining simulation training have made only moderate use of expert empirical data as a basis for determining training content and delivery. Much of what differentiates levels of expertise in medicine resides in tacit knowledge and problem-solving skills. Sternberg et al [48] argues that both tacit knowledge and problem-solving skills can be developed through experiential learning combined with efforts to make tacit knowledge explicit and shared. Modeling and observational learning are a primary means of achieving behavioral changes and acquiring new technical skills [49,50]. Scholars researching tacit knowledge argue that the methods that stimulate the process of thinking about what one is doing will facilitate the development of expertise when this thought process is shared with others. From this perspective, one might argue that in order for the trainee to develop expert critical thinking skills, the expert's thought processes need to be demonstrated or modeled. Modeling has been shown to be effective in learning and acquiring skills [51]. During observation, learners selectively take in information about performing; from these observations, a mental image is created that provides a cognitive reference for the learner. This mental image, or cognitive model, becomes a standard of reference for future performances. Obtaining an accurate cognitive depiction is necessary for skill proficiency [52]. Morrison and Reeve [53] used video to teach various aspects of expert performance; the video instruction group had higher mean scores in a skill analysis test compared with a traditional verbal instruction group. The use of video review in this manner is referred to as self-modeling or learner-modeling; both have been shown to improve skill acquisition [54]. When comparing verbal and visual presentations, Martens et al [55] (1976) found that visual demonstrations of performance were preferred over verbal demonstrations. Participatory modeling is when the expert and the novice each participate in modeling the process for accomplishing a task; they then compare the novice performance to that of the expert. In real medical crises, our experts are reacting in an automatic fashion; the trainee cannot hear the thought processes, and in most, cases the expert cannot relay this information to them in action. Modeling forward reasoning in conjunction with performing technical and behavioral skills may allow the learner to more completely grasp the skill set used in expert performance.

1.9. The future for simulation as an educational strategy

Educational psychology offers numerous inroads in potential simulation research; important questions emerge from the discussion above.

- How can we accurately, yet efficiently, assess our learners' needs? How do we measure challenge and support in our learning environments?
- How can we best study the process of reflection-in-action? Can we identify and demonstrate expert thought processes and tacit knowledge? Can we package this information in a teachable format?
- Not all forms of feedback promote meaningful learning. Feedback must be presented as information intended to guide the learner's construction of knowledge and instill motivation. Can we investigate various methods of feedback and the effects on learning and performance? Is instructor, peer, or self-feedback (or some combination) most effective in changing behavior or acquiring new skills?
- How can we best develop reflection-in-action skills to move our trainees toward expertise thought processes?
- As a community of educators in simulation, how can we contribute to the field of expertise? Can we define expertise in each of our domains and study the effects of teaching in simulation using this content?
- Cognitive apprenticeship involves modeling, coaching, and scaffolding. Modeling occurs when the instructor describes his or her thought processes in the course of carrying out a task. Coaching occurs when the instructor offers feedback to the trainee who is carrying out the task. Scaffolding is needed when a student is working on a task but is not yet able to successfully manage each part of the task without support; the instructor performs the tasks the trainee is unable to perform. How can we effectively apply these concepts in our simulation teaching strategies?
- Can we further explore motivation for learning? According to self-efficacy theory, students learn best when they are confident in their capabilities to learn the material. Can we measure confidence? Can we devise educational programs that enhance trainee confidence?

2. Conclusion

As scholars of teaching and learning in medicine, we are profoundly aware of the potency and impact of our instruction. Human lives depend on the performance of our trainees; thus, the educational methodology used to transform our learners into experts are of paramount importance. Given this enormous responsibility, we are searching for technologies designed to enhance learning and simplify instruction. Elaborate high-fidelity technology may enhance instruction, but it cannot replace curricular design or finely tuned educational strategies. We must continue to emphasize on the importance of personnel, methodology, and educational principles in our pursuit of better educational experiences to address our healthcare problems. Simulation is not a technology; it is an educational strategy. Effective use of simulation requires educators explore and apply educational theory as they discover who the learner is, how the learner learns, what the learners' needs are, and which planned learning experiences are best suited to meet the learner's specialized needs. Our challenge is to use not only the available technology, but also the knowledge, theory, and collective clinical experience around us to create needs-based goal-oriented curricula that will equip our learners with the ability to use forward reasoning and reflective practice to advance their expertise and ultimately improve the outcomes of their patients.

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