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Aha! Taking on the myth that simulated surprise enhances learning

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Abstract

Objective: To discuss a recurring education problem of the high fidelity simulation myth. In the current instantiation, educators erroneously believe that trainees benefit from authentic uncertainty and surprise in simulation-based training. We explore the origins of this myth within experiential learning and social constructivism theories and propose an evidence-based solution of transparent and guided instruction in simulation.

Background: Constructivist theories highlight meaning making as the benefit of inquiry and discovery learning strategies. Inappropriate translation of this epistemology into an element of curriculum design, creates unfortunate unintended consequences. We propose that the translation of constructivist theories of learning within simulation-based education has resulted in a pervasive myth that scenarios must introduce realistic tension or surprises to encourage exploration and insightful problem solving. We argue that this myth is masquerading as experiential learning. In this narrative review, we interpret our experiences and observations of simulation-based education through our expertise in education science and curriculum design. We offer anecdotal evidence along with a review of selected literature to establish the presence of this previously undetected myth.

Introduction

> *Wasn't clear to me exactly what we'd be doing today until we got here, and even as we moved room to room.* (anonymous trainee)

Simulation-based medical education creates opportunities for trainees to solve clinical problems in realistic and authentic contexts (1, 2). The pursuit of realistic contexts increased demand for technological solutions to replicate realistic environments (3-8). However, the inclusion of technology to achieve 'high fidelity' did not guarantee effective education design (5). Others emphasized authenticity; constructing learning experiences that evoke realistic emotions, uncertainty and stress(9-11). This pursuit for authenticity may support a belief that the experience of uncertainty that accompanies clinical practice is required in simulation-based education design. However, intentionally including uncertainty in simulation curriculum design may have negative consequences on learning outcomes.

> *"I didn't realize that the heart sounds were actually muffled - I thought it was just the mannequin - If I had known the heart sounds were muffled, then I would have followed the tamponade algorithm"* (anonymous trainee)

In reference to the previous quote, if the objective was assessment and management of tamponade, then the trainee did not even start to learn, and is unlikely to benefit from any feedback as they perceive that *fidelity* completely mires the interpretation of their performance.

In this narrative review we draw on personal experience, content expertise, observations and anecdotes to define the education problem of surprise induced learning, which may be limiting the effectiveness of simulation-based education. Evidence of the existence of the myth incorporates our observations. Evidence for consequences of the myth incorporates anecdotes from anonymized evaluations of simulation-based training sessions. The solution to this problem is rather straightforward: simulation-based education is more effective with clear learning objectives that are matched to the curriculum and the scenario(12-17).

Factors that contribute to the myth of surprise-induced learning

The misuse of theatre-based simulation

Theatre-based simulations involve many elements which, if employed inappropriately, may interact to obscure learning objectives(8). If you have never viewed or participated in a theatre simulation, hopefully you have seen enough medical dramas to visualize a typical operating theatre (e.g.

hospital bed, blood pressure cuff, ventilation equipment, etc.). These environmental features often include electronic devices or mannequins to play the part of the patient. In terms of participants, there are the trainees, educators, staff and confederates. Health professions trainees are engaged in a pre-briefing session to orient them to the room, equipment and any other participants. A single trainee or a team may enter the operating theatre with little additional information. It is the trainee's or team's goal to quickly define the problem, form a plan and bring the scenario to a conclusion. The educator helps design the scenario, conduct the pre-briefing (15-17) and debriefing sessions (18, 19). There are support staff in the background controlling the simulation technology, creating the appropriate feedback from the simulated scenario. For example, support staff ensure that mannequins emit relevant sounds. Confederates are not there to learn, but are trained to facilitate realism. In addition to participants, a critical element is the expense, given the requirement of support staff, confederates, specialized technology and educators(20). Therefore, care is taken in designing and testing scenarios for the theatre; often these scenarios are very brief and confederates have clear directives to move everyone to the intended conclusions. In many cases, the trainee, focused on performing a procedure well, will be nudged by confederates, actively guiding them to the conclusion of the scenario. Trainees are shepherded towards uncovering some hidden element as much for cost management purposes to reduce the time spent in a simulation as for ensuring the learning objective is met. We observed this aspect of theatre-based simulation leave trainees confused, which led us to question the use of expensive resources to deliver a learning objective that could have easily been the topic of an academic half-day or case-based group discussion.

> *Lots of unexpected prompting was necessary to have the learners recognize the worsening congestive heart failure and respiratory failure of the patient. I left the session unclear of whether this was a fixation error on the part of the learners or whether this was due to technical resources.* (anonymous faculty)

If the goal is to create an opportunity for a trainee to identify and solve a problem, how does imposing a time limit affect learning? Why hide the learning objective? What benefit does simulation serve if trainees expect others to have the answers and may rely on others to prompt them?

Simulation induced complexity

In our observations or experiences with simulation-based training, faculty tend to focus on broader learning objectives, like helping trainees develop problem solving skills. Educators attempt to encourage creative problem solving with plot twists, hidden elements, and extreme or rare events. For example, within a scenario, confederates may report certain test values that are unusual, or trainees may be expected to detect extreme values on monitoring equipment. Possibly most worrisome, theatre based simulation has gained the reputation of involving hidden tricks, crises and unexpected events(21). Unfortunately, learners may reach the solution through unintended strategies.

> *The learners appear to be "primed" to rare diagnoses. They recognized the potential for thyroid storm almost immediately and acknowledged that they felt it happened because of simulation and their presumption that the cases would be "weird and wonderful".* (anonymous faculty)

Being primed to detect rare conditions does not seem like a valuable use of simulation resources. Important learning may be shifted to the debriefing session, rendering it independent of the simulated experience and calling into question the need for theatre-based designs. Alternatively, explicit learning may not occur. Institutional data from an immediate post-simulation survey (30% response rate) completed by trainees of multiple disciplines and training levels (N=3693 responses), indicated that 10% did not think the learning objectives were clear, while the majority of respondents could not identify the practical value or link the learning objective to future behaviours; only 13% reported concrete learning outcomes. The common response: *"I realized I just have to go home and read up on [*some topic*]..."* is an anemic educational endpoint from a resource intensive simulation session.

Simulation induced stress

Some education literature proposes that an emotive experience is vitally important for authenticity in simulation (9, 22-24). In our observations, the goal of authenticity leads to scenarios designed to be stressful and chaotic.

> *When I took my first trauma course (i.e. brand new, never experienced it before), the simulations in the course were all large-scale, horrific traumas that quickly spiraled out of control. It turned out that the facilitator's intent of the simulations was about resilience and managing the team space. However, we weren't aware those were the objectives of the simulations, considering many of us came into the simulation thinking it was about honing in on our trauma skills.* (anonymous trainee)

Extreme, chaotic scenarios do not support refinement of a core skill or practice of a routine procedure. In these extreme or surprising scenarios, it is also unclear if trainees develop useful, generalizable strategies for managing teams or chaos. If the learning objective is too broad or abstract, how can we be sure what trainees walk away with? It is also possible that the scenario context limits their ability to apply what they learned to a new situation (25-30). The assessment literature highlights the challenges of context specificity; performance in one context may not generalize to another(31-34). Similarly, hoping to develop a general resilience to stress through simulation may be misguided as trainees are exposed to very limited simulated contexts(35). Alternate approaches of investing in developing resilience in the workplace or other more common learning activities may be more successful.

The Yerkes-Dodson law (yet another myth in education (36-39)) suggests a positive role for stress in performance. This mythical *law* may lead to the assumption that stress is beneficial for learning, but also that stress acts independent of other factors like arousal. Additionally, educators may assume that stress should be induced artificially. However, the simulation environment is innately stressful, with the mere presence of peers and a faculty member increasing stress, often above productive levels. Furthermore, the source of stress can easily become the object of heightened memory (e.g. the simulation center and observing faculty) rather than the intended learning objectives. Research suggests that careful attention must be paid to the design of the scenario, the internal rationalization of the trainee regarding the simulation itself, the timing of the stress and whether the stressor is critical to the learning objective, or simply incidental to the content (i.e. necessary only for realism or stress inoculation). Indeed, the effects of stress within an education context may be unpredictable (26).

LeBlanc and colleagues showed that performance, on a task that required calculation of drug dosages, was reduced if paramedics had just experienced a highly stressful simulation, compared to paramedics who completed the task in a quiet classroom(26). Others have noted that preparing for a simulated scenario may induce heightened levels of anxiety or stress that can also impair both performance and learning(40). In some studies, stress impaired working memory, or the ability to retain important information while working on a task(41). Alternatively, if the stressor was seen as more of a challenge than a threat, working memory was not impaired(41). Therefore, depending on how the trainee internalizes the knowledge that their performance in a simulation will be evaluated, such as during the debriefing, their performance and their ability to learn from it can be enhanced or impaired. It may be that by reducing the element of surprise through more transparent learning objectives and simulated scenarios, trainees would accept them as challenges, rather than threats.

> *[…] a trainee who takes part in simulation sessions in which the primary source of stress is a socioevaluative one (being observed and assessed by a faculty member or fear of "losing face" in front of peers) will remember those aspects of the simulation session. However, the trainee's memory of the simulated scenario and associated learning points will not be enhanced.(26)*

LeBlanc's findings suggest there may be benefits to forgoing surprise and investing in preparing the trainee for a simulation (26, 42, 43). In addition, consider whether the stress or stressor is important. If the learning objective is to experiment with strategies to manage the stress or the stressor, then learning may be enhanced (43). But when stress acts as a distractor, trainees may fail to encode relevant information (43). For example, the same scenario that involves a distressed parent being disruptive while a medical resident attempts to perform a sterile procedure may have two contradictory and separate learning objectives(44, 45). On one hand, the trainee must engage strategies to manage the parent's behavior. On the other hand, the trainee must engage strategies for maintaining sterility while also managing the child's fear. Both learning objectives are very context specific skills. Maintaining sterility may be more or less challenging depending on the cooperation level or relative age and size of the patient. Using this example, it would be preferable for trainees to practice mastering different challenging aspects of the same scenario targeting different learning objectives until they can effectively integrate all skills required(45).

Simulating lived experiences

Our observations indicate that some medical educators are inspired to create simulation scenarios based on their own personal experiences because they want to share their *lived* experience with their trainees. Educators suggest that by recreating these events, they can directly pass on their own insights in powerful ways. Although we argued that constructivist theories may be responsible for these assumptions, constructivism does not support the belief that lived experiences will lead to the same insights for everyone. Instead, constructivism suggests that individuals are likely to create *their own meaning* from experiences. As an epistemology, constructivism acknowledges simply that truth is not a unitary construct(46); each individual transforms experience and knowledge into their own unique truth. Instead of realizing insights similar to those of the educator, trainees learn that surprise is part of the gamesmanship of simulation-based learning without recognizing the practice implications of the hidden learning objective (21).

We know from experimental and observational work that several factors can influence what is learned or remembered from an experience. For example, interest, confidence and motivation were among 44 important factors seen to influence performance in a study of simulation with business students (47). These same factors influence learning or recall(48-50). Experience level can also influence what is perceived or learned(51).

> *Kirschner (1991, 1992) also argued that the way an expert works in his or her domain (epistemology) is not equivalent to the way one learns in that area (pedagogy). A similar line of reasoning was followed by Dehoney (1995), who posited that the mental models and strategies of experts have been developed through the slow process of accumulating experience in their domain areas. P 78(52)*

> *The major fallacy […] is that it makes no distinction between the behaviors and methods of … an expert practicing a profession and those students who are new to the discipline and who are, thus, essentially novices. P 79 (52)*

The insight gained from an experience by an expert, or more skilled physician, cannot necessarily be matched or replicated for a more novice trainee. Additionally, lack of prior experience with the required skill set and novelty of the situation, can restrict attention to important information, and impair long term encoding and learning (53). The complex blend of factors within an experience that lead to insight and learning cannot be replicated.

Clarifying the role of experiential and discovery learning

Experiential learning theories follow the premise that learning is enhanced through experience and interactions with others (46). Socio-cultural interactions with others are important for learning but may influence individuals differently (46). Kolb's experiential learning cycle identifies a 4-step process beginning with i) a concrete experience that motivates ii) reflective observation and iii) abstract conceptualization (46). Reflection and conceptualization prepares the trainee for iv) active experimentation (46). Examining the 4 steps in the cycle, a simulated scenario might serve as a concrete experience that motivates. However, instructional design in simulation-based education often ignores step (iv); active experimentation. Rather than offer trainees multiple opportunities to practice skills theatre-based simulation activities are typically restricted to a one-time exposure to a complex case, with a lengthy debriefing and no follow-up. Without the active experimentation steps in the simulated context, trainees cannot apply their newly constructed understanding in a safe environment; they are left to experiment in the workplace. It is also possible that a simulated scenario is nothing like a concrete experience that motivates at all. If anything, the motivating experience belonged to the educator who designed the scenario.

Activity theories propose that action is interconnected with learning (54). Rather than explaining how learning occurs, this framework emphasizes the need to understand how actions and consciousness interact with the environment to produce learning (54). Activity theory has rather long-standing roots in the philosophy of Kant and Marx (54) and is radical only in that it emphasizes action before learning and not learning before action (54). Accepting that activity can lead to learning is a weak rationale for designing simulation-based education without clear learning objectives.

Discovery learning is often associated with the generation effect demonstrated in some studies that revealed better memory for words that were generated than for a given list that was studied and memorized(55). Given the popularity of discovery learning at the grass roots level of education scholarship (56) there is a notable absence of evidence supporting unguided learning in applied or higher education contexts. Indeed, meta-analyses point more to the effectiveness of guided learning (55, 57).

> *"As Mayer has pointed out, it has been the accepted practice to consider hands-on activities as equivalent to constructivism, but active instructional*

methods do not always lead to active learning, and passive methods do not always lead to passive learning (55)."

"With the random effects analysis, the 108 studies had a mean effect size of d = –0.38 (95% CI [–.50, _.25]), indicating that explicit teaching was more beneficial to learning than unassisted discovery."(55)

Critically, none of these theories guarantee that a given activity will produce the same learning outcomes or insights for everyone. These theories offer explanations of the mechanisms that support learning, without making predictions about what will be learned. Hence reliance on only these theories does not offer guidance for optimal instructional design (58).

The influence of both activity theory and steps ii and iii in Kolb's learning cycle is apparent in our observations of simulation-based education design, which is steeped in a culture of debriefing (12-14, 18, 19) and reflective practice (59). Educators apply these theories intuitively as they see the need for trainees to practice applying basic principles in action, rather than simply memorizing facts (60). Discovery learning is at the extreme end of this spectrum, tasking the learner to discover through action, rather than by structured instruction or instructor-led methods. Unfortunately, while there is value in exploration, which can lead to noted beneficial learning strategies, such as self-explanation (56) or learning through mistakes (2, 61, 62), opportunities for these self-directed learning activities must be cautiously integrated into the simulation curricula(25, 46, 52, 53, 55, 57, 58).

Emphasizing a role for learning objectives

Learning objectives are action-oriented statements that describe the skills, knowledge or attitudes that trainees can expect focus on within a structured education activity (63). Learning objectives enhance communication between the educator and learner and decrease ambiguity around expectations (64). Although ambiguity is almost central to the nature of clinical reasoning (65, 66), ambiguity does not lead to effective clinical education (55, 58). Learning objectives can focus students' attention and improve confidence in course material (64), help instructors and students organize their time around learning activities and guide the evaluation of learning outcomes (64, 67). Both instructors and learners benefit from clear learning objectives and several scholars have recommended clear learning objectives as part of the pre-brief and debrief sessions (12-14, 18, 19, 68, 69). In our experience, many learning objectives for simulation are deliberately constructed using vague terminology to preserve the element of surprise (e.g. "demonstrate the ability to diagnose and identify clinical problems that may be encountered in the course of providing anesthesia care"). Certainly, the ability to diagnose or identify clinical problems can reliably be evaluated using written cases (70-72), particularly for a formative context (73). Unnecessary ambiguity minimizes instructors' ability to focus learners on the educational goals of the simulation.

Conclusion

How we choose to define curriculum or education activities does not alter the actual mechanisms of learning, or the operational principles (58). How we choose to translate learning theories into curricula and learning activities certainly impacts learning. Education design decisions are most effective when based on sound evidence rather than norm based beliefs. Empirical evidence does not support the integration of surprise in scenario design. Constructivist learning theories offer an epistemological explanation for learning through life experience, but may not support effective curriculum design for planned education activities. Having a clear learning objective upfront does not deprive learners and educators of an educational moment. Instead, clear, transparent simulation-based learning objectives focus attention on the intended educational outcome. This focus optimizes learners' actions and reflections towards appreciating the complexity of the educational outcome itself rather than ferreting out the simulated surprise.

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