

THE SIMULATION THEATRE: A MEANS TO ENHANCED LEARNING IN THE 21ST CENTURY

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Abstract

The increasing role of simulation in medical education has paralleled advancement of this technology. Full environment simulation (FES) can be employed to effectively replicate rare medical catastrophes with exacting realism. It has been suggested that emotion can significantly enhance learning by producing memories that are processed and stored via the amygdaloid complex which is relatively impervious to extinction and thus forgetting. Theoretically the addition of emotional content to simulated crises during FES can be used to affect such changes in the participants and thus facilitate learning. We discuss the theoretic benefit and the use of FES with emotional enhancement as it relates to improved memory and learning.

Introduction

Full environment simulation (FES) is an adjunct to medical education that has been extensively developed by anesthesiologists. In fact, the first mannequin used to teach airway and resuscitative skills was developed by two anesthesiologists, Dr. Peter Safar from the United States and Dr. Bjorn Lind, a Norwegian, during the 1950's¹. Dr. Lind worked with a toy manufacturer to develop what has been known for over half a century as "Resusci-Annie". Some ten years later, Dr. Stephen Abrahamson, also from the United States, presented the advantages of training anesthesiologists

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with his full scale computer controlled human patient simulator². But the time and technology were not right.

Towards the end of the 1980's, two teams of anesthesiologists, one from the University of Florida (Drs. Michael Good and John Gravenstein) and the other from Stanford (led by Dr. David Gaba) developed a realistic mannequin simulation. They combined engineering skills and the idea of the using simulation in education, for team training and with an aim towards improving patient safety. The result was an interactive, realistic, patient simulator that could model the human response to various physiologic and pharmacologic interactions without real patient inclusion³. At the same time, Dr. Hans-Gerhard Schaefer and his colleagues in Basel, Switzerland, developed full scale simulators for crisis resource training of operating room teams⁴. The American Society of Anesthesiologists (ASA) formed an Ad Hoc Workgroup on Simulation Education in 2004, from which was developed an outline for the rationale and plan for implementation of simulation based continuing medical education for anesthesiologists⁵. Early simulators were made at departmental levels but have been commercially available now for over 15 years.

One might question why anesthesiologists need simulators when experience taught by those with many years of practice has served us well for years. The world of anesthesia is changing. Most cases, certainly in the United States are now performed on an out patient basis with less time afforded patient interaction. Continuity of care has also decreased as time limits are placed on work hours. Immigrants change the demographics of a country and with that often the response to therapy and the introduction of new disease processes... not to mention language barriers. The human genome has been unraveled and understood, which will enable us to adapt drug therapy to the genetic makeup of the patient safely. As nurse anesthetists, hospitalists, other technicians and non physicians take over much of routine anesthetic care in the coming decades, anesthesiologists should be poised to become more involved in tertiary and critical care medicine. Moreover, other specialties have capitalized on the early work of anesthesiologists and made enormous strides in developing simulation training for many procedures. To maintain our involvement in simulation methods and to preserve patient safety, it is important that we incorporate

Individual task trainer simulators, such as this pneumothorax simulator, may be used to allow individuals to practice tasks such as chest tube insertion



*Fig. 2
Full Environment
Simulation (FES)
Advanced Cardiac Life
Support Class in Progress*



*Fig. 3
The debriefing, which
takes place after the
simulated event, is the
most important part of
the simulator class*



simulation education as part of all training programs.

Full Environmental Simulation

Full-environment simulation (FES) includes the patient (simulator mannequin), other healthcare professionals and ancillary equipment and supplies designed to replicate the clinical environment. Current mannequin-based simulator designs are computer and model-driven, full-sized infant, child, or adult patient replicas that are capable of delivering “true-to-life” scenarios that simulate reality. Incorporating the simulated patient into a simulated operating room environment, complete with an anesthesia machine, monitors, and adjuncts commonly found in real operating rooms, allows participants the ability to suspend disbelief thus creating a highly effective learning environment. Now the lessons learned can be more real when compared to simpler screen-based simulators.

Many reports have discussed the efficacy of simulation-based education for teaching basic and advanced skills in anesthesiology, management of rare and critical events including advanced cardiac life support (ACLS) protocols, and team training through crisis resource management. FES provides the unique opportunity to not only practice procedures but to allow educators the ability to stage realistic scenarios in which the principal focus can be human behavior and interaction. In this environment, participants can be allowed to make mistakes and experience bad outcomes without patient harm. These adverse outcomes can facilitate the generation of negative emotions amongst the participants; no healthcare professional wants to be responsible for contributing to patient harm through a bad clinical outcome, especially when witnessed by colleagues. One of the major manufacturers alleges that its device “exhibits clinical signals so lifelike that students have been known to cry when it ‘dies.’” We theorize that the effectiveness of the simulator as an educational tool not only depends upon the ability of the simulator to realistically emulate human physiology and physiologic responses, but also depends on the specially designed facilities and the expertise of the educators to accomplish full environment simulation that triggers these emotions.

FES and Anesthesia Training

Simulation technology has gained widespread acceptance in medical education due to the safety on the environment, the ability to demonstrate multiple patient problems, the reproducibility of content, and the ease of simulating critical events⁶. With the increased use of simulation (coupled with an aggressive medico legal system in the United States), the idea of learning difficult and error-prone tasks by making errors on live patient or animals is progressively less acceptable. It has been said that we remember from our failures not our successes. It is those events that end with an untoward outcomes that creates “seasoned” veteran clinicians. Through the use of FES, clinicians may become “seasoned” without actually harming patients. In addition, rapid trajectory learning (i.e., “see one, do one, teach one”) has been replaced by the ability to repeat a task over and over again prior to an actual patient encounter.

FES and Learning Theory

Constructivism, a theory of teaching and learning, asserts that knowledge cannot be handed from a teacher to a student, but must be constructed by each learner through interpretation and reinterpretation of a constant flow of information. From the work of the Swiss and Russian psychologists Piaget and Vygotsky, constructivism reflects the cognitive psychologists’ view that the essence of learning is the constant effort to assimilate new information.

Simulation is built upon the principal format associated with constructivism, the problem based learning discussion (PBLD), in which the participants develop their own understanding through active participation, and may occur on different levels. These levels range from simple demonstrations through screen-based “video game” type simulations to FES. Flight simulators are perhaps the most highly developed form of FES, in which full cockpit environments undergo the movements associated with real flight (It should be noted that pilots are required to undergo cockpit simulator flight training annually and whenever they become credentialed on another plane). Even the highly advanced patient simulators in use today can be used along a continuum of detail, reflecting the time and resources

available to the instructor. Students may be run through a simple induction or presented with an intra-operative complication and evaluated on their performance. In this case there is a checklist of things that should be done, usually in a specific order, and students either complete the required tasks or fail to do so.

On the other end, the detail spectrum is the simulation theater, where more detail, sometimes subtle, sometimes not so subtle, is thrown into the mix, creating emotion, confusion, distraction, and adding that element of reality which helps to solidify the lesson. Instead of simply completing the tasks on an anesthesia checklist (i.e. cannulate vein, apply monitors, pre-oxygenate, induce anesthesia, intubate, etc.), participants may interact with a difficult or inappropriate patient, a verbally abusive family member, or member of the surgical staff. This theatre, which adds to the reality of the simulation experience, can be laced with emotional content to enhance the learning experience.

FES, Learning and Emotion

Although mannequin-based anesthesia simulators can be incorporated into a variety of teaching modules, two major approaches seem to garner the most attention. One focuses on human factors via crisis resource management (CRM), the second focuses on clinical performance in the simulated environment. With CRM, scenarios tend to be staged with actors playing the role of various OR personnel and the principal issues are communication and leadership. The second approach utilizes the mannequin to more directly demonstrate physiology and for the performance of procedures. Simulations that evaluate clinical performance do not require actors and focus on the response to physiology and skill development rather than communication and leadership. In general, human factor researchers utilize more emotional content in their scenarios; however there has been little explicit examination of the role of this aspect of simulation. In the absence of a sophisticated approach to the nature and quantity of emotional content in the scenarios, the value of a more realistic environment is commonly advocated as an important justification for complex simulation centers.

Literature regarding the emotional content of learning environments is intriguing. Researchers have attempted to evaluate the relevance and value of realism in simulation under a variety of conditions. Previous studies in both aviation and anesthesia simulators have shown that increased realism may not necessarily be advantageous⁷. These studies suggest that simpler and much less expensive screen-based simulators may be equally effective. However, it is well known that events with high emotional content are fixed in human memory via a pathway that involves the amygdala—a phenomenon that can be blocked by propranolol, and that memories stored in this manner are more easily recalled and, perhaps, more solidly constructed. The quintessential examples of such events are the assassination of world leaders (Kennedy, Hariri) or the World Trade Center disaster on September 11th 2001. Individuals exposed to those events have extraordinarily well fixed memories. On a less dramatic level, Cahill has shown that including emotional content into a basic story increases memory fixation of simple story details⁸. Based on these concepts and empiric observations, the emotional content of the learning scenario represents a key manipulability construct that modifies the effectiveness of full environment simulation.

Our common experience tells us that emotional events tend to be well remembered. Extensive scientific evidence confirms anecdotal observations that emotional arousal can strengthen memory. Over the past decade, there is growing evidence from human and animal subject studies regarding the neurobiology of emotion-enhanced memory. Today there is little doubt that memory from emotionally arousing events is better than that associated with neutral stimuli. McGaugh and colleagues reviewed the extensive animal research that implicates stress hormones and the amygdaloid complex as the primary modulators of memory consolidation for emotional events⁹. They described the considerable evidence that suggests that the amygdala is not a site of long-term explicit or declarative memory storage, but rather serves to influence memory-storage processes in other brain regions, such as the hippocampus, striatum and neocortex. Although the amygdala is not the site of memory storage, activation of the amygdala, which is associated with higher emotional content, does have a profound influence on the

function of the brain's memory centers. Emotional memories that are established through the amygdala are relatively impervious to extinction and forgetting processes¹⁰. Human studies are consistent with the results of animal experiments showing that emotional responses influence memory through the amygdala (at least partially) by modulating long-term memory storage. During and immediately following emotionally charged arousing or stressful situations, several physiological systems are activated, including hormonal release¹¹.

The relationship of perceived emotional content to the physiologic stress response is explicit. In a telemetry study, heart rate was found to be directly influenced by the emotional content of television programming. In this study, heart rate was followed as patients watched a drama, a comedy and a documentary. The investigators also demonstrated that both the increase in heart rate and heart rate variability could be prevented by beta adrenergic blockade. Cahill has described the ability of propranolol to block the effect of emotional content on memory consolidation and the direct ability of propranolol to block activity in the amygdala as seen on functional MRI¹².

Conclusion

The emotional content of scenarios presented in the simulator environment is an important and manipulability construct associated with memory formation. Full environment simulation commonly utilizes emotional content, particularly in crew-based simulation; however there has been no systematic evaluation of this concept, particularly in the field of medical simulation. The lack of controlled emotional content may explain Nyssen's inability to detect a difference between learning by screen based as compared to mannequin-based simulators. FES provides an ideal environment for presentation of material with emotional content. Since the emotional content of the learning scenario represents a key manipulability construct that underlies the potential effectiveness of full environment simulation, further controlled studies should be able

to demonstrate a significant difference between lessons with and without emotional content.

Many institutions are grappling with the financial justification to build and develop costly simulator centers that can be used to create full environmental simulation. To date validation studies that demonstrate improved learning, medical competency, patient safety or clinical outcome from simulator-based training do not exist. Here we hypothesize that the true benefit of simulation-based education and training in a full environmental simulation, is the ability to create scenarios where healthcare providers are allowed to make errors that would result in patient harm and poor clinical outcome. It is these potent negative experiences that generate significant emotional changes in the participants, which then causes persistent learning. Our justification for developing simulator centers and conducting clinical education in a full simulated environment is simple. Since clinical educators could never knowingly allow a student to make a medical error that could harm a patient, the only environment where such powerful learning experiences could take place is a simulated one.

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