Medical Education by Simulation and High Fidelity Mannequin

First Stage Students

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1. Introduction

Many nations employ simulation as a teaching and learning aid in undergraduate and graduate medical education. Many medical schools across the world have explicitly incorporated simulation into their curriculum because of the almost infinite range of skills that may be duplicated in a simulated environment without compromising patient safety. To supplement their courses, almost all UK medical schools use a range of simulation approaches, many of which incorporate some or all of the characteristics of high-fidelity patient manikins, such 3G. In medical education, simulation is a common teaching method that is frequently delivered utilizing manikins of varying degrees of realism. Despite the effectiveness of manikin-based simulation instruction having been demonstrated (1)

Simulation-based education (SBE) with high-fidelity simulation (HFS) provides early clinical experience to medical students that enable the development of clinical scenarios and management.

Historically, texts and lectures have served as the base of medical education's preclinical training as shown in the figure (1) the use of simulation-based education (SBE) in the medical industry has increased due to major advancements in research and technology (Computers, real patients, and high-fidelity patient simulators) over the previous 20 years (2)

Figure (1): The trauma bay's mannequin simulation room is set up (3)

The simulation literature does not always utilize the term "high-fidelity simulation." Nonetheless, a large body of published research is trying to quantify its impact. Scholars have examined the impact of HFS on student confidence and anxiety, contrasted it with SBLE with less fidelity, and assessed its influence on the acquisition of information and skills across almost all healthcare disciplines and learner levels (4).

Internationally, the use of simulation-learning environments in medical education has increased rapidly over the last number of years. Simulations have been recognized as improving patient safety, providing clinical opportunities for student to gain experience in a safe and controlled learning environment and improving learning outcomes (5).

Student psychological characteristics that impact their actual clinical performance, such as their level of confidence and anxiety in the patient care environment, are important. Because they lack clinical knowledge, skill ability, and patient communication abilities, students who are just beginning clinical practice feel nervous and unconfident in the clinical situation (6)

This study looked at how medical students' confidence and anxiety were affected by high-fidelity simulation experiences (7).

2. Literature review

2.1. Medical education

Education has always been an inextricable part of medicine. In the beginning, Galen and Hippocrates gathered their novices for instruction. As medical sciences became more famous, Sir William Osler introduced his journal clubs. The printing press elevated the output of eminent scientists and educators, paving the way for the advancement of the works of Gray, Marino, Goldfrank, Rosen, and Tintinalli. Access to medical knowledge was regulated and vetted by medical academics and medical colleges. Since there was no other way to become a trainee ship in medicine, those who wanted to become doctors would go trips to observe excellent lecturers in the classroom and in clinical settings (7) In the new century and with the exponential evolution of information technology, the development of the internet fundamentally altered how we obtain information. The internet environment has become even more accessible with the advent of smartphone technologies and wireless connectivity. Students now have rapid access to a large portion of the world's knowledge; teachers and supervisors were no longer the main information sources (8).

Studies on adult learning have had a significant impact on medical education, especially continuing medical education (CME). Education is now seen as facilitating learning rather than providing instruction, as a result of the finding that learning, not teaching, is what motivates doctors to alter their practices. Research on the factors that influence physicians' practice changes, including learning's role in those changes, has served as the foundation for this paradigm shift (9)

The current state of medical education is changing gradually but significantly. As part of the ongoing transition, the preclinical education period is being shortened from 24 months to 12 to 15 months, potentially resulting in a shorter time spent in medical school overall. Increased training in the outpatient sector, which is the primary location of care, is another development. Furthermore, the validation and evaluation of finished training will move from time spent in

school to demonstrated competencies. It takes a while to incorporate all of these changes—unbelievably long for many. However, it appears that these adjustments are unavoidable (10).

The three fields of medical education that currently exist are undergraduate, graduate, and the continuing professional development of established clinicians. The idea of continuity in medical education is a reflection of the ongoing professional and personal growth that medical students require (11).

2.2 Medical Education Modern Methods

The most popular and gold standard approach in conventional teaching and learning practices has been didactic lectures (DL). DL is dependent on the teacher, who imparts a lot of knowledge with little involvement from the students. It is usually carried out in an instructor-centered classroom, which centralizes the students' knowledge, material, and involvement (12)

During our review of the literature, we discovered nine distinct categories of contemporary learning strategies. These modern teaching and learning methods are widely used around the world to meet particular educational objectives and have received extensive validation (13).

2.2.1. Case based learning (CBL)

Clinical cases are used in CBL, a teaching-learning approach, to supplement standard lectures. CBL has been utilized to make up for the lack of motivation in didactic lectures through promoting active learning. Students have the chance to investigate actual cases that include patient signs, symptoms, history, clinical and laboratory results (14).

2.2.2. Evidence Based Medicine (EBM)

EBM gives students the skills they need to read, understand, and evaluate medical literature.

Five phases comprise EBM: The processes involved in this process are as follows:

a) Converting unclear information into a question that can be answered.

b) Locating the best available evidence.

c) Critically analyzing evidence to ensure internal validity

d) Putting findings into practice.

e) Performance evaluation. Allowing the careful and rational Application of current medical data in patient care choices promotes lifelong learning and disciplined thinking (15).

2.2.3. Problem Base Learning (PBL)

PBL is a contemporary educational approach that blends complementing pedagogical ideas into the structure of a clinical case. Its specific goal is to raise the caliber of learning results by utilizing integrated, cooperative, self-directed, and thorough learning (16).

2.2.4. Stimulation Based Learning (SBL)

A man-made example of the real world used to achieve educational goals through hands-on learning is simulation. The fundamental idea of simulation learning is to imitate actual clinical situations with the use of simulation tools. While medical simulation is relatively new, it has long been utilized in other high-risk professions like aviation. Instead of learning in an apprentice-style fashion, medical simulation enables the recovery of clinical abilities through intentional practice. When used in place of actual patients and clinical situations, it can be helpful (14).

2.3 High Fidelity Mannequin in medical Education

Mannequins provide a secure learning environment for students to practice, repeat, and develop clinical skills. Life-size mannequins known as high-fidelity simulators are capable of simulating a variety of human processes, such as breathing, beating, pulse, pupil size changes, blinking, and more. Manikins have become more realistic with each generation, showing things like blinking,

pupillary changes, and cyanosis, but these systems are very expensive. With the use of virtual scenarios that mimic real-life situations through a computer interface, screen-based simulation has made progress. However, only one learner has typically been able to interact with the program or software, whereas inter professional teams are needed for clinical care in code situations. There hasn't been much effort made to close the gap and use virtual tools to improve the immersion and realism of widely accessible simulation mannequins in training labs or in-person simulation settings for multiple learners receiving clinical training (17).

Different aspects of the simulation, "modality" and "fidelity" can have different effects on the activity. The levels (low, medium, and high-fidelity) relate to the degree of realism offered in the scenario and equipment selection, while the modality is associated with the kind of equipment utilized as shown in the figure (2).

Figure (2): Image shows the HF mannequin (18).

The level of accuracy attained and the experience's legitimacy are referred to as fidelity. The learning objective influences the simulation level selection. The literature has published similar results comparing high-fidelity (HF) and low-fidelity (LF) simulations for training; however, the first group reports higher satisfaction and self-confidence. HF is a useful approach for imparting competencies and skills that are based on learning goals. Because of its synesthetic feature, students can learn how to do it and demonstrate it to their

peers. Additionally, it is the best tool for evaluating diagnostic ability across a wide range of technical and non-technical skills. By interacting with the manikin, participants can make decisions, interpret changes faster, and retain information, all of which can help with the real patient's assessment in the future. Improved team integration and communication during emergency care and simulated exercises is another benefit of HF (19)

A person's actions are based on their performance, knowledge, and competence,

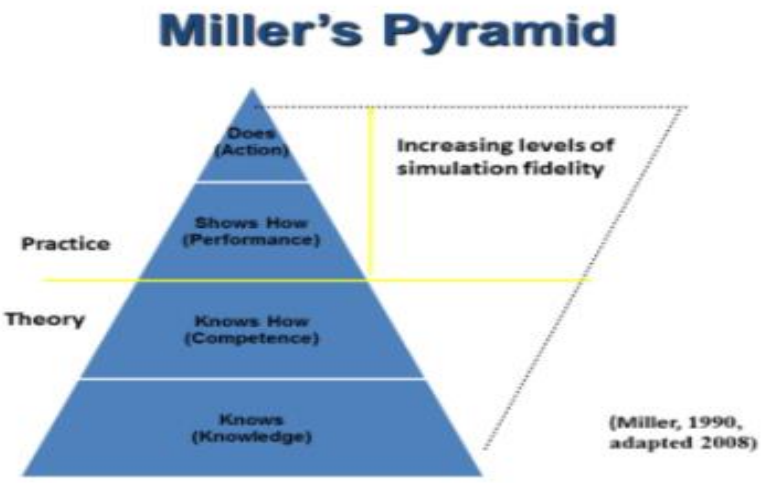

Figure (3): The illustrated by the pyramid that Miller drew in 1990.

An improvement in simulation quality could be associated with a shift from knowledge to performance, competence, and eventually action (20).

There are three levels of fidelity in simulators used for simulation-based training: low, medium, and high fidelity. The level of realism in a simulation is referred to as its "fidelity." With spoken cues from instructors, practitioners can exhibit fundamental knowledge as well as technical and behavioral skills on low-fidelity simulator (LFS) mannequins. An LFS mannequin may or may not be equipped with chest elevation, ECG tracing, and intubation capabilities. Although they display physiological reactions on a computer screen, medium-fidelity simulators (MFSs) do not provide the necessary cues for users to interact with the simulated environment. A medium-fidelity mannequin, for instance, can make breath sounds but not a corresponding rise in the chest. With the aid of high-fidelity simulators (HFSs), trainees can engage with patients in a manner

similar to that of a real clinical setting. For the trainee to respond to, high-fidelity simulators can depict physiological signals (such as heartbeats, breath sounds, pulses, oxygen saturation, and blood pressure). The trainee is challenged to use the appropriate interventions, such as oxygen administration, endotracheal intubation, or chest drain insertion, in response to the mannequin's shifting physiologic feedback in order to improve the simulated mannequin's condition (4).

More fidelity does not always equate to better quality. The fidelity trap, which assumes that pupils learn in proportion to the level of realism, is something simulation instructors need to avoid. There is a potential bias toward higher levels of fidelity among educators and learners; students report higher levels of satisfaction with HFS and believe it provides advantages over simulation-based learning experience using lower levels of fidelity.

Before using HFS, it is necessary to define the term and investigate the various levels and types of fidelity. Determining the type or types of fidelity necessary to achieve the necessary level of realism for the accomplishment of the stated objectives is another crucial component of simulation design, in addition to figuring out the right level of fidelity. Physical, conceptual, and psychological fidelity are the three main categories of fidelity. A simulation activity's various fidelity levels can either enhance or diminish one another. For instance, including suitable background noises into a scene improves its physical fidelity and gives the participant stress-inducing stimuli, which boosts its psychological fidelity (21)

The literature currently in publication offers two more classifications of fidelity: functional fidelity and sociological fidelity. When teaching technical or psychomotor skills, functional fidelity—which is defined as the dynamic interaction between the participant and the assigned task—is essential

The level of functional fidelity required increases with skill or procedure precision.

The sociological fidelity which relates to how participant interactions impact realism, is being discussed in relation to inter-professional education (IPE) simulation activities.

The simulation modality chosen will depend on the type and level of fidelity that is required. HFS is attainable regardless of the simulation modality. Without utilizing technology, standardized or simulated patients, or SPs, offer a simulation modality with certain inherent high-fidelity features. In SBLE, trained individuals known as SPs are used to represent patients with particular conditions. Certain aspects of fidelity can be improved by using real people as simulated patients, but it's important to be aware of the constraints and challenges. Not all invasive procedures can be carried out, just as not all physiological reactions can be replicated. If achieving the stated goals depends on these elements, the simulation educator can offer a task trainer for the procedural skill and show the intended physiologic parameters on a bedside monitor (22).

2.3 Advantages and Disadvantages of High Fidelity Mannequin

- Advantages of HFM

Numerous benefits of simulation include filling in the gaps when clinical experiences are scarce, offering atypical clinical experiences in a secure setting, and minimizing needless risk or discomfort for patients. There is little evidence to support the use of high-fidelity mannequin-based simulation as opposed to standardized patient-based simulation with beginning nursing students, despite the fact that simulation has been shown to improve learning outcomes and the development of psycho-motor skills (23)

Since the benefit of using other simulation techniques or high-fidelity mannequins is that it is possible to obtain objective data directly from them. Given that the data is completely objective and aligns with the goal of using simulations to provide a more objective evaluation method, it would be extremely valuable (24)

Compared to traditional mannequins, high-fidelity simulators offer an advantage because they generate a patient that is lifelike and changes in clinical condition in real time. As a result, an educational setting is produced that closely resembles a real pediatric code.

- Disadvantages of HFM

HFS offers many benefits, but these simulators are expensive and do not offer human base interactions (25)

2.5. Training using Cadaver

For hundreds of years, cadavers have been a significant component of medical education and their use in teaching is still common. Even though it's debatable, using cadavers to teach people about the human or animal body is considered to be one of the best ways to learn about anatomy. The authors of this manuscript examine cadaver preservation techniques, the history of cadaver use in education, applications of cadavers in medical and veterinary education curricula, and suggested substitutes for cadavers in education as shown in the figure (4),(26)

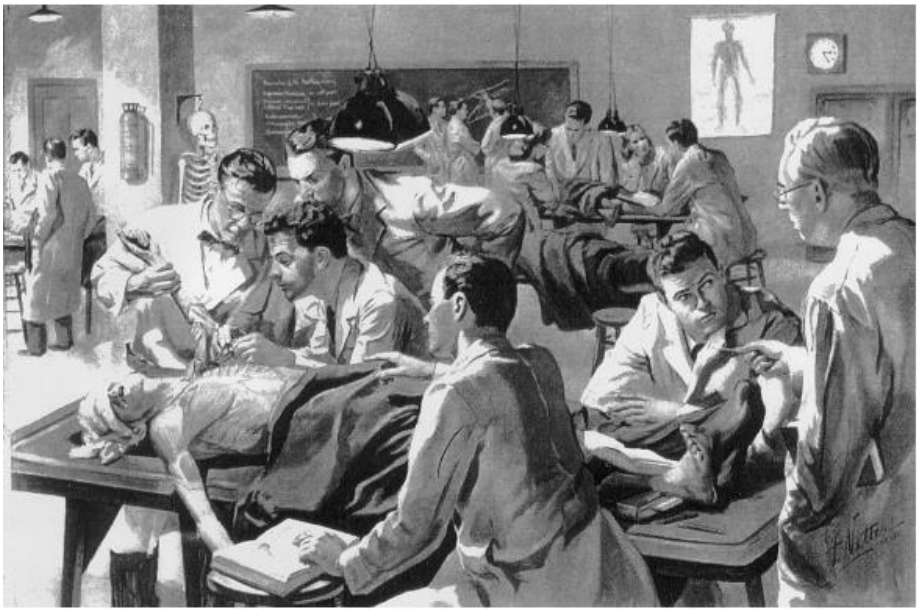

Figure (4): Painting of a gross lab session by Dr. Frank H. Netter (27).

The need for more efficient anatomy training has grown as surgical procedures become more complex. Understanding anatomy is essential for both basic and advanced clinical training, as well as for understanding the human body. Fresh frozen cadavers (FFCs) are renowned for having realistic tissue quality among the various cadaver models (28).

As medical care has become more technical and medical education has become more procedure-focused, it has become harder to include humanistic values in the curriculum. When teaching students about the human anatomy at the beginning of the medical curriculum, dissection is still a crucial component. As a result, humanistic education would make sense to begin in the dissection hall. Students may benefit from learning about the moral and humanitarian implications of cadaveric dissection in the early stages of their education, as it may broaden their perspective on the subject (29).

For medical students, cadaveric dissection is a powerful educational tool that dates back centuries. While demonstrate constant respect for the departed person until their very last moments, a body must be dissected with dignity. This kind of training is given to the student’s right from the start of their studies in order to make them more aware of the handling of cadavers and to help them comprehend the importance of a body donor's contribution. This has a profound effect on the way that the students feel about cadavers. Teaching medical students about the ethical issues involved in handling cadavers for teaching and research is essential. This would be the first step toward treating patients with dignity and compassion in their future careers (30)

Using cadavers to learn about anatomy has a long history that extends over 2500 years. The use of cadaveric dissections in anatomy education offers a number of benefits, including the encouragement of engaged and in-depth learning, preparing students for clinical practice, exposing them to death, practicing clinical skills, helping them to develop empathy and stress management techniques, and establishing a link between pathology and symptoms in patients.

Even though cadaveric dissection is a time-tested, traditional method of teaching anatomy, there are drawbacks, including expense and formaldehyde exposure. Although virtual cadaver dissection, skeletons, prosections, mannequins, models, radiographs, plastinated specimens, and surface anatomy are commonly used in human anatomy education, cadaveric dissection is still the widely accepted "gold standard." (26).

2.4.1. Benefits of Cadaveric Dissection

a) the using cadavers for many students, dissection is their first experience with death, which serves as a reminder of the reality of illness.

b) Students can learn from cadavers how to respect their patients even after they pass away. When dissecting on a cadaver, one can also best appreciate depth perception.

C) Cadaveric dissection that is frequently mentioned is the spatial orientation and visualization of the relationships between structures.

d) A cadaver teaches an appreciation of the anatomical variability between individual specimens and places regional anatomy in the context of the entire organism.

e) Dissection offers kinesthetic learning with 3D visualization of anatomic structures, assisting students in identifying structures along with tactile information on tissue texture. Proficiency in human anatomy is particularly crucial for health professionals who will be working with patients, so this is especially important in their education.

2.4.2 Disadvantages of Cadaveric Dissection

a) The inability to reconstruct a structure after it has been cut or damaged during cadaveric dissection is one of its main drawbacks.

b) Cadavers are frequently unwieldy and challenging to move, which limits students' ability to visualize particular structures.

c) Using a cadaver, the dissection procedure is also largely set. For instance,

dissecting the anterior abdominal wall is a prerequisite for dissecting the abdominal organs. This makes revisiting finished dissections on a cadaver difficult.

d) Cadaveric dissections take two to four times as long to complete for students as other human anatomy learning methods. It will take longer to remove the

e) The ongoing expense is a drawback of employing cadavers and dissection. Examining the financial responsibility of institutions is becoming more important as the cost of higher education keeps rising. The expenses associated with procuring cadavers, upholding a functional dissection environment, and tending to the remains of cadavers are not negligible (31)

2.5 Pros of Medical Education by Simulation:

i. Immersive learning: The simulated events are realistic enough to elicit emotional responses from learners, giving a one-of-a-kind learning experience Such as the high-fidelity mannequin "patient' talks, breathes, blinks, and moves like a genuine patient (32).

ii. **Experimental education:** Learning is always enhanced by practical application. Thus, the simulation provides the students with an opportunity to practice the knowledge and abilities they have learned**.**

iii. Improved understanding of theoretical concepts: Because simulation helps students realize theoretical concepts of basic science that are challenging to perceive with regular discourse, it can improve understanding of basic concepts of medical science, such as pharmacology and physiology, from the very beginning of the undergraduate medical curriculum**.** (33).

iv. **Attainment and maintenance of skills:** Simulation-based educating is a more effective way for students to acquire clinical skills than didactic lectures alone**.** (34), (35)

v. **Student gratification and self-assurance:** Students' confidence is increased when they get instruction through simulation before performing a process. In one of the experiments, medical students were trained to manage recovery

during severe shock using simulation. According to the learners, it increased their confidence in their ability to manage circumstances that are comparable in the future. Similar findings in the student satisfaction levels were also revealed by a study done by Ten Eyck and colleagues (36), (37)

vi. **Preparing for rare events:** Simulation is used when the real system cannot be used because it is unavailable, unsafe, or inappropriate to use. Education professionals can conduct regulated training scenarios in a range of settings, even uncommon or dangerous ones, thanks to simulation (38)

vii. **Classroom-based instruction:** One approach that enables students to study for didactic reasons in a classroom is Simulation-Based Medical Education. They may comprehend the ideas more clearly this way than if they learn in congested medical environments.

viii. **Patient safety:** Without first practicing techniques, medical students are not allowed to conduct tests on human patients. Through the use of simulations, education can be provided in a secure environment where patients are not put in danger by procedures carried out by novice students. (39)

ix. Evaluation of performance: Simulators have also been proposed as a perfect tool for grading students' clinical skills. The goals of an objective, standardized test for clinical competency are met by such a simulator. This system duplicates the same objective findings and allows for the quantitative assessment of competency (40)

x. Training organizing: Rather than relying on infrequent case availability, simulator-based clinical training can be scheduled using preplanned clinical encounters**.** (41).

xi. Training and retraining Students can repeat operations as many times as necessary to correct errors and hone their skills through simulation-based training. The people will contend with one another as It also makes it possible to compare how well others perform at the same level and to give suggestions (40).

xii Analysis of the training: Teachers and students are able to examine the training that has been given. A simulation can be stopped to facilitate debate,

after which it can be rerun or different approaches shown. The facilitators have great possibilities to review the training through audio and video recordings of simulated scenarios [30]

xiii. Team building: Because it gives teachers the chance to see participants, simulated environments can be used to teach multidisciplinary team building as well as specific behavioral and communication skills. Several patient scenarios were introduced to emergency medicine residents through high-fidelity simulation in a research by Small et al. Empirical evidence suggests that this kind of simulation enhances team cohesion and leadership (41)

2.6 Cons of Medical Simulation:

i. **Inadequate replication of human systems:** Human systems are diverse and highly complex. The data obtained from instruments is not as complete as the data obtained from people. Models and equipment will never be exactly like humans.

ii. **Inappropriate learning:** A badly built simulation can exacerbate unfavorable teaching. Students might fail to look for physical cues, for instance, if they are absent from the simulation. In addition to encouraging short cuts like skipping safety and patient consent protocols, simulation-based learning may also foster fake rather than genuine communication abilities (41)

iii. **Learners' Attitude:** Using a simulator will always be different for participants than in real life. Two typical attitude shifts that can happen are:

(a) too watchful, which a result in unwarranted anxiety since the person knows something is going to happen.

(b) haughty conduct that takes place when it's clear no human life is in danger(41)

iii. **Technical challenges:** Simulators are unable to teach certain physical discoveries, such as skin color.

iv. **Price factor:** Simulators, particularly high-fidelity models, come at a significant expense, both for the initial purchase and ongoing upkeep. Therefore, many educational hospitals cannot afford them.

v. **Time factor:** It can be challenging to fit a simulation time slot into an already demanding medical course.

vi. **Student specific teaching not achievable:** educators may want to set up ideal learning environments based on the skills of various students (advanced work for proficient students, simple tasks for inexperienced or slow learners). Learning via simulations does not allow for this kind of tailored instruction.

vii. **Difficulties with programming:** Facilitators and simulation technologists need to work with the simulation models to reproduce a desired physiological response under certain circumstances. It is typically laborious to use these systems in tandem with desired simulation objectives(40).

3. Conclusion

According to the study, HFS can help medical students improve their critical thinking abilities and increase their retention of what they have learned.

The HFS experience was rated highly by both participant groups in terms of satisfaction and confidence. HFS is a potent tool for enhancing and boosting the critical thinking abilities and confidence levels of practicing professional medicine in addition to being effective in preparing medical students for practice .

In medical education, high-fidelity simulation is a helpful teaching tool, particularly when errors could have catastrophic or permanent effects. Given that it can raise stress hormone concentrations, it may be useful as a teaching tool even for senior medical faculty students

We found that in order for medical students to feel psychologically stable and be able to competently treat patients in a clinical setting, they must be exposed to simulation education experiences on a regular basis. One practical drawback is

the lack of opportunities for medical students to interact with patients during their hospital clinical rotations.

Therefore, more opportunities for students to engage in simulation education so they can experience real-world medical conditions are needed to produce excellent doctors.

Introducing a cadaver education module is a creative way to raise awareness at having been made aware of them among medical students. The students felt th at an early age would have made it easier for them to build a practice based on professionalism, empathy, and human values .

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