Education

Simulation in medical education

Hing Yu So[1], Phoon Ping Chen[2], George Kwok Chu Wong[3], Tony Tung Ning Chan[4]

Abstract

Simulation is a method or technique to produce an experience without going through the real event. There are multiple elements to consider for a simulation programme, and technology is only one of the many dimensions. The ultimate goal is to engage learners to experience the simulated scenario followed by effective feedback and debriefing. Simulation is a useful modality to supplement training in real clinical situations because it enables control over the sequence of tasks offered to learners, provides opportunities to offer support and guidance to learners, prevents unsafe and dangerous situations, and creates tasks that rarely occur in the real world. It is also an effective method for interprofessional education. To use simulation effectively for education, particularly interprofessional team training, adult learning theory needs to be applied and effective feedback given. Future development in simulation depends on overcoming issues related to technology, research, cost and faculty development.

Correspondence to:
Hing Yu So
Room 30
Administrative Offices
11/F, Clinical Sciences Building
Prince of Wales Hospital
30–32 Ngan Shing Street
Shatin, NT
Hong Kong

Email:
sohy@ha.org.hk

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What is simulation?

Simulation is a method or technique that is employed to produce an experience without going through the real event.[1] Simulation opens up opportunities that are not available in real event learning, such as apprenticeships, and at the same time provides a multifaceted safety container for learning. Safety container is an important consideration for learners, especially in professional training. Simulation can provide a safe environment to reflect on and learn from mistakes without threat to professional identity.[2] While healthcare simulation can substitute real patient encounters or other clinical situations for learning purposes, it is important to understand that it is not the only method available and it may be combined with other learning methods to achieve the education goal.

Simulation activities are a powerful form of enactive experiences (direct purposeful experiences, contrived experiences or dramatic participation), and are typically followed by a debriefing to facilitate reflection, learning, abstraction, conceptualisation and connections to real events. It is regarded that more concrete and enactive experiences have a higher retention for learners and can potentially change behaviour in future encounters. Abstraction and conceptualisation are important for learners to gain the knowledge, skill and attitude required for generalisation and improvisation to deal with variants and novel encounters.[3] Introduced by Edgar Dale in his 1969 textbook on audio-visual methods in teaching, the 'cone of experience' is a visual device meant to summarise the various types of learning experiences.[4] The organising principle of the cone is a progression from the most concrete experiences (at the bottom of the cone) to the most abstract (at the top). The labels for Dale's ten categories are: direct, purposeful experiences; contrived experiences; dramatic participation; demonstrations; field trips; exhibits; motion pictures; radio – recordings – still pictures; visual symbols; and, verbal symbols. The categories are further grouped into enactive, iconic and symbolic modes of learning.

Gaba describes healthcare simulation through categorisation into 11 dimensions: aims and purposes of the simulation activity; unit of participation; experience level of participants; healthcare domain; professional discipline of participants; type of knowledge, skill, attitudes or behaviours addressed; the simulated patient's age; technology applicable or required; site of simulation; extent of direct participation; and, method of feedback used.[1] The most salient understanding is that simulation extends beyond just technology, such as high-fidelity mannequins, which is only one of the dimensions.

[1]Honorary Deputy Director and Chairman of Quality Management Subcommittee, Hong Kong Jockey Club Innovative Learning Centre for Medicine Consultant in Intensive Care, Prince of Wales Hospital, Hong Kong; [2]Honorary Director, Hong Kong Jockey Club Innovative Learning Centre for Medicine Consultant in Anaesthesiology, North District Hospital and Alice Ho Miu Ling Nethersole Hospital, Hong Kong; [3]Honorary Deputy Director and Chairman of Education Subcommittee, Hong Kong Jockey Club Innovative Learning Centre for Medicine Professor in Neurosurgery, Chinese University of Hong Kong, Hong Kong; [4]Honorary Deputy Director and Chairman of Research & Development Subcommittee, Hong Kong Jockey Club Innovative Learning Centre for Medicine Associate Consultant in Emergency Medicine, Kwong Wah Hospital, Hong Kong

The Simnovate Engaged Learning Domain Group provides a novel approach to summarise a simulation activity. Simulation activities can be characterised by three dimensions: scope, modality and environment. After the first step of analysing the needs and goals of the learners, more concrete learning objectives can be defined. The educator can then proceed to design the simulation activity, taking into consideration specific, measurable, attainable, results-focused and time-focused properties required of the activity.[5]

Scope addresses the extent of clinical encounter to be incorporated. It can range from an isolated direct-focused skill station of tying a knot or a contrived task of a contaminated skin wound for wound cleansing and suturing, to a scenario simulation of road traffic accident trauma calls with simultaneous multiple victims in which one victim develops hypovolemic shock with a profusely bleeding scalp wound. Scope also addresses the time factor. Depending on the learning objectives, the scenario may be focused on the identification and treatment of pneumothorax in the trauma resuscitation room or a full scenario starting from accident and emergency department triage and surgery and resuscitation in the operating theatre to hand over to intensive care unit doctors and nurses.[5]

Modality is commonly the first practical consideration that comes to mind when people are asked about simulation activities. The objective is to have a desirable degree of fidelity to allow behavioural, emotional and cognitive engagement, which suspends disbelief to facilitate desirable clinical performance and effective participation and learning. Task trainers (which are a modality of simulation) aim for a direct purposeful experience, such as bronchoscopy or echocardiography (the role of that modality). Mannequins play an important role as the 'patient' and may present with the desired physiological responses, such as blood pressure and pulse, while at the same time allow invasive procedures, such as needle decompression of pneumothorax, external cardiac compression, intubation and intravenous injection. Mannequins are typically involved in team training for medical crises and resuscitation. Standardised 'patients' are real people and trained actors. Standardised patients are ideal for communication training where nonverbal components are also important. Training of actors to ensure standardisation is crucial to a successful discharge of the context for the simulation. Computer-based or virtual simulation opens up constraints regarding the organisation of the simulation training sessions. With current advances in three dimensional (3D) virtual reality games, it is anticipated that the cross-pollinated application of these gaming technologies in healthcare simulation is not far away. Indeed, the concept of serious games has been proposed. The digital nature of the simulations also does not require learners to gather to start. Some of these simulations are available in portable computer notebooks or even mobile phones.[5]

Finally, but should not be forgotten, is the environment. In situ simulation refers to simulation in real clinical areas, such as operating theatres or the emergency room. Safety concerns should be carefully considered as these areas are typically equipped with sharps, potent medications and anaesthetic gases. In addition, attention should be given to avoiding any mix-up of the training material and equipment with those used in the real clinical environment. Overwhelming emotions concerning performance in a high-realism workplace setting may also occur. More commonly the simulation activity takes place in an environment that mimics the real setting, such as in a simulation centre, where there is no serious safety concern. Also, video recording and debriefing rooms are coupled to facilitate reflection and learning. Ad hoc simulation in tutorial rooms can suit task or procedural training well. Virtual reality ranging from audio-visual effects in a scenario setting, such as road scene or road traffic, to a full immersive environment of a serious game may also enhance the learning experience.[5]

Why should we use simulation for learning?

At the end of the last century, multiple reports from the World Health Organization, the Organization for Economic Cooperation and Development and the Commonwealth Fund have reported on persistent gaps in healthcare quality and safety across the world.[6] The Institute of Medicine documented high rates of preventable medical errors and demanded a fundamental change in the healthcare delivery system. One of the 13 recommendations in their report was the need to re-structure medical education to be consistent with the principles of the twenty-first century health system.[7]

The traditional approach of medical education is to continually reduce healthcare tasks to simpler or smaller components, such as facts and simple skills, for the purpose of teaching. However, healthcare tasks frequently vary with the need to adapt to particular situations and learners taught in this manner may not be able to grasp the dynamics of variation and adaptation to integrate or link the various components in a way that is clinically meaningful and relevant.[8] To overcome problems of compartmentalisation and fragmentation, modern educators adopt a holistic approach and make use of authentic tasks to promote integrated learning.[9] Authentic tasks are obviously available in the real clinical environment, but simulation is a useful adjunct to learning with real patients for a number of reasons:[9,10]

1. Control over the sequence of tasks offered to learners. For educational purposes learners should start with easier tasks and then proceed to more challenging ones. However, in the real world, it is not always possible to control what tasks are available at the time of training. On the other hand, it is possible to provide learners with tasks of a suitable level of challenge in a simulated environment. Furthermore, simulated tasks are reproducible and can be standardised for training and assessment purposes.

2. Opportunity to provide support and guidance. Learners require support and guidance in learning, which may not always be available in a real clinical setting. This is particularly important as the traditional apprenticeship model, based on the prolonged and repeated interactions between junior and senior healthcare professionals, is increasingly under threat owing to changes in the healthcare system.[11] The ability to pause, restart and replay a clinical encounter provides invaluable opportunities to apply educational principles to the clinical setting.
3. Prevent unsafe and dangerous situations. It is important for learners to experience failure, and to recognise when they are approaching or crossing the limits of their competence. However, growing concerns about patient safety made the idea of inexperienced trainees practicing their skills on real patients morally unacceptable. The simulated environment provides opportunities for learners to practice without the risk of harming patients.
4. Create tasks that rarely occur in the real world. Some clinical scenarios, such as malignancy hyperthermia or para-mortem caesarean sections, happen rarely and it is much better for learners to learn in a simulation environment rather than waiting for these situations to happen in a real clinical setting.
5. Create tasks that would otherwise be impossible owing to limited materials or resources. One example is having student dentists fill cavities in porcelain molars rather than filling cavities in the teeth of real patients.

The effectiveness of simulation-based medical education has been analysed in a recent meta-analysis.[12] Simulation, in comparison with no intervention or when added to traditional practice, was associated with better learning outcomes. Effects were large for knowledge, skills and behaviours, and the confidence intervals excluded small associations. Effect sizes for patient-related outcomes were smaller but still moderate.

Health delivery is increasingly becoming a collaborative process involving well-defined teams or looser alliances of health professionals. Such collaboration is necessary as medical knowledge increases and patient care becomes more complicated. There is a need to break down the professional silos of contemporary training and to better prepare graduates for team-based care delivery.[7,13] Interprofessional education can be summarised as a process in which ‘knowledge, ideas, attitudes and values are developed as a result of relationships with people’[13] and is best achieved through experiential and social learning.[14] Simulation provides that opportunity of experiential and social learning and its effectiveness has also been demonstrated.[15]

Simulation is a useful education modality to supplement training in real clinical situations, and helps to overcome the constraints of the traditional model of medical learning apprenticeship.

How can simulation be used for learning purposes?

As mentioned above, there are different modalities of simulation that could be used to enhance learning. Using virtual reality or augmented reality systems together with web-based systems, the interaction between trainer and learner is no longer limited to clinical areas. Instructors can monitor the progress of learners and give feedback without being physically near the learners.[16] The advances in 3D printing not just overcome the limits of producing anatomically accurate models for training, they also produce patient-specific models for preoperative training.[17]

Regarding interprofessional team training in healthcare education, the focus is on communication, situation awareness, leadership and decision-making rather than pure technical skills. Full-scale mannequin-based simulation lends itself well to such training.[18,19] In a full-scale simulation, a computerised full-body mannequin, in the role of a ‘patient’, provides realistic physiological response to learners’ actions. Learners will interact with each other, with the environment and with the ‘patient’ in order to successfully carry out their care plan in simulation.

Adult learners learn differently than children because of maturity and life experience. Therefore, the design of the education activity should take into account the nature and assumption of adult learning.[20] There are a number of elements that are needed in order to create an effective learning environment for adult learning using full-scale simulation:

1. A team of learners who interact as they have done or would do in real situations.
2. An environment resembling a real clinical environment.
3. Equipment that they would use in real practice.
4. Learning experience that is problem centred and is close to real clinical encounters.
5. Learners need to feel safe to express themselves.
6. Learners receive timely feedback from different sources.

In order to engage learners in simulation, educators should use anatomically correct high-fidelity mannequins, graphically real images on screen, behaviourally appropriate actors and realistic scenarios. From the point of view of learners, the level of realism of the simulation is not only affected by the degree of resemblance of the simulation environment to the real world, but also how the simulation theoretically resembles an unfolding scenario given the actions of learners and the degree to which a simulation draws the learners into the situation.[21] The concept of ‘sociological fidelity’ may also play a role in affecting the quality of the learning activity, particularly in interprofessional healthcare simulation programmes.[22] Carefully designed scenarios taking into account all factors that affect learners' perception of realism will help learners engage in the simulation.

In addition to the above factors for scenario design, in order to engage learners educators often establish a 'fiction contract' with learners in which educators acknowledge the limitation of mannequins despite their best effort and learners are explicitly asked to treat it as if they were in a real clinical situation.[2] This is usually carried out in the prebriefing session at the beginning of simulation.

McGaghie et al. have provided a summary of features and best practice in simulation-based education that could lead to effective learning.[23] Among these essential features, feedback to learner is the most critical component to ensure effective learning. There are three key components for effective feedback to occur:[24]

1. Plan: simulation educators should plan how and when feedback will be provided. Examples include clinical protocols accessible by learners during simulation and structured debriefing according to predetermined learning objectives. Flexibility should be allowed to examine unplanned learning objectives generated by learners.
2. Prebriefing: before going into a scenario, simulation educators should explain to learners the rules and expectations, such as confidentiality issues and being respectful to each other. Simulation environment and simulators are introduced to learners during prebriefing. The purpose is to let learners feel psychologically safe during the simulation and in post-event reflection.
3. Provide feedback: feedback can be scripted in the simulation scenario so that learners' actions lead the simulator to provide feedback. Feedback and debriefing can be 'on-demand' using pause and discuss during a scenario.[25] The most common form of feedback in full-scale simulation is post-event debriefing. There are different approaches to facilitate and optimise debriefing.[26] They differ in their frameworks, conversational technique or deepness of reflection. The general structure for post-event debriefing starts with inviting learners to share their emotional reaction, followed by deep reflection and analysis, and finally learners summarise to distil the lessons learned.

High-fidelity simulators and well-equipped simulation facilities have provided great support to the training need of healthcare workers in the twenty-first century. Faculty development in the form of training in simulation programme design, feedback and debriefing skills for simulation can equip educators with the necessary skills to ensure the effective use of simulation.

Challenges and way forward

The greatest benefit of simulation-based education is the ability to provide an experience by immersing and engaging learners in an artificial environment that captures their attention and exposes them to important contextual characteristics relevant to their performance.[27] This method is particularly well accepted by younger learners who have grown up with the internet and game-based environments.[28] While simulation-based education has become increasingly popular, there remain a number of barriers to its greater acceptance and utility.

Technology

While some scenarios may be too complex and difficult to simulate conceptually, technological limitations may also make it difficult to produce realistic physical characteristics and clinical signs in the mannequin, such as changes in skin colour and facial expression, as well as an inability to respond accurately after clinical interventions. As a result, the simulation experience may not replicate the learners' expectation in a similar real encounter to achieve sufficient engagement to translate the experiential exercise into an effective learning experience.[7] Current practices, however, indicate that fidelity may not be a major obstacle in simulation of common clinical events. Progressive advances in technology allow greater diversity and choices of realistic simulation modalities, and improvements in innovative instructional designs will further facilitate complex training scenarios, as witnessed in the gaming industry.

Research

A major concern regarding simulation-based education is the lack of concrete evidence on its effectiveness in improving patient outcome. While there are increasingly more data supporting its effectiveness, only a few studies have provided solid foundation for change in clinical practice.[23,29] Although there is now evidence of effectiveness to improve knowledge, procedural skills, behaviour, teamwork and communication, these studies do not typically report impact on clinical outcomes.[12,30–32] This uncertainty has led to scepticism towards this learning method and a reluctance of funders to support this training method. There is, therefore, an urgency to assess and quantify the benefits and effectiveness of simulation training in a systematic manner.

Standardisation in simulation modality, equipment and environment are crucial to achieve consistent results in research with the same objectives and learning outcomes. More detailed descriptions of the context including simulation modalities and instructional design within which the interventions occurred in simulation research have been recommended.[33] The development of a quality assessment guide for research design as well as learning exercises in simulation-based education may help to guide the accumulation of high-quality evidence for healthcare simulation for education and training.

Cost

Simulation gives the impression of a high-technology, high-cost training method. Although high-fidelity simulators may be costly, some simulation training may be effectively undertaken with lower fidelity mannequins and hence reduced equipment costs and constraints.[34] In situ simulation training may also reduce the need to conduct the simulation in a fully equipped training centre, thus avoiding the facility cost. However, busy clinical departments may find it difficult to identify available time slots to fit the staff training in already heavily occupied by hospital services. Standardised patients or 'trained actors' may facilitate healthcare professional–patient interaction training with lower associated training and running costs.

Simulation training involves small group teaching and may incur greater trainer costs. In some countries, incorporating simulation-based education in an already burdened healthcare system or tertiary medical curriculum is difficult. Both trainers and learners need to be released from clinical duties to attend training courses with healthcare and hospital cost implications.

Faculty development

Attention is needed to develop a pool of qualified trainers, while at the same time a credentialing system may be required to ensure maintenance of standards. Many trainers in postgraduate healthcare education are full-time healthcare professionals and part-time trainers, and may not have the time to teach frequently, and, therefore, may have the potential to lose their debriefing skills. It is therefore important for healthcare organisations to invest in a viable infrastructure to ensure sustainability and achieve the desired results with simulation training.

Conclusions

Apart from the application of simulation in training, simulation is employed in summative assessment. Although more research and validation are required to facilitate general acceptance of simulation for assessment, we have already witnessed increasing utilisation of simulation in credentialing and certification processes in healthcare.[35,36]

With the continuous advances in technology, it is inevitable that the fidelity and cost of simulation-based education will have a more favourable impact on the effectiveness and utility of simulation. Simulation is already an integral part of mainstream medical and healthcare education and will likely play an even greater and more important role in the near future. Standardisation of training practices and research methods will further enhance the utility of simulation.

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