The world we live in – how should simulation be part of continuing professional education?

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Background
At present, continuing professional development (also known as continuing medical education or CME) is expressed as “hours of training attended” and not as knowledge and/or skills attained. This is an insufficient and unsatisfactory method of ensuring that clinicians remain up to date with knowledge, skills and attitudes. There are several initiatives afoot to actually measure and evaluate clinicians to ensure they are able to perform their duties, albeit in a simulated environment. I believe an hour spent on active learning with simulation provides better professional development than a passive learning hour listening to a lecture.

There are two sides to professional development: the first is education, and the second is assessment. Let us examine these two issues using the history of simulation in aviation as a guide.

Education
Aviation started with simulation almost 75 years ago using lower fidelity simulators, and gradually increased the realism. Similarly, I believe we can use the present medical simulators for the continuing professional development of clinicians, while still increasing the fidelity and realism. For instance, we can use the present human simulators for:
- The experiential, hands-on learning portions of professional development
- Higher levels of knowledge (Bloom’s classification – see Table I)
- Attitudinal professional development to promote team work

Assessment
Aviation has a long history of incorporating aircraft simulators for high-stakes summative (pass-fail) examinations. The top end aviation simulators cost in the range of US$ 45 to 96 million. These are highly realistic simulators and are considered as being of sufficient realism and fidelity that it is acceptable to pass or fail a pilot using such a device. The presently available higher-end human simulators cost in the range of US$ 0.20 to 0.25 million. These are clearly not as sophisticated nor as realistic as the flight simulators, and I do not think the present generation of human simulators is suitable for high-stakes (pass-fail) examinations.

This paper will focus on how simulation should presently be part of education in continuing professional development, rather than as part of the assessment (which will come much later).

Identifying and specifying what should be taught as part of continuing professional development
A brief description of educational objectives is needed here to indicate how the application of objectives to simulation training differs from the objectives in a typical lecture-based curriculum.

Let us start with an educational objective and then convert that into a simulation-based set of terminologies. We will use Bloom’s taxonomy of educational objectives.

Table I: Bloom’s taxonomy of educational objectives

| Level | Description |
|-------|-------------|
| FACTUAL KNOWLEDGE | Recall of specifics, of ways of dealing with specifics, or of the major patterns by which ideas are organised; demonstrated by bringing information to mind without changing it. |
| COMPREHENSION | Knowing what is communicated and being able to use it; demonstrated by paraphrasing, summarising, or extrapolating from information. |
| APPLICATION | Using abstractions in concrete situations; demonstrated by remembering generalisations or principles and bringing them to bear on a new problem. |
| ANALYSIS | Breaking down material into constituent parts and recognising relationships between them; demonstrated by distinguishing facts from hypotheses, checking the consistency of hypotheses against a set of data, or detecting causal relationships. |
| SYNTHESIS | Drawing on information from many sources and putting them together into a structure not clearly there before; demonstrated by producing a plan to test an hypothesis or by formulating an appropriate hypothesis to explain data. |
| EVALUATION | Making judgments and comparisons about the value of ideas based on either internal consistency and logical accuracy or in reference to external criteria. This level of knowledge is the most difficult to demonstrate; in medical decision making it often entails evaluating the response of the patient to treatment derived from analysis and synthesis and may require the learner to cycle back through these two processes in order to come to the correct diagnosis. |

Given the goal of maintaining competence with a pulmonary artery catheter, and using the pulmonary arterial catheter to treat shock, we can expand the objectives for a lecture as follows:
- Recognise the normal pressure wave forms and patterns for the superior vena cava (SVC), right atrium (RA), right ventricle.
A broad definition of simulation
What do we understand under the rubric of simulation?
- Often, simulation is considered to only be simulation when a full human simulator is used to present a crisis to the trainees. The crisis event is videotaped and discussed (debriefed) afterwards as an “after-action review”. There are actually many other ways (strategies) to use a full human simulator (see Table II).
- In many ways, a morbidity and mortality conference can be seen as “simulation” when one asks: “What would have happened if we had tried a different therapy?”
- Practising intubation with new supraglottic airway devices on an intubation head is considered simulation using a “part-task trainer”.
- Learning physiology and pharmacology using a simulation programme on a computer (PC) is also simulation.

Note that these objectives cover mainly the knowledge and early (lower) levels of Bloom’s taxonomy.

For a practical, hands-on simulation curriculum, we can cover all the levels of Bloom’s taxonomy (including the higher and more complex levels) as follows:

- Factual knowledge: Define shock and list typical abnormalities, including changes in systemic and central haemodynamics. Recognise the normal pressure tracings for the SVC, RA, RV, and PA. List normal values for these pressures. List factors measured by the PAC which determine cardiac output and peripheral vascular resistance.
- Comprehension: Explain the pathophysiology of three types of shock (hypovolaemic, cardiogenic, distributive/septic).
- Application: Based on your knowledge of the pathophysiology of the three types of shock, design and explain appropriate therapy. Predict the direction of abnormalities of central haemodynamics with the three different types of shock.
- Analysis: Examine and analyse the history, signs, symptoms and vital signs (including tracings and calculations from the PAC) in a specific simulated patient to predict the type of shock and the extent (degree) of abnormalities.
- Synthesis: Develop a treatment plan for this patient. Based on the previous analysis, plan appropriate therapy (combining information garnered above).
- Evaluation: Evaluate and compare the effects of therapy (IV fluids, inotropic drugs, etc.) on cardiovascular parameters to determine if the diagnosis and treatment plan are correct and effective. Which therapy should be tried first (is the best) – fluids or inotropic agents?

From this discussion it will be noted that there is a need to identify and specify, in some detail, exactly which knowledge, skills and attitudes are required to be maintained by a clinician under the auspices of continuing professional development using simulation.

Let us now discuss the three main headings of Bloom’s taxonomy, namely knowledge, skills and attitudes, to see how simulation can be used to cover all three aspects for continued professional development.

Knowledge
How can we use simulation for continuing professional development related to knowledge?
- Factoids: a certain basic medical knowledge is needed, requiring a huge amount of memorisation. Simulation is NOT the best way to get this kind of information across to trainees. For instance, clinicians have to have knowledge of anatomy (heart muscle, valves, conduction system, etc.), physiology (inotropism, oxygen supply and demand, etc), pathophysiology (abnormal electrical conduction patterns and recognition using an ECG, etc).
- Simulation as a training methodology to maintain competence in higher levels of Bloom’s types of knowledge is an ideal methodology. For instance, to maintain familiarity with patients suffering from a myocardial infarct, especially in practices where such a crisis is an uncommon event. Simulation can be used to practice diagnosis and therapy.

Note that we have to think of simulation in a wider sense for the above. A flat screen simulator (PC-based program) can be

| Table II: Strategies using a full human simulator |
|-----------------------------------------------|
| **A. Observation** |
| This is similar to a teaching ward round where the diagnosis is known, using a “look here, see this” teaching strategy/mode. Bloom’s objectives of “facts” and “understanding” are addressed. |
| **B. Diagnosis** |
| The trainees are presented with a “diagnostic challenge”, as the diagnosis is not known. An advantage of the full human simulator is that trainees can perform a diagnostic test or therapeutic manoeuvre (administer fluids or drugs) and use the response of the system as a diagnostic aid (“ping the system”). The diagnostic mode can be used a) in slow time (“step by step”), or b) in real time (with or without videotaped debriefing). In addition to the previous, Bloom’s objectives of “application”, “analysis” and “synthesis” are addressed. |
| **C. Treatment** |
| In this mode, diagnosis may be a preliminary step, but the emphasis is on the treatment of the problem. The treatment strategy can also be a) in slow time, or b) in real time, which includes “Crisis Management”, also called “Critical Event Management”, where video debriefing is commonly used. Bloom’s objectives addressed include all of the previously mentioned objectives, as well as the “evaluation/comparison” of different therapies. |
| **D. Crisis Resource Management (CRM)** |
| In this mode, the actual problem or crisis is not the issue but team work and leadership are emphasised as well as using all the resources, calling for help and avoiding fixation errors. Bloom’s objectives addressed include the previous, as well as “attitudes”. |
| **E. Credentialing** |
| A natural progression is to use the full human simulator as an examination tool to test the trainees’ expertise in a simulated practical environment. This intuitively seems to be a better method than a pencil and paper test. |
used at home as a training tool. Various complexities can be added to really enhance the continuing professional development. For instance, a patient suffering from myocardial ischaemia could be simulated as being under anaesthesia (negative inotropism, vasodilation, baroreceptors affected to various degrees, etc.). The simulated patient could be made to be hypotensive (bleeding, trauma, ruptured abdominal aortic aneurism), or experiencing an anaphylactic episode, etc.

Psychomotor (practical, hands-on) skills
How can we use simulation for continuing professional development related to psychomotor skills?

The most common skill required to be maintained by anaesthetists probably involves the difficult airway.
- We can use various cheap intubation heads to evaluate and compare various airway devices (supraglottic devices, indirect video-laryngoscopes, etc).
- We can practise with the device we have selected to use in our practice.
- We can maintain our fibre-optic intubation skills using simulators.

Examples of other skills that need to be maintained include:
- Cardiopulmonary resuscitation. The new mantra for compressions is “fast and deep”. Simulators can measure the rate and the depth of compressions and give immediate feedback.
- Automated external defibrillators (AED). These have become ubiquitous, for instance in aircraft. The manufacturers also provide a training device for use in simulation.
- Other specialties. For instance, carotid stenting can be practised in a very sophisticated simulator. Coronary artery stenting simulators have progressed to the point where cardiologists can actually import a patient’s data (CT and MR) and practise on the patient that they will be handling the very next day.

Many of these psychomotor skills will be available only in a simulation centre, where the economies of scale for the continuing professional development of multiple disciplines will make it worthwhile to acquire and maintain the devices.

Attitudes
How can we use simulation for continuing professional development related to attitudinal aspects of knowledge?

At present, continuing professional development in the medical environment follows basic medical training in that the individual is trained and assessed in isolation from other healthcare workers. In the aviation arena, it was found that many near-misses and accidents were due to “human factors failures” that could have been prevented, as someone in the team actually had the knowledge to prevent the disaster. The concept of “cockpit or crew resource management” (CRM) was developed to address and train aviation personnel to function as a team. Dr David Gaba, an anaesthesiologist and a pilot, transposed the aviation concept to “anaesthesia crisis resource management” using the same basic principles of team training. This is now also used for training interdisciplinary teams under the rubric of crisis resource management (CRM), as well as being used in a non-medical environment for leadership training.

This type of team training is typically offered only in highly sophisticated simulation facilities by experienced individuals. As the need increases, special efforts will have to be made to increase the pool of trainers.

Assessment of efficacy of continuing professional training
At present, surgeons in the USA who wish to re-certify fill in little blocks with a pencil on a multiple choice questionnaire. This is not really satisfactory for the practical aspect of a speciality. The American College of Surgeons (ACS) is trying to address this lack of practical evaluation by certifying simulation sites as ACS Certified for training and certifying purposes. They have not yet defined what skills will be tested, nor how these skills will be tested.

The American Society of Anesthesiologists is also moving towards certifying simulation facilities for anaesthesia training and assessment. We can therefore expect that continuing professional development will eventually be performed and evaluated in simulation facilities on a worldwide scale.

Conclusion
When simulation started in aviation, it was small and primitive. However, after 75 years, flight simulation is a mature and sophisticated science. It is totally woven into the fabric of aviation training, with extremely comprehensive manuals detailing every eventuality that has been encountered and/or imagined to be possible. The highly individualistic “captain of the ship” doing it “his way” has long been replaced by a uniform system of management of each crisis event in aviation. Each member of the team knows what to expect and how to act under this specific eventuality. Crises are practised every six months in a high-fidelity aviation simulator.

In medicine, we are dealing with a much more complex object, the human body. We should be taking the early, first steps to train and assess aspects of continuing professional development, which should include more than just memorised factoids. Hopefully, the process of incorporating simulation into medical continuing professional development will take less time to mature than did aviation simulation.

References
1. Bloom BS, Engelhart MD, Furst EJ, Hill WH, Krathwohl DR. Taxonomy of educational objectives. Handbook I: cognitive domain. New York: David McKay; 1956.
2. Murray WB, Foster PAF. Crisis resource management among strangers: principles of organizing a multi-disciplinary group for crisis resource management. Jnl Clin Anes 2000;12(2):633-8.
3. Murray WB, Henry J, Jackson L, Murray C, Lamoreaux R. Leadership training: a new application of crisis resource management and distance education in a large group format at a medical simulation facility. JEPM 2002;4(1):1-14. Available: JEPMadmin.org/ce/murray010911.pdf (Accessed: 12/12/2007).
4. Kyle R, Murray WB. Clinical simulation: operations, engineering and management. London: Elsevier Press; 2008.