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Room R

This article will deal with simulation as an educational resource and consider how it can best be incorporated into anaesthetic and critical care teaching.

INTRODUCTION

A number of factors have been responsible for the increasingly important role that simulation is assuming in the education of health care professionals.

First, quite sophisticated simulators have become more readily available and cheaper to purchase. Second, simulation fits well with developments and applications in medical education over the last 20 years, especially in the UK and USA where legislation to reduce junior doctors hours is forcing a reappraisal of training. Third, societal values, especially in Europe and North America, have changed. It is no longer acceptable to patients or to the medical profession to have doctors learn new techniques by practicing on patients. Technology has brought new treatments but misuse of these techniques can result in major morbidity and mortality. There is now an expectation in society that health care professionals will have mastered a basic level of competence before applying practical procedures to patients.

CLASSIFICATION OF SIMULATORS

A working group in the Society in Europe for Simulation Applied to Medicine (SESAM) is currently reviewing this. A useful classification is as follows: [1].

- Part task trainer
- Computer based system
- Virtual reality and haptic systems
- Simulated patients
- Simulated environments
- Integrated Simulators
 - instructor driven
 - model driven

The choice of simulator will be driven by the educational needs of the learner. These in turn will depend on the stage of development of the learner and the learning outcomes to be achieved. This will be dealt with in the next section. The term 'fidelity' is often linked with simulation. There are two key components that need to be considered in order to avoid confusion or ambiguity; these are engineering fidelity and psychological fidelity [2]. Engineering fidelity (or physical fidelity) is the degree to which the training device or environment replicates the physical characteristics of the real task. Psychological fidelity (or functional fidelity) is of much greater importance. This is the degree to which the skills in the real task are captured in the simulated task. Consider endotracheal intubation; mastery of the very basic skills requires a part task trainer only. It would be an inappropriate use of a model driven integrated simulator to teach basic intubation skills because most of the available features are not required. Dealing with advanced airway skills in a complex clinical case is another matter. The greater level of engineering fidelity of the integrated model driven simulator is necessary to allow psychological fidelity (the information gathering, the decision making etc.) to be achieved.

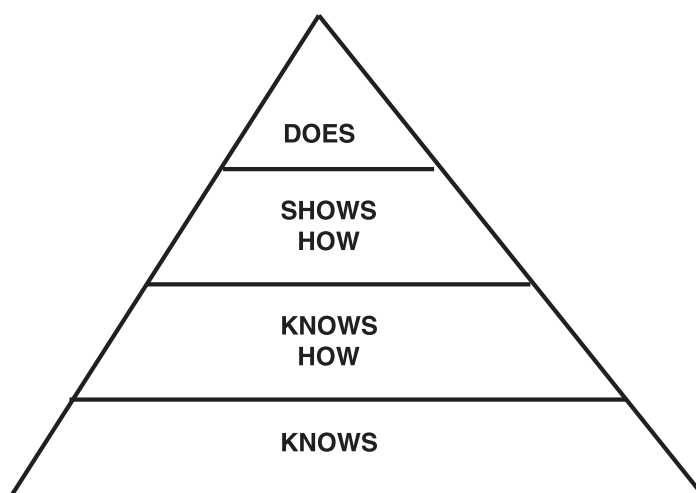
SOME RECENT DEVELOPMENTS IN MEDICAL EDUCATION

Simulation is a means to an educational end. The key to effective use of simulation is the appropriate application in the context of the educational settings. To understand this better we need to know something of recent developments in medical education.

1. COMPETENCY-BASED TRAINING

Traditional models of medical education were largely input based. That is, the curriculum was specified in terms of the experiences undertaken by the learner; for example, a three-month rotation to a paediatric anaesthetic unit, a two-month block in an intensive care unit and so on. The assumption was that the learner would acquire the necessary knowledge, skills and attitudes. However, very little formal assessment of these individual components took place at a workplace level to see whether they were actually acquired. The emphasis is now moving to an outcomes based approach. The essence of an outcomes based approach is that the curriculum is specified in terms of what the learner should be able to do, whether that be at the end of the programme as a whole or an individual component of that programme. The obvious challenge in an outcome based curriculum (also referred to as a ‘competency based curriculum’) is defining what those outcomes should be. Most outcomes based curricula are described in terms of the well known triad of ‘knowledge, skills and attitudes’. A useful tool for structuring individual competencies is Miller’s triangle [3].

Figure 1 – Miller’s Triangle



The base, ‘KNOWS’, can be thought of as the key facts and concepts necessary to understand the area in which the doctor works, such as physiology & pharmacology. The second level, ‘KNOWS HOW’ deals with the selection and application of that knowledge to deal with a particular clinical situation. For example, “describe how you would manage a patient with insulin dependent diabetes undergoing emergency surgery for a compound fracture of the distal tibia”. The third level is ‘SHOWS HOW’. Unlike level two, the trainee now has to actually demonstrate that he or she can manage the particular situation. Amongst other abilities this will require the application of some practical skills. Traditionally assessment tools have concentrated on ‘KNOWS’ and ‘KNOWS HOW’ but the competency based approach requires that the learner is also assessed at a ‘SHOWS HOW’ level. The final level of Miller’s triangle is ‘DOES’. How does the trainee perform when the examiner or teacher are no longer present? This level will involve, amongst other things, value systems and attitudes. Table 1 links the levels with the appropriate assessment tools and the relevant simulation devices.

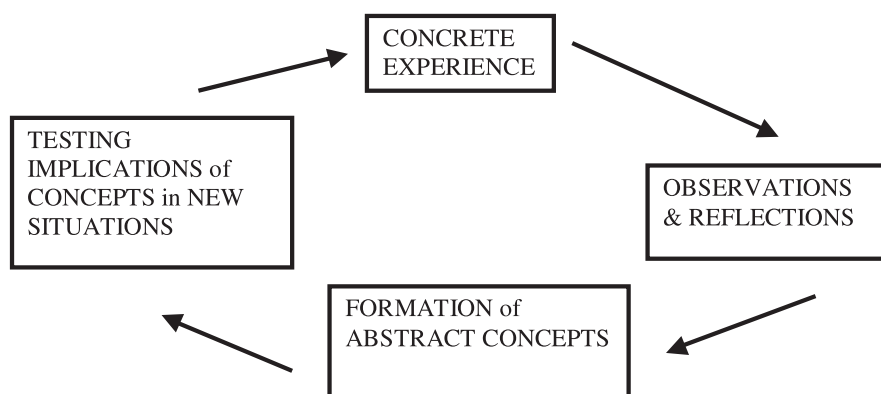
TABLE 1 – LEVELS OF MILLER’S TRIANGLE, ASSESSMENT TOOLS CURRENTLY USED AND SIMULATION DEVICES APPROPRIATE TO THE LEVEL.

| MILLERS TRIANGLE | | |
|------------------|---|--|
| LEVEL | ASSESSMENT TOOL | SIMULATION DEVICE |
| DOES | 360 ^o assessment | |
| SHOWS HOW | Objective Structured Clinical Examination | Part task trainer, virtual reality / haptic systems, simulated patients, simulated environment, integrated simulator |
| KNOWS HOW | Written Exam, Viva | Computer based |
| KNOWS | Written Exam, Viva | Computer based |

2. EXPERIENTIAL LEARNING

This combines two of the major themes in current medical education – experience and reflection. This is best exemplified in the learning cycle described by Kolb [4] in Figure 2.

Figure 2 – The Experiential Learning Cycle



The starting point is an episode of concrete experience, such as managing a clinical case. The second step is to reflect on that case. Reflection includes asking oneself questions such as ‘What is happening here?’ and ‘How can I explain the phenomena I observe?’ This will either fit in with existing theoretical models (third stage) or will identify a gap or even a contradiction in those existing models – this is a very potent stimulus for learning. The fourth stage is to try and resolve this conflict by generating a hypothesis and an experiment that can help with the resolution. The conduction of that experiment (that is, trying a new approach the next time one encounters such a clinical event) becomes the concrete example of the next stage of the cycle. Simulation works well with this model – see table 2.

TABLE 2 – STAGE OF EXPERIENTIAL CYCLE AND ROLE OF SIMULATION

| STAGE | ROLE OF SIMULATION |
|--------------------------------|---|
| CONCRETE EXPERIENCE | Provide examples of cases of suitable level of complexity to fit in with the trainees educational needs. Can provide examples of unusual cases. |
| REFLECTION & OBSERVATION | Time and opportunity to review events. Video recording (if available) to review, protocol adherence, monitor displays, actions etc |
| FORMATION of ABSTRACT CONCEPTS | Opportunity to review existing knowledge, opportunity to link existing knowledge to particular clinical context, identify areas poorly understood or not well known |
| TESTING IMPLICATIONS | Opportunity to try actions without fear of harm to patient. |

3. REFLECTIVE PRACTICE

There are other educational models, most notably those of Donald Schön [5], that also emphasise the importance of reflection. Schön’s thesis is that professional practice is characterised by uncertainty; there are so many variables that can arise in professional practice that one cannot learn the solutions to all the potential problems. Epstein describes these problems as complex, meaning that a solution that was successful on a previous occasion may not be applicable next time. We all recognise features such as the inter-individual variation in patients in response to similar mg/kg doses of induction agent. Schön describes reflection during the professional challenge and after the challenge (reflection-in-action and reflection-on-action, respectively) as being important drivers for the development of the professional. Simulation can help by not only providing the clinical or professional challenge but can also facilitate the reflective process by allowing time to review the participant’s performance, especially when aided with a video-recording of the management of the event.

4. THE NOVICE TO EXPERT CONTINUUM

Work by Dreyfus and Dreyfus [6], Klein [7] and Perry [8] amongst others has concentrated on the way in which learners transform their practice by a change in the way in which they use the knowledge and skills they have acquired. A novice behaves very differently from an expert, not because they possess fewer facts than the expert but because the expert is able to take a different view (Table 3).

TABLE 3 – DREYFUS MODEL OF SKILLS ACQUISITION

| | |
|----------------------------------|---|
| Level 1. NOVICE. | Rigid adherence to taught rules or plans Little situational perception. No discretionary judgement |
| Level 2. ADVANCED BEGINNER | Guidelines for action based on attributes or aspects (aspects are global characteristics of situations recognisable only after some prior experience) Situational perception still limited All attributes and aspects are treated separately and given equal importance |
| Level 3. COMPETENT | Coping with crowdedness Now sees actions at least partially in terms of longer term goals Conscious deliberate planning Standardised and routinised performances |
| Level 4. PROFICIENT | Sees situations holistically rather than in terms of aspects Sees what is most important in a situation Perceives deviations from the normal pattern Decision-making less laboured and more intuitive Uses maxims for guidance, whose meaning varies according to the situation |
| Level 5. EXPERT | No longer relies on rules, guidelines or maxims Intuitive grasp of situations based on deep tacit understanding Analytic approaches used only in novel situation or when problems occur. Vision of what is possible |

Novices often need very little engineering fidelity, unlike experts, where the engineering fidelity must be sufficient to provide the necessary cues to allow performance at an intuitive level. The engine that drives a learner through the stages of this continuum is experience. Jensen [9] has described features of experiences that make them more effective in this process

- Number of experiences
- Variety of experiences
- Meaningfulness of experience
- Relevance of experience
- How recent the experience was

Simulation has an obvious role in being able to provide experiences with these characteristics, experiences that would serve as the ‘CONCRETE EXPERIENCE’ of Kolb’s experiential learning cycle.

EDUCATIONAL ADVANTAGES OF SIMULATION

Kneebone [10] has proposed four key advantages of simulator based learning.

1. The training agenda can be determined by the needs of the learner, not the patient. Learners can focus on whole procedures or specific components, practising these as often as necessary.
2. Because the environment is safe, learners have ‘permission to fail’ and learn from such failure in a way that would be unforgiving in a clinical setting. This gives an opportunity to explore the limits of each technique rather than having to remain within the zone of clinical safety.
3. Simulators can provide objective evidence of performance, using their in-built tracking functions to map a learner’s trajectory in detail. For example when learning a technique such as colonoscopy the percentage of surface area visualised, the amount of time in ‘red outs’ etc can be objectively recorded in a way that would be impossible with existing routine clinical equipment.
4. The capacity of simulators to provide immediate feedback in digital form offers a potential for collaborative as well as individual learning.

The educational equivalent of Evidence Based Medicine is Best Evidence Medical Education (BEME). The BEME collaborative has looked at several issues including simulation [11]. The systematic review conducted by the simulation group identified aspects of studies associated with high fidelity simulation that led to effective learning. 11 features were associated with better rated articles / articles with most positive findings. These are listed on the BEME website. Included are the following:

- A set of standards for the skills studied is determined and appropriate for learner level
- Educational intervention is fully integrated in the required curriculum during the period of study
- Subjects have opportunity for repetitive practice
- Formative feedback is provided during the educational intervention
- Outcome measures used to assess subjects are appropriate for the skills learned

These findings draw attention to the importance of good educational design with application of sound educational principles for courses involving simulation. An example of a failure to achieve a lasting change in the behaviour of learners was described by Olympio [12]. Participants were taught a new educational intervention – a new method of dealing with oesophageal intubation. Teaching was largely confined to the simulated environment and was not reinforced or taught to anaesthetic trainees in the real workplace, consequently it is not surprising that only a minority of participants were able to ‘SHOW HOW’ to apply this technique on a subsequent visit to the simulation centre. This highlights the importance of integrating activity at the simulation centre with activity in the real workplace.

INCORPORATING A SIMULATION BASED COURSE INTO A CURRICULUM

The following stages have been helpful in achieving effective learning and ensuring successful integration into a curriculum and demonstrate the application of some of the educational findings as discussed above.

1. RECRUIT A FACULTY WHO WILL HELP RUN THE COURSES.

Simulation is labour intensive and needs several people to provide a consistent approach to courses. Good preparation of courses, ensuring relevant documentation etc will make the course easier to run and ensure that the desired goals are consistently achieved. The majority of faculty members should be active clinically in the chosen area and should be involved in teaching in the workplace. This helps ensure that consistent messages are being delivered at both simulation course and workplace

2. CONDUCT A NEEDS ASSESSMENT EXERCISE.

Which competencies cannot be delivered in the workplace? The strength of simulation is getting from the ‘KNOWS HOW’ to ‘SHOWS HOW’. Potential course participants and faculty must both be involved in this exercise (it is helpful to include a representative of the target group in the Faculty for that course)

3. DERIVE EDUCATIONAL OUTCOMES FROM THE NEEDS ASSESSMENT EXERCISE

The needs assessment exercise should help highlight the clinical area where the greatest problems or difficulties are seen. These can then be converted into educational outcomes (competencies). What should the participants be able to do at the end of the simulator course? This may include skills from different areas including those specific to the clinical area under review and those that are more generic. For example, in a course intended for anaesthetists working in the obstetric area the problems may be ignorance of some key protocols combined with poor team working between the different members of the group.

4. CONVERT THE EDUCATIONAL OUTCOMES INTO SCENARIOS

The aim of the scenario is to give the participants the opportunity to acquire the identified competencies. This can range from techniques used in basic surgical skills courses such as tying knots using minimal access equipment to the management of less common conditions such as malignant hyperpyrexia. The bulk of the learning (the transition from ‘KNOWS HOW’ to ‘SHOWS HOW’) may take place during debriefing, with the scenario acting as a way of highlighting what the participant can and cannot do to the required standard.

5. DECIDE ON THE COMPLEXITY OF SIMULATION DEVICE(S) REQUIRED

The educational outcomes will determine the level of psychological fidelity. The next stage is to determine what level of engineering fidelity is required. More than one simulation device may be required. Kneebone [13] has published on combining part task trainers with simulated patients to teach and assess different types of skill, for example conducting urinary catheterisation while communicating effectively with the patient.

6. ENSURE THAT THE FACULTY HAVE THE NECESSARY SKILLS TO RUN THE COURSES

This continues to be an area of great interest. The skills required will depend on several factors, including the level of experience of the participants and the nature of the learning outcomes. A lot of work has been published on small group teaching. A key role is creating the appropriate environment for learning. Reflection will be more effective if participants can admit to their strengths and weaknesses. This requires a climate of intellectual honesty in which participants can make mistakes without fear of humiliation or punishment. The issue of who will 'drive' the simulator and ensure that props and resources are in place will vary from centre to centre.

7. ENSURE THAT THE NECESSARY EQUIPMENT AND RESOURCES ARE AVAILABLE

These fall under the heading of engineering fidelity and so the level of psychological fidelity will determine to what level such resources are required. Participants should be encouraged to obtain information in a way that is appropriate for the task – if this means reviewing case notes then these should be available, if the onus is on the participant to obtain lab results then this should be replicated. This becomes even more important when generic or non-technical skills feature in the learning outcomes and when the participants are at proficient or expert level.

8. THE PURPOSE OF ASSESSMENT SHOULD BE DECIDED IN ADVANCE

Assessment can be carried out in a summative (pass –fail or ranking order) manner or a formative (diagnostic) manner. If the performance in the simulator is being used in a summative fashion then the level should be consistent with any summative tools used in the workplace. Participants should also be clear of the purpose of any assessment being carried out.

CONCLUSION

Simulation is already playing an increasing role in delivering educational outcomes. It is an expensive educational resource in terms of both the capital investment to set up and equip centres and the continuing expenditure to maintain centres, run courses and so on. That cost is heavy in both time and trained staff. This probably continues to be the biggest hurdle to setting up centres. There are many anecdotes of hospitals buying integrated simulators which then languish in cupboards because there are no members of staff who can incorporate them into existing teaching programmes. As the public become more aware of the potential for poorly trained health professionals to do harm then pressure from outside the profession may prove a useful lever to further inclusion of simulation into existing programmes.

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13. Kneebone R, Kidd J, Nestel D, Asvall S, Paraskeva P, Darzi A. An innovative model for teaching and learning clinical procedures. *Medical Education* 2002;**36**:628-34

Two useful publications are

14. Bradley P, Postlethwaite K (eds.) *Simulation in Clinical Learning*. *Medical Education* 2003;**37** (Suppl.):S1-78
15. Greaves JD, Dodds C, Kumar CM, Mets B (eds.) *Clinical Teaching: A guide to teaching practical anaesthesia*. Lisse, The Netherlands: Swets and Zeitlinger; 2003

Two useful organisations are:

Society in Europe for Simulation Applied to Medicine (SESAM)
<http://www.uni-mainz.de/FB/Medizin/Anaesthesie/SESAM/welcome.html>

Society for Medical Simulation
<http://www.socmedsim.org/>