Simulation in medical education

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KEY MESSAGES
• Simulation is a powerful learning tool when learning outcomes are clearly defined.
• Simulation should be integrated within the curriculum.
• Simulation provides a safe, learner-centred educational method.
• Debriefing and feedback are essential components of any learning experience.
• The authenticity required should relate to the learning context of the simulation.

Introduction
This is an exciting time to be involved in simulation, as with an increasing emphasis on patient safety,(1,2), simulation is becoming an essential component of most medical education and training programmes.(3,4) This chapter introduces the reader to the potential of simulation in medical education and in doing so covers four key areas:
• definitions and classifications
• application of educational theories
• the role of debriefing and feedback
• practical applications.
As research into simulation has hitherto been limited – often to descriptive, low-level evaluation(5) – we will try to provide a balanced overview of the field and consider the theoretical underpinnings of simulation, in the hope that this will point the way towards areas for further research.

A Brief Historical Perspective
Simulation has been around for centuries in many areas of human endeavour.(6) Simulators in healthcare learning date back as far as 18th-century France when Madame Du Coudray used her foetal model and pelvis to train midwives.(7) The modern movement in simulation training coincided with developments of the part task trainer. Resusci Anne led the way in standardising resuscitation training by making available a simple, low-cost, practical and effective manikin.(8) Sim-One, a higher fidelity human patient simulator, was developed by Abrahamson at the University of Southern to help novice anaesthetists develop skills in inserting endotracheal tubes.(9,10) Since then anaesthesia has been at the forefront of simulator development. The 1980s saw the development of the Gainesville Anaesthetic Simulator(11) and the Comprehensive Anaesthesia Simulation Environment (CASE).(12) The CASE group linked the simulator to a programme on anaesthesia crisis resource management,(13,14) which was the start of many disciplines using simulation for learning both technical and non-technical skills.(15,16) Barrows introduced simulated patients, providing learners with a controlled, staged experience of simulated practice.(17) Following recent technological developments, computer-assisted simulation, virtual reality and the use of haptics (tactile sensations) have been added to the simulation armamentarium.

What Is ‘Simulation’?
The narrow, popularist view of simulation is that of advanced technologies recreating the clinical experience, such as those found in virtual reality and advanced computer-controlled human patient simulators. But simulation does not focus exclusively on technical or psychomotor performance; it encompasses a broad perspective, incorporating both cognitive and affective domains. Simulation may involve a wide range of techniques and approaches applicable to learners at all levels of seniority, from novice to expert, one of the major underlying drivers being to develop safe healthcare practitioners (see Figure 12.1).
Simulation in medical education

To Err Is Human(26) and An Organisation with a Memory(27) increased our awareness of clinical adverse events and their underlying causes. The patient safety agenda and clinical governance requirements for standards of practice can, in part, be addressed through prior exposure, using simulation to prepare for rare and unexpected events.(28) Simulation can help educate staff in defined processes in a realistic healthcare context with defined and assessed outcomes. It can improve patient care through team-based approaches,(29–36) and aid the development of non-technical skills.(2–4,37–39)

Safe technical skills can also be enhanced and standardised using simulation. New diagnostic and therapeutic technologies, for example, endoscopy and minimally invasive surgery, have revolutionised clinical practice, but they have also imposed a requirement for safe, effective training for both trainee and established practitioners.(40–46) New interventional techniques can be pioneered through simulation.

Worldwide, there have been major changes in medical education, both undergraduate and postgraduate, which recognise the need to incorporate all aspects of a doctor’s practice, including knowledge, skills and expected attitudes, within an outcomes-based framework.(47–53) The defined outcomes of competency-based curricula lend themselves well to a simulation approach. With more emphasis on the cost-effectiveness of clinical care and a reduction in working times, clinical teaching has been squeezed, with learners receiving less time on direct bedside teaching.(54–56) There has also been significant evidence of the failure of traditional serendipitous approaches to skills acquisition across a wide range of core skills.(57–65) The traditional apprenticeship model in this context is no longer effective, and simulation offers a feasible alternative for learning procedural skills(66) and the opportunity to rehearse performance in complex integrated scenarios in a safe, protected, learner-centred simulated clinical setting.(31,67,68)

Assessment and monitoring of both non-technical and technical skills can also be delivered in educationally supportive clinical skills and simulation centres.(69–73) Behaviours observed in a simulated environment can provide a prediction of how professionals will behave in the reality of practice.(74) A more extensive list of potential applications is listed in Box 12.1.

Fidelity of Simulation

Meller developed a classification scheme for a medical simulation with four components(75):
- the patient and/or disease process
- the procedure, test or equipment
- the physician or other practitioners (learner)
- the expert practitioner (teacher)
BOX 12.1 Potential applications of simulation(6)

- Routine learning and rehearsal of clinical and communication skills at all levels
- Routine basic training of individuals and teams
- Practice of complex clinical situations
- Training of teams in crisis resource management
- Rehearsal of serious and/or rare events
- Rehearsal of planned, novel or infrequent interventions
- Induction into new clinical environments and use of equipment
- Design and testing of new clinical equipment
- Performance assessment of staff at all levels
- Refresher training of staff at all levels

BOX 12.2 Fidelity

Miller(76)

- Psychological – degree to which the skills or skill in real task are captured in the simulated task.
- Physical or engineering – degree to which the device or environment replicates the physical characteristics of the real environment

Rehmann(77)

- Equipment fidelity – relates to the degree to which the simulator duplicates reality.
- Environmental fidelity – concerns the extent to which the simulator duplicates the visual and other sensory clues.
- Psychological fidelity – concerns the degree of reality perceived by the trainee or student.

However, an analysis that looks at the fidelity of the simulation, the simulator and the component parts is probably more meaningful. Simulation can be viewed as a continuum that runs from low to high levels of fidelity and from low to high levels of authenticity, dependent on the learners and learning context. (see Box 12.2).

Fidelity is the extent to which the appearance or/and behaviour of the simulation or simulator matches the appearance and behaviour of the real system.(78) Miller(76) made the distinction between two different types of fidelity: psychological and physical. Rehmann further expanded physical fidelity to incorporate equipment and environmental fidelity.(77) This typology is, of course, based on the trainer’s perspective. The required overall fidelity configuration is best determined by intended learning outcomes.(79)

Simulation has also been classified as high (hi) or low (lo) fidelity, traditionally related to the level of technical sophistication. However, hi- or lo-fidelity relates to more than advanced technology and simulation authenticity should be considered in relation to the real world and community of practice. Such classifications of fidelity do not fully embrace all the determinants of realism relating to a defined simulation event. The fidelity of simulation required for teaching a novice venepuncture is very different from that needed to recreate a multi-professional team in the throes of an operating theatre-based crisis. Contextual fidelity, which has both clinical and temporal components, is a very important consideration. Our own model, which describes simulation not as a task, but as an event influenced by a number of factors relating to fidelity, is shown in Figure 12.3.

Classification of Simulators and Simulations

A range of simulators and types of simulation event are used in medical education (see Box 12.3), and in this section we will review those in common use.(26,80) An extensive list of available simulators is available at http://www.pennstatehershey.org/web/simlab/home.

Part-task trainers

Part-task trainers (PTTs) are often used to teach and learn psychomotor, procedural and technical skills. They are used to develop mastery of these skills in an educational setting. As well as lo-fidelity trainers, for example venepuncture arms, PTTs also include highly sophisticated computerised human patient simulators such as Harvey and Simulator K.(81,82)

Taking venepuncture as an example, with a PTT (and a little imagination) the tutor can incorporate clear demonstration of communication skills, health and safety issues (including patient identification, clinical hygiene, hand washing, safe disposal of sharps and clinical waste, and use of universal precautions),
completion of documentation, labelling of specimens, safe handling of specimens, and proper handling and despatch to ensure the best-quality specimens arrive at the laboratory. Therefore, even for this relatively low level of skill, a fairly sophisticated set-up and performance may be required, placing the learning in the context in which it will eventually be applied. (31,83)

### Computer-based systems

There have been significant developments in computer-based simulations. Learners are provided with interfaces that allow them to interact with materials relating to basic sciences, which can be staged and can progress at the student's own pace. These programs ensure learners receive relevant feedback to reinforce their learning.

A number of programs have been produced that include sophisticated physiological models. Some also provide feedback on the decision-making ability and performance of the user; in the case of Laerdal’s MicroSim suite, it can be used to reinforce an emergency care curriculum.

### Virtual reality and haptic systems

Virtual reality generates images representative of objects or environments with which the user interacts and which respond to those actions. Haptic systems provide the kinaesthetic and tactile sensation. These two approaches may be combined to provide training in basic skills such as venepuncture, and more sophisticated skills such as endoscopic, laparoscopic and endovascular procedures. Such simulation systems can also generate user data, which can be presented subsequently as detailed feedback on performance and maintained as an ongoing record.

### Integrated simulator models

Integrated simulators combine a whole- or part-body manikin with a computer that controls the model’s physiology and the output to monitors showing graphic displays. The observed clinical vital signs and the electrical readouts can be controlled and altered in response to interventions and therapies initiated by the users interacting with the manikin. The capabilities of modern integrated simulators are extensive, encompassing the life-like representation of body parts and functions, to generating realistic monitoring data such as electrocardiography and pulse oximetry, and providing a hi-fidelity means of rehearsing a range of procedures such as the insertion of a chest drain or urinary catheters.

Integrated simulators are divided into two subgroups: model and instructor driven.

Also called hi-fidelity simulators, model-driven simulators are built around physiological and pharmacological models that directly control the manikin’s responses to intervention and treatments. Examples include the highly sophisticated METI (Medical Technologies Inc) simulation systems, which can range from simple single-use disposable modules to complex multi-use models that are capable of generating a comprehensive range of physiological responses to interventions and therapies. These systems can also simulate the environment in which the procedures will be performed, such as simulated wards, operating rooms, and intensive care units.

### Classification of simulators

<table>
<thead>
<tr>
<th>Simulator type</th>
<th>Examples</th>
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<tr>
<td>Part-task trainers</td>
<td>Venepuncture arms, arterial arms</td>
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<td></td>
<td>Male and female pelvic models</td>
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<td></td>
<td>Skin and tissue jigs for injection and suture practice</td>
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<tr>
<td>Computer-based systems</td>
<td>Emergency medicine (Microsim, Laerdal)</td>
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<td></td>
<td>Anesoft – range of modules including anaesthesia simulator,</td>
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<td></td>
<td>haemodynamic simulator, critical care and bioterrorism</td>
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<tr>
<td>Virtual reality and haptic systems</td>
<td>Venepuncture trainer</td>
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<td>IV Cannulation</td>
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<td></td>
<td>Endoscopy trainer</td>
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<td></td>
<td>Ultrasound trainer</td>
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<td>Complex manipulation</td>
<td>Minimally invasive surgery</td>
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<td></td>
<td>Complex surgical procedures</td>
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<td>Integrated simulators</td>
<td>SimMan</td>
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<tr>
<td>Instructor-driven simulators</td>
<td>METI (Medical Education Technologies Inc adult and paediatric simulators)</td>
</tr>
<tr>
<td>Model-driven simulators</td>
<td>Simulated wards, operating rooms, intensive care, etc.</td>
</tr>
</tbody>
</table>

Adapted from Kneebone(80) and Maran and Glavin(29)
Education Technologies Inc) adult and paediatric simulators, which have up to 100 changeable physiological parameters to recreate accurate patient responses to illness and therapies. Hi-fidelity simulators usually require dedicated facilities, faculty and specialised technical support.

Instructor-driven or intermediate fidelity simulators respond to instructor intervention, either directly via the computer keyboard or via a pre-written computer algorithm. They are less resource intensive than hi-fidelity simulators and are widely used by skills and simulation centres.

Simulated patients
The terms ‘standardised patient’ and ‘simulated patient’ are often used interchangeably. Barrows defined a simulated patient as ‘a well person trained to simulate a patient’s illness in a standardized way’. (17) Here the emphasis is on the simulation of reality, and there is now widespread use of simulated patients in medical education in teaching, learning and assessment. Simulated patients may be usefully involved in the teaching of a number of domains, including communication and consultation skills, physical examination, non-invasive procedural skills and the assessment of professionalism. There is also a special group that provides learners with opportunities to undertake male and female genital and digital rectal examination, and female breast examination. These people are trained and give the learners feedback on all aspects of their performance. (84–86)

Simulated patients need training and considerable organisation in relation to matching simulated patient training needs to scripts and in timetabling simulated patients for both training sessions and student/learner training programme and needs. This can be even more complex when simulated patients are required to provide feedback to students or to participate in assessment or complex healthcare scenarios when simulated patient training may require more than one session. A database can be used to manage the bank of simulated patients effectively. (67) There will also need to be considerable investment in time and resources, and the financial costs may be high, particularly if your simulated patients are professional actors.

Script development for simulated patient exercises can be used to support wider learning outcomes beyond the simulation and immediate learning goals. Inevitably, however, there are some physical signs and situations that cannot be simulated and such patients can in no way substitute for direct clinical experience (see Box 12.4).

Simulated environments
The development of clinical skills and simulation centres provides varying degrees of recreation of the clinical setting in a protected environment. (70, 87–89) Within these venues, application of contextual fidelity enables the suspension of disbelief and facilitates transfer to the real world. It might be argued that real clinical settings are better places for learning; however, the disruption of normal clinical activity and the distraction of peripheral events may prevent the required learning. One advantage of a dedicated facility is access to additional educational and audio-visual resources (see Boxes 12.5 and 12.6).

The Theoretical Basis of Simulation
A number of theories of learning and instruction underpin the design and delivery of the simulated clinical experience, and these can be used not only to affirm educational credibility but also to develop appropriate research questions. What follows is a short description of the major relevant educational theories,
with examples of their relevance to simulation. For a more detailed exposition of some of the educational theories described, see Chapter 2 by Kaufman and Mann.

**Behaviourism**

Behaviourism (91,92) ignores the ‘black box’ of the mind and describes a model in which a stimulus is used to produce a response that may be ‘rewarded’ or ‘punished’ to reinforce or weaken the response through a process known as ‘conditioning’. Knowledge is therefore seen as a repertoire of behaviours. Neo-behaviourists, such as Bandura (93) also point out that a reciprocal determinism exists between the behaviour, the environment and a number of personal factors, such as personality, affect and knowledge.

In simulation training, feedback is used extensively to bring about new behaviours. Simulation also permits ‘over-learning’ as a means of making such behaviours automatic. An example of such a behaviourist approach in simulation is the ‘skills and drills’ of resuscitation training to which we are all exposed throughout our undergraduate and postgraduate career (94,95).

**Cognitivism**

Cognitivism, as expounded by Piaget (96) and Bruner (97) posits that learners develop new ideas, constructs, hypotheses and decisions based on their interaction with the world and their own prior knowledge as an internal mental process. Learning is assimilated (the experience fits into the existing structure and adds to the body of examples) or accommodated (the experience does not fit the existing structure, which must be changed to incorporate the new knowledge) into a cognitive structure that gives meaning and organisation to the knowledge.

In the context of simulation, the tutor can help facilitate the learners’ learning by establishing their preconceptions, presenting a cognitive conflict, drawing attention to the discrepancy between learners’ expectation and experience of the event, asking questions and engaging in dialogue to prepare the learners to be receptive to new ideas, teaching the new ideas and drawing attention to the way in which they are better than the learners’ previous knowledge structures.

**Social constructivism**

Based on the work of Vygovsky (98) social constructivism emphasises social interaction as the means of learning. Language and culture are considered central to human intellectual development and how the world is perceived. Knowledge is co-constructed as a social phenomenon.

The tutor can work collaboratively to support (‘scaffold’) the learner’s development and in time remove such support to encourage independence. Through, for example, discussion of salient points and problems arising, the tutor mediates social interactions. Constructivism requires the learning environment to be safe, where ridicule or embarrassment will not follow mistakes and, by extrapolation, patients would not be at risk.

**Situated learning and cognitive apprenticeship**

Lave and Wenger (99) introduced the term ‘legitimate peripheral participation’, describing the position of learners within a community of practice. The learning is described as a product of the activity, culture and context (the social interaction within the workplace). As a learner moves from the periphery towards the centre, they become more actively involved and socialised (accepting beliefs and behaviours) and take on more senior and expert roles. This process is often not deliberate but evolutionary.

In a related model, Collins et al. (100) developed the concept of the cognitive apprenticeship, where the processes of the task are identified and made visible; abstract tasks are situated in the context of authentic settings; situations are varied to emphasise commonalities; and transfer of learning is promoted, that is, through a process of

- **modelling**
- **coaching**
- **scaffolding**
- **articulation**
- reflection
- exploration/transferability.

The cognitive apprenticeship approach can be used in the teaching of a practical skill prior to its integration, application and transfer to the clinical environment, whereas situated learning is the more appropriate paradigm in the workplace environment where a junior learner would increasingly become part of the team during a clinical attachment and their learning would benefit from that socialisation.(101)

**Experiential learning**

Although criticised as an oversimplification with a weak theoretical basis, experiential learning, as defined by Kolb,(102) provides a useful model for simulation training (see Figure 12.2). Experience provides the main motivation for learning and new knowledge is established from reflection. The model of learning from experience includes concrete experience (apprehension) and abstract conceptualisation (comprehension) as means of perceiving experience, and critical reflection (intension) and active experimentation (extension) as means of transforming the experience.

Engaging learners in a healthcare exercise using simulation provides both the realism relevant to the learner’s experience and the time in which to analyse and interpret different potential scenarios and their outcomes. The experiential learning process using simulation techniques allows learners to reflect critically on how they felt during the exercise. They can then begin to formulate concepts and hypotheses concerning the experience through discussion and individual reflection. Further experimentation with newly formed concepts and experiences can then lead to further reflection on experimentation. In this way, simulation provides a safe opportunity to experience healthcare, again without compromising patients.(103,104)

**Reflective and transformative learning**

Reflection-in-action (thinking on your feet) and reflection-on-action (evaluating after the event) are key concepts in the work of Schön.(105,106) Reflection-in-action occurs during an event; little time is given or available and recall of reflection might be limited, but prior experiences and knowledge are drawn upon and applied (almost experimentally) within the content of an unfolding situation, adding to the wealth of experiences already in place. Reflection-on-action is more indirect and formalised; writings, recording and other recall may be used to analyse an event, actions and outcomes.

Transformative learning(107) involves the reconfiguration of ideas, knowledge and meaning stimulated by a process of critical reflection. Learners are empowered to identify and incorporate new learning as their own. The use of video recordings in the learning of communication skills is an example of these educational approaches. Video can result in reflection both in- and on-action, and through facilitated discussion after the event it can result in a transformative restructuring and the development of an action plan and new learning goals.(108–111)

**Activity theory**

Based on the work of Vygotsky and other Soviet psychologists(112,113) and Cole,(114) activity theory posits that conscious learning comes from activity. Activity denotes the forms of behaviour that are socially formed and conscious. Human activity is structured, dynamic and self-regulating, motivated by needs and objects. Activities create motor and mental actions directed by conscious goals. Actions themselves are implemented through operations, which are dependent on conditions in the (external and internal) system(115).

This seemingly complex interaction illustrates the underlying principle that learning, knowledge and activity are intrinsically interlinked and that learning is a socially mediated activity. Relationships between one activity system and another, for example, the simulated environment and the clinical setting might help us understand issues surrounding the transfer of skills and how clinical education might best be engineered. A crisis resource management or interprofessional exercise would find this educational approach most beneficial in a simulated setting. This would enable teams to rehearse their skills using hi-fidelity simulation and to transfer the skills into clinical practice.(116–118)

**Models of expertise**

In considering all the educational approaches above, it is also important to recognise the development of expertise and its impact on any simulated exercise. Expertise may be considered as the end point in a stepwise development of cognitive, psychomotor and affective skills. The Dreyfus brothers describe five levels of development of expertise from novice to expert,(119) and experiences in simulation should be modelled in accordance with the levels of expertise expected of the learner.

**Feedback in Simulation**

Feedback is an essential component in simulation – closing the learning loop. Feedback may be intrinsic or extrinsic. Intrinsic feedback, as described by Laurillard, refers to a conversational framework embedded within the teaching and learning experience.(120) Extrinsic feedback, by contrast, is usually available only after the event has taken place.

In an ideal world, learners should be able to compare their own performance with a standard, and be able to diagnose their own strengths and weaknesses. A simu-
lated learning environment should permit such self-criticism, providing an atmosphere of trust and encouraging excellence. Most learners welcome the opportunity to discuss their strengths and areas for self-improvement, and in maximising the impact of learning from a simulation episode, extrinsic feedback is crucial. But when, how often and how well it is done is often disappointing.(121)

**Who should give feedback?**

In recent years, there has been a move towards the widespread use of multisource feedback, particularly as evidence of performance in the workplace.(122,123) Such a tool can also be useful in the simulated context where the event has involved a team.(124) Peer-group feedback can give learners a realistic perspective on standards of performance.

Simulators themselves can provide instant feedback by collecting data of events and interactions and from attached monitors. Video-recording a simulated learning event, whether a hi-fidelity scenario(109) or other simulated encounters,(125) may also provide the learner with an opportunity for later reflection,(126) although it may be no more superior for immediate feedback than for oral feedback alone.(111) Tutors and facilitators can provide feedback where the main focus is on striving for better professional practice, and trained simulated patients can also offer a unique perspective on the learning episode(127,128).

**The purpose of feedback**

Feedback ensures that learners are clear about the learning outcome expected, can have areas of performance clarified, are given time and space to make connections with what they already know and can generalise to what training might be required in the future.(129) Feedback also raises the learner’s self-awareness. It can reinforce good practice and be corrective by encouraging modifications of behaviour. Feedback should be an integral component of the learning process and is analogous to the reflective thinking process needed for safe clinical practice.

**The feedback process**

Within any simulation event, there are four stages to the feedback process, although with practice they may be run together seamlessly.

1. **Preparation for feedback:** This is important and should be addressed prior to the simulation exercise. Learners can be asked to complete a questionnaire or to discuss in small groups the intended learning outcomes for the simulation exercise. This process helps to assess prior knowledge or similar experiences, to explore awareness of the learners’ own competence and confidence, and to identify previous concerns or difficulties.

2. **Coming out of role:** During a simulation a learner takes on a health professional role caring for a ‘patient’ (simulator) in a situation of ‘suspended disbelief’. Giving time to come out of role is important to allow the emotional responses of the learner to be addressed. This should not diminish the consequences of inappropriate action but helps promote conditions for deep learning. A learner has to acknowledge himself or herself as a student in learning, not a doctor or a healthcare professional responsible for the safety of the patient’s life.(130) Concern for emotional impact must also be considered in relation to the experiences of simulated patients.(131–133)

3. **Constructive feedback:** Several models for constructive feedback exist which are relevant to learning from simulation. Most of these share a common goal of constructing what learning from performance has occurred. Examples include Pendleton’s Rules(134) and the Cambridge–Calgary SETGO method,(135,136) both of which are widely used in consultation skills training; CORBS,(137) from the supervision literature; and GREAT,(138) a simple checklist developed specifically to debrief after simulator-based training.

4. **Contemplation:** In this final stage the facilitator encourages the student to link up what has happened in the simulator with prior relevant learning experiences and to think about transfer of learning to the workplace – to generalise their learning so it is accessible in different contexts. A subsequent post-encounter meeting can further support this process. Feedback and its role in formative assessment and development is covered in more detail in Chapter 18.

**Practical Approaches to Teaching, Learning and Assessment Using Simulation**

To illustrate some of the theoretical concepts already highlighted in this chapter, this section explores the practical applications for simulation in the teaching and learning of technical and non-technical skills, and how the influence of the environment on practice can be analysed by recreating healthcare settings.

**Teaching and learning a practical skill**

Whether teaching components of a practical skill or learning more complex professional skills using simulation, knowledge is required to underpin practice. However, in medicine, as in other complex areas of professional work, it is not just necessary to recall facts, but it also necessary to be able to use knowledge.(139)

Eraut categorises knowledge as propositional, procedural and personal; the latter two being gained only through experience and reflection, whether simulated or real practice.(140)
Gagne lists three phases in instructional design when contemplating the teaching of a technical skill. (141)
1 Early or cognitive phase – consciously developing a routine with cues from a facilitator.
2 Intermediate or associative phase – component parts become integrated.
3 Final or autonomous phase – skill becomes automatic, enabling other cognitive activities to be addressed.

Studies have shown that rest periods interspersed with periods of practice are more effective than continuous practice. A practical application of the above is found in the Advanced Trauma Life Support and Advanced Life Support courses, and this approach can be further adopted and adapted. (142) Joyce and Showers (143) stressed the importance of learning in context, modelling through real-time demonstration, repeat demonstration with explanation of actions, supervised practice and feedback to guide further development through further repeated practice. Their work also emphasised the importance of feedback and further coaching in ensuring effective implementation of new learning (see Box 12.7).

This standardised approach to skills teaching and learning is less easily transferable to a setting where there may be large cohorts of learners and smaller teaching faculties. However, it is possible to build on the model, as Joyce and Showers (143) also identified that while feedback and coaching were essential in skills training, they did not necessarily have to be done by the trainers or in the initial training session. Therefore, a modified approach may be adopted in which initial teaching is delivered to groups and learning is consolidated through deliberate practice and peer review (see Box 12.8).

**Learning using patient scenarios**

Planning and structuring are essential to developing successful patient-based scenarios, and here it is important to avoid the lure of the ‘bells and whistles’ of the technological capabilities of simulators. They are a means to an end. Patient scenarios can form a useful teaching aid in a variety of settings at all levels of simulation complexity. Salas et al. provide a simple but effective blueprint for such an approach (144) (see Box 12.9).

In patient scenario teaching, particularly when using hi-fidelity simulators, the feedback is often referred to as the debrief. This has two elements: the clinical/technical aspects of the exercise and the non-technical professional skills. Useful frameworks have been validated to support non-technical skills debriefing, such as the Anaesthetic Non Technical Skills (ANTS) framework (145) and others. (146) Again, feedback to learners is absolutely essential, (147) and the stages of feedback described above should be followed.

**Learning using different healthcare settings**

Simulations representing the real healthcare environment are increasingly being used to develop and rehearse non-technical skills, such as prioritisation, decision making and situational awareness. Examples include simulated ward environments, (31, 148) anaesthetic settings (149) and complete operating thea-
In a simulated healthcare environment, significant events in practice can be recreated with errors and adverse events built in to test systems. In a simulated healthcare environment, significant events in practice can be recreated with errors and adverse events built in to test systems. Hi-fidelity simulators offer the potential to examine higher levels of expertise among clinicians, testing knowledge, procedural and psychomotor skills, decision making, team working, communication and professional behaviour. Of key importance is that the testing process must be rigorously assessed itself for reliability and validity if the assessment is going to be used in a high-stakes setting. It should be noted that there is currently limited evidence to support the use of hi-fidelity simulators and complex clinical scenarios in high-stakes assessments.

The apex of Miller’s pyramid – ‘does’ – can be assessed through simulation, but in the real practice environment, an example being incognito simulated patients who are trained to visit a practitioner in their practice and then score their performance. Simulation is not, and can never be, a replacement for authentic experiential learning in the real world of clinical practice. It can, however, prepare practitioners for the real world, providing a structure for deliberate practice analogous to the hours put in by a professional golfer on a golf range or a concert pianist working their way through books of technical studies. Simulation is not a tool to replace other modes of learning, but a powerful adjunct, and at its most useful when fully integrated into the curriculum. Simulation should not be viewed as limited to training but as enhancing all aspects of professional education, particularly in relation to clinical reasoning and professional judgement.

There is a question over the transferability of learning from the simulated to the clinical environment. Recently, there have been concerns expressed about a disparity between confidence and assessed competence of new graduates, and calls for the improved and systematic teaching of clinical skills. However, it is still not clear how well these transfer into practice and it may be that simulation, while providing varying degrees of fidelity, does not attend to the noisy, messy and emotional reality of clinical practice. An approach exposing learners to this milieu may...
have more relevance,(66,83) and it has also been suggested that close geographical location of workplace and simulated learning facilities where learners can more readily avail themselves of learning opportunities as their needs are identified is important. Training should be more aligned to fulfilling capability and less to time-limited competency end points.(174)

Planning of learning needs to support the development of skills through a process that stages acquisition linked to increasing authenticity.(101) It should be realised that learning in the simulated environment is not an end in itself. It is unrealistic to expect that one or two episodes of teaching and learning using simulation are sufficient to produce competence or proficiency. Learners still need to apply their learning in the real world, under supervision, and to receive feedback so that their skills base may become consolidated, refined and adaptable. In terms of unintended learning, there may be the danger of abnormal risk-taking behaviours being adopted by learners if their simulated experience, which is risk and harm free, is not tempered with the need for them to recognise their own limitations and to call for senior help in difficult circumstances.

Some learners may form a comfort zone within the simulated environment and might retreat to this in the face of a challenging clinical workplace – ‘simulation-seeking behaviour’; these learners require encouragement and support to put the lessons from simulation into practice in the workplace, with suitable supervision and feedback, akin to Vygotsky’s ‘zone of proximal development’.(175)

The workplace may also be the source of contradictory practice and negative role modelling that causes dissonance for the learner, who needs to be prepared for this eventuality.

There is no doubt that there are significant costs associated with establishing simulation-based learning, whether this is in clinical skills facilities or simulation centres,(176) The costs relate not only to the technological aspects but also to the physical infrastructure, the personnel and the ongoing costs associated with a programme of this sort. This needs to be offset against the potential gain in terms of patient safety, potential reduced litigation and the satisfaction of a better-prepared healthcare workforce. However, it is important to ensure the most cost-effective approach is used for learning and to recognise that simulation may not always be appropriate.

**The Future of Simulation**

Simulation needs more supportive evidence, both in relation to its effectiveness and its efficiency in medical education (see Box 12.11). Simulation is resource intensive, both financially and in manpower costs,(176) and therefore has to justify its role both in terms of outcomes and deliverables. Despite an almost exponential boom in the simulation literature (see Figure 12.4), more robust studies are required that link educational theory with the demands of service, studies which demonstrate changes in workplace behaviour that impact on patient outcomes, occurring as a direct result of simulated interventions. More specifically, there is also a need for an explicit understanding of clinical thinking; rehearsal of decision-making processes through simulation may help to avoid errors and increase physician awareness,(192) but the most effective and efficient way of doing this has yet to be identified.

For the moment though, with an increasing professional and societal emphasis on patient safety, it looks like simulation is not only here to stay, but will become even bigger business over the next few years. Greater public accountability will require that doctors rehearse and practise their skills away from the bedside, consulting room or operating theatre before putting patients in the firing line. The challenge for simulation is to prove that it can make a difference.

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**BOX 12.10 How to: Enhance transferability**

- The role of the facilitator or tutor in a learning episode involving simulation is crucial in ensuring integration and transfer through a reflective action.
- Place the learning in context.
- Stage the simulation in a progressive and staged manner.
- A haptic component of a simulator in a simulated learning episode can add value to transfer of learning to context.
- The non-verbal skills of simulated patients, more than the content of their script, promote engagement with the learner. The resulting deep learning creates transferability potential.
- Recreation of the real clinical environment facilitates ‘suspension of disbelief’ and aids transfer of competence to performance.
- Structuring the learning to move from the specific to the general at the end of a learning session using simulation promotes transfer.
- Giving inexperienced learners specific relevant tasks in the workplace can reinforce learning in the simulated setting.
- Build a time into the learning session to encourage generalisability to the workplace.
- Feedback is crucial in enabling learners to generalise their learning for future practice.
- Ensure learning facilities using simulation are located close to or in the context of the workplace.
- Link the timing of the simulation to workplace experience.
There is an increasing literature regarding the use of simulation in medical education (see Figure 12.4), but most studies have been at the lower levels of Kirkpatrick’s evaluation hierarchy. Some research has looked beyond learner satisfaction and has reported on impact on learning. For example, analysis of performance data from virtual reality simulators has shown that simulator training is associated with a reduction in performance time and enhanced proficiency and, more importantly, that this gain transfers to the real world.

Simulation is increasingly being used to investigate performance-shaping behaviours, such as fatigue, or the introduction of new equipment, techniques and facilities for trial and rehearsal prior to being implemented in the workplace. The use of simulation may also improve cognitive ability, as suggested by Rogers et al. in a study of fourth-year medical students’ thinking and application of skills for managing critically ill patients, and similarly by Steadman et al. There have also been reports of simulators used to teach basic sciences with the aim of bridging the theory-practice gap.

That said, there are also several studies that indicate simulation’s lack of impact. In a recent systematic review, Issenberg et al. identified that although much of the primary literature was weak, certain features of hi-fidelity simulation were consistently reported as facilitating learning. These were:

- providing feedback
- allowing repetitive practice
- integrating within curriculum
- providing a range of difficulties
- being adaptable; allowing multiple learning strategies
- providing a range of clinical scenarios
- providing a safe, educationally supportive learning environment
- active learning based on individualised needs
- defining outcomes
- ensuring simulator validity as a realistic recreation of complex clinical situations.

References

50 Accreditation Council for Graduate Medical Education (1999) *ACGME Outcome Project.* Accreditation Council for Graduate Medical Education, Chicago, IL.
185 Rogers PL, Jacob H, Thomas EA et al. (2000) Medical students can learn the basic application, analytic, evaluative, and psychomotor skills of critical care medicine. Critical Care Medicine. 28: 550–4.