Chapter 3
Simulation

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3.1 Introduction

The starting point for this chapter is that simulation already occupies a central position in surgical education, both at undergraduate and postgraduate levels, and that this role seems certain to expand. The preeminence of craft within surgical practice means that simulation has traditionally played a more prominent role there than in other specialities.

Many of the other contributors to the book allude to simulation, and some (especially Chap. 8) consider selected aspects in great detail. This chapter takes a more philosophical perspective, highlighting some issues that are often overlooked during discussions of specific simulation approaches and challenging some assumptions that are implicit in current strategies.

First of all, it will outline the place of simulation in current surgical practice before going on to consider some more innovative applications. The discussion will focus on the use of physical simulation applied to surgical procedures, recognising but leaving aside for the moment other uses of simulation in healthcare education (such as the use of Simulated Patients to practise history taking). A detailed account of simulator and e-learning design is presented by Bello and Brenton in Chap. 8, highlighting potential synergies between these approaches. The current chapter does not address issues of e-learning.

To many people, simulation implies using inanimate models and mannequins for gaining procedural skills, offering a safe alternative to carrying out procedures on real patients. I will argue that although necessary, this aspect of simulation is not sufficient to satisfy the growing demand for alternatives to traditional clinical learning. As highlighted by other contributors to this book (see Chaps. 11–13),

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learning is a social activity which takes place within and alongside the highly complex processes of clinical care. From this perspective, simulation should recreate sociocultural practice rather than focusing exclusively on the acquisition of component skills.

This is not to belittle the value of simulation in practising procedural skills. Of course, such approaches are not new – generations of medical students have honed their skills by suturing blankets and giving injections into oranges. In recent years, a range of inanimate models and computers of varying levels of sophistication have emerged, allowing learners to practise a widening array of techniques. Indeed, dedicated 'skills centres' form an essential part of any contemporary medical school. In such centres, students can practise how to take blood, insert urinary catheters, set up intravenous infusions, and give injections. Benchtop models or 'part task trainers' offer deliberately simplified, decontextualised versions of clinical tasks, allowing learners to become familiar with techniques before trying to apply them to real patients (Issenberg et al. 2005/1; McGaghie et al. 2010). The key aim is to reduce the pressures of clinical practice as well as eliminating the potential for causing harm.

Yet, this view of simulation privileges inanimate models and a task-focused view of procedural skills. Although the case for acquainting novices with the basics of a new procedure in a safe setting is compelling, such an approach carries a number of assumptions. This chapter tests some of these assumptions, viewing simulation through a critical lens and attempting to tease out and examine key concepts. The aim is to scrutinise established practices, examining how they fit the needs of surgical education at postgraduate level. In the process, some controversial views will be advanced.

3.1.1 Simulation as a Mirror for Clinical Care

A widely held view is that surgical training should be based on the progressive acquisition of propositional and procedural knowledge and the mastery of operative skills, initially 'straightforward' but moving to increasing levels of difficulty. By simplifying these skills and stripping away the distractions of context, simulation (the argument goes) allows first things to be mastered first.

An alternative view, however, is that the most important aspect of any operation is not a surgeon's technique, but their ability to function effectively in a setting where members of a team share responsibility for the care of the patient undergoing surgery. In a sense, the operating theatre functions as an ecosystem, whose inhabitants function individually but in a profoundly interrelated way. The survival of the whole depends on the interlocking of its parts. From this perspective, communication, professionalism, and the ability to work collectively to solve problems are not extras to be added once technique has been mastered, but constitute the essential attributes of safe practice.

These elements of surgical practice are more complex, more subtle, and far harder to define than specific operative techniques. When working well, they are invisible, and it is only when things go wrong that they become evident. Yet, if simulation is to be effective, it must address these complexities and render them visible.

A more satisfactory conception of simulation might therefore be as part of a spectrum of resources drawn up alongside clinical care in order to complement its richness. Acknowledging that learning must be rooted in the complex and unruly world of actual care, a menu of additional resources (including e-learning and simulation) provides additional support to be used selectively when needed. Bello and Brenton develop the concept of the Simulation Journey in Chap. 8.

3.1.2 Drivers for Simulation

Chapter 1 highlighted some key drivers that are changing the landscape of clinical care. From a surgical perspective, these include reductions in working hours, dwindling opportunities for hands-on experience in the operating theatre, a changing ethical climate, and an unstoppable rise in the role played by technology in surgical care. Dwindling opportunities for clinical exposure are affecting undergraduate and postgraduate education alike, and there is growing concern that clinicians will not have gained adequate experience by the time they complete their training. Simulation offers an attractive solution. Until relatively recently, however, simulation was regarded as the province of a minority of enthusiasts – of clear benefit in specific settings (such as resuscitation and anaesthesia training), but peripheral to mainstream training.

Simulation has a particular resonance in the case of surgeons, as it seems ideally suited to their particular needs. In particular, it appears to allow them to master their operative craft through repeated practice without endangering patients. Current developments in health policy are throwing simulation into even sharper focus and profoundly altering its position on the stage. The Chief Medical Officer's 2009 report (CMO 2009) highlighted the centrality of simulation within healthcare training of a multiprofessional workforce. More recently, the Temple Report has identified simulation as a key plank in addressing the challenges of providing effective education within a limited working week (Temple 2010). Implicit in these reports is a need to make simulation-based education widely available – yet it is not obvious how this might be achieved, especially within increasing resource constraints.

On closer inspection, moreover, fault lines appear in this apparently self-evident view of simulation's benefits. In spite of a growing acceptance in many quarters of simulation's key role, there remains confusion about exactly what simulation is and how best to use it. In the current financial climate, established approaches to so-called 'immersive' simulation (focusing on a small number of extremely expensive, resource-intensive specialised centres) seem unsustainable. And with the increasing prominence of simulation has come mistrust of its rise and resistance to what is sometimes perceived as its centralised imposition.

Even the word ‘simulation’ itself is not neutral, but carries many meanings and holds many resonances. Simulation activity, although widespread, frequently takes place without a clear definition or theoretical framework. To some, simulation is synonymous with simple benchtop models as described above. Others think of sophisticated mannequins and ‘drills’ for practising emergency procedures. To others again, Simulated Patients (professional actors) provide opportunities to explore subtleties of consultation dynamics and technique. Given this variety of meanings, it is not surprising that misunderstandings sometimes arise.

This chapter explores some of those meanings, attempting to set out such a framework for debate. It will distinguish between *simulation* (in the wider sense of a means of safely recreating elements of a complex clinical reality) and *simulators* (the use of models, mannequins, or computers for learning specific tasks) – a distinction also drawn by Bello and Brenton in Chap. 8. It will argue for simulation to be grounded in relevant theory, underpinned by a sound knowledge of education and related fields as well as a deep understanding of clinical care. Crucially, it will argue that simulation should address the conditions of clinical practice (with all its complexity, uncertainty, and contingency) rather than only focusing on selected components.

Elsewhere (Kneebone 2005), the author has brought together key theories relating to the acquisition and retention of expertise; ways in which knowledge and skill are learned and taught (proposing a Vygotskian conception of simulation as a resource within an individual’s Zone of Proximal Development) (Wertsch 1985); the relationship between formal teaching and the workplace-based communities of practice where such knowledge is applied (drawing on contemporary apprenticeship theory); and the affective or emotional climate of learning and teaching. Such an overview must now be extended to take into account societal changes such as the widespread adoption of social networking and the impact of Web 2.0 technology on e-learning.

3.2 What is Simulation About?

This chapter asserts that simulation, if is to be meaningful, must reflect clinical practice, and that this involves far more than dexterity or technique. At the heart of any clinical encounter stand two people: a patient and a clinician, linked in a relationship of care. Such care consists of many elements, sometimes (though not always) including invasive procedures or operations. But always the anchor is a personal relationship, one which develops and unfolds within the complexity and unpredictability of people’s lives. In real-world clinical care, there is a sense of uniqueness, of contingency, and of ‘unruliness’. No person is exactly like another, and everyone brings to a clinical encounter their own history and experience as well as their body. Working with this complexity is an essential part of becoming a clinician. The application of knowledge and skills in the context of individual care is a key element of effective practice.

Box 3.1: Limitations of Simulation

Alongside the benefits of simulation centres mentioned above, key limitations include the following:

- The primary relationship is between a learner and a machine/model, rather than between two human beings (a clinician and a patient).
- Skills are learned within the confines of a dedicated simulation centre, where the primary activity is seen to be simulation rather than clinical care and where a clinical context is absent.
- The horizon of learning is confined to component tasks, often without a sense of progression or an awareness of the wider context of team work and communication. Skills acquired in a simulation centre are treated as snapshots rather than building a progressive trajectory of clinical expertise.
- Simulation centre activity often carries a sense of imposition and of external control which may generate resistance and impede widespread acceptance. Simulation centres can be driven by agendas (such as the need to achieve throughput targets and ensure financial viability) that do not mesh with the expectations of learners.
- Simulation centres may carry connotations of assessment, kindling memories of summative examinations and being placed under scrutiny. An undue focus on reliability can detract from validity.

The argument for acquiring and refining clinical skills in a simulated environment before using them in real life is compelling. But in order to make sense educationally, such learning needs to resonate with the conditions of clinical care. At present, a narrow definition of simulation seems widely prevalent. According to this view, simulation offers a way of practising individual tasks and procedural skills, as outlined above. Simulators are seen as central to this activity and range from simple benchtop models to sophisticated mannequins and virtual reality computer programs.

This primacy of simulators immediately raises the important issue of authenticity. Of course, there are obvious benefits in mastering the essential constituents of a clinical task before trying to apply it to a real patient. It clearly makes no sense to attempt a procedure without understanding the equipment which must be used to perform it or the aims that it must achieve. But frequently within task-based simulation there is a lack of realism, a sense that the simulation is taking place in a separate universe that is somehow disconnected from the real world. This disconnection is accentuated by the fact that simulation activity commonly takes place within dedicated facilities or simulation centres, as described above. Box 3.1 outlines some limitations of current approaches to simulation.

By their nature, simulation centres do not deal with real patients. Instead, they deal with representations of patients (usually inanimate models or computers) which allow clinicians to 'do things;' that is, to invade without the normal consequences of invasion. Simulation centres provide a space within which such invasion can be practised in safety, using inanimate simulators as proxies for real patients.

The core relationship is therefore between a person (the learner) and an object or machine (the simulator). But a machine, however sophisticated, must remain a machine. The human-machine relationship will always be qualitatively different from the relationship between two people. Increasing the complexity and sophistication of the machine will not address this fundamental limitation. Paradoxically, indeed, efforts to increase the sophistication of a mannequin may result in a *reduction* in perceived realism. Highlighting the physicality of the simulator may interfere with participants' internal imaginative processes, forcing the artificial nature of the encounter into the foreground. This is especially evident in surgical procedures, where simulator representations of tissues and organs are seldom sufficiently realistic to overcome a natural disbelief.

The lens of critical discourse analysis is helpful here (Hodges et al. 2008). The context and environment described above might be summarised as a *discourse of the simulation centre*. This discourse frames simulation itself as the primary activity, and highlights the benefits of abstracted, depersonalised training. The vocabulary of the simulation centre includes words such as assessment, reliability, validation, and other terminology that can seem alien to clinicians whose primary aim is to learn. Within this discourse, a powerful voice is that of simulator developers. Often rooted in engineering and software design, such developers may lack understanding of the clinical issues within which learning is embedded.

The term 'discourse of the simulation centre' is not used in a pejorative sense in this chapter. On the contrary, abstraction of the kind which simulation centres provide offers immense power and great benefit. But a conflation of ideas around simulation has muddied the waters of debate. This chapter proposes that another discourse must underpin that of the simulation centre – a *discourse of clinical care*. These discourses are often divided from one another, and the relationship between them is problematic. A major challenge for simulation is to reconcile the two discourses while preserving the essentials of both.

3.3 Conceptualising Simulation

There is an obvious tension here. In one sense, too much abstraction can lead to a lack of realism and authenticity. Yet, surgical operations have characteristics which surgeons are required to master, irrespective of the patients upon whom the operations are performed. An appendicetomy is definable as a procedure, without having to be linked to an individual who undergoes it. Moving beyond the care of one individual person to gain widely applicable knowledge and skill therefore demands a simplification, a reduction, a boiling down – in other words, a *representation* of care which moves away from the particularity of an individual patient. So, how can this circle be squared, ensuring that abstracted knowledge and skill are always placed at the service of real-world clinical care?

It is worth trying to elucidate the relationship between the real world of clinical care and the world of simulation a little further. In his recent book *The Master and his Emissary: the divided brain and the making of the Western world*, McGilchrist offers an interesting viewpoint that may help to crystallise the issue (McGilchrist 2009). McGilchrist takes the title of his book from a story by Nietsche of a powerful ruler who dispatches an emissary to distant parts, entrusting him with powers to rule on his behalf. The emissary gradually takes over the functions of the ruler himself, with disastrous consequences for both. McGilchrist uses this as a metaphor for the relationship between the cerebral hemispheres.

> There are two fundamentally opposed realities, two different modes of experience; each of is ultimate importance in bringing about the recognisably human world; and their difference is rooted in the bihemispheric structure of the brain (p. 3).

Although not writing with simulation in mind, he argues that a central difference in the functioning of the two hemispheres underlies two different yet complementary views of the world which, if out of balance, create major problems. McGilchrist proposes that the world of the left hemisphere depends on abstraction and the ability to manipulate things out of context. This provides great analytical power, but is ultimately lifeless and self-referential. The world of the right hemisphere, on the other hand, is the messy and unpredictable world of real life – unimaginably complex and impossible to tie down or precisely define, but the only mediator of directly lived experience.

Drawing extensively on evidence from psychiatry and the neurosciences, McGilchrist describes a *reverberative* relationship between the two hemispheres. The left hemisphere selects, abstracts, and generalises from what the right hemisphere feeds it – but must then return what it has processed to be subsumed by the right hemisphere. Both these realities are critically important, but they must be interwoven. Undue dominance of either leads to a destructive imbalance. But this crucial final stage of synthesis does not occur when the left hemisphere holds sway.

The concept of an emissary who arrogates to himself the wider functions which he should serve offers a cautionary tale for the relationship between the simulated and the real. Without wishing to overstretch the argument, McGilchrist's view offers a helpful metaphor for the relationship between clinical reality and simulation, highlighting the crucial importance of reintegration. The touchstone must be actual clinical care, with all its individuality and unruliness (a right hemisphere world). To achieve the educational objectives of institutions and society (such as learning, assessment, or certification), this reality must be counterbalanced by abstraction into a setting where variables can be controlled, safety ensured, and performance measured (a left hemisphere world). To remain effective, the outcomes of this left hemisphere process must be fed back directly into the everyday world of care (Kneebone et al. 2004).

The reverberative process can work in two ways. If well adjusted and mutually respectful, abstraction works in the service of care. The learning of those aspects which lend themselves to abstraction is temporarily brought into a brightly-lit world where edges are hard and there are few shadows. Specific elements can be practised and assessed. But these activities must remain part of a bigger picture; soon they are ‘returned’ to their natural setting where the lights are dimmer and the shadows begin to emerge.

If ill-adjusted, however, the circle can become vicious. Approaches which are appropriate in the simulation centre do not always transfer to real people. If decontextualised simulation becomes the dominant discourse, learners’ *clinical* behaviour can be moulded by the world of impersonal abstraction and the tail wags the dog. Procedures (rather than the patients who need them) can become ascendant, and the technical can come to dominate the human. If that happens, clinicians may start to treat real patients as ‘procedures’ (‘the appendix in Bed 3’).

According to this view, the key issue is the relationship between the clinical and the simulated. If the two worlds are aligned effectively, each enriches the other. If the alignment fails, the activities of the simulation centre do not mesh with the everyday world of work in which clinicians are immersed and simulation becomes detached from its roots (Bligh and Bleakley 2006). How then can we frame simulation so that it meets these demands for alignment? In Chap. 8, Bello and Brenton develop the concept of a ‘simulation continuum’, where a wide range of simulations, simulators, and e-learning resources support each learner’s trajectory as it unfolds.

3.4 Authenticity, Expertise, and Dexterity

A key issue here is the extent to which simulation can capture real world practice. Writing in 1993, Grant Wiggins wrote:

> If we want competent performance later, we need to introduce novices to that performance from day one. Only a deep and ancient prejudice about academic learning keeps us thinking that intellectual competence is achieved by accretion of knowledge and movement through simple logical elements to the complex whole – instead of movement from a *crude* grasp of the whole to a *sophisticated* grasp of the whole (Wiggins 1993b) p. 202.

But intellectual competence is only one component of surgery. Amongst many others, dexterity skills are central to the surgeon’s craft (Sennett 2008). It is clear from the extensive literature on expertise that such mastery requires many years of sustained deliberate practice (Ericsson chapter & refs) (Ericsson 2004; Ericsson et al. 2006, 2007; Ericsson and Charness 1994; Guest et al. 2001) – a case made by Ericsson himself in Chap. 7. In the case of surgical procedures, the acquisition of technical mastery requires repeated practice, allowing fundamental skills to become part of the surgeon’s unconscious repertoire. From there, they can be called into play whenever needed. Many such techniques, especially at an early stage of training, lend themselves well to simulation-based practice. In both open and minimal access surgery, basic skills of handling instruments, tying knots, dissecting tissues, and performing anastomoses can be effectively practised in a simulation centre setting.

Yet craft skills are always applied within a specific context, where each work is unique and outcomes cannot be guaranteed. Pye distinguishes between the workmanship of certainty and the workmanship of risk (Pye 1968). The former implies a factory-like process, where the result is predetermined and unalterable once production begins. In the latter, however, the quality of the result is not predetermined, but depends on the judgement, dexterity, and care which the maker exercises during the process of making. In the case of a surgeon, this workmanship of risk requires an interplay between human tissues and manipulative skill in a setting whose complexity defies predictability (Heidegger 1968). This need to adapt, to respond appropriately to the unexpected, becomes especially evident in complex operations on sick patients.

But dexterity is not only an indispensable attribute of surgeons for the obvious reason of being able to perform operations safely. It is also crucial to the formation of a surgeon's identity *as a surgeon*, to the kind of professional they are or want to become. To surgeons, deftness and precision are not just desirable skills to have, but are central to who they are.

At first glance, simulation centres seem ideally suited to support the acquisition of expertise, as they allow component skills to be performed as often as required. Yet, as outlined above, surgical expertise is not confined to procedural dexterity. Indeed, there is far more to surgery and being a surgeon than what takes place in the operating theatre. A surgical patient's trajectory encompasses many elements, including preoperative diagnosis, the operation itself, the postoperative phase, and preparation for discharge. Every stage requires an amalgam of complex and highly demanding professional qualities and skills, including communication, leadership, decision making, and team work, as well as the obvious need for technical mastery.

The concept of routine and adaptive expertise is useful here, and is explored further by Epstein and Moulton in Chap. 10 (Bereiter 2002; Bereiter and Scardamalia 1993; Mylopoulos and Regehr 2007). Routine experts become highly proficient in dealing with similar tasks repeatedly. Although this is very effective when all goes well, such experts tend to frame unexpected problems according to solutions they have already determined. Adaptive experts, on the other hand, generate new solutions for every situation, deliberately challenging themselves by working outside their comfort zone. Each type of expertise is valuable, and both are required within surgical practice. If successful, simulation can provide the conditions for acquiring both – for acquiring that 'sophisticated grasp of the whole' which allows a range of integrated qualities to be tested within conditions of uncertainty (Wiggins 1993a).

Rather than defining an individual's expertise as falling into one category or another, it may be more helpful to think in terms of *dimensions* of expertise, which everyone possesses to a greater or lesser extent. From this perspective, the challenge becomes how to recognise and apply the most appropriate dimension in a given set of circumstances. Simulation has much to offer here.

3.4.1 Risk and Safety

A key requirement of clinical care is to ensure the safety of patients. In surgery, this concern is especially well founded. The dangers of operative surgery are plainly evident, and a botched operation causes immediate damage. At an obvious level, simulation centres offer insulation from harm, ensuring that even novices can practise without jeopardising patients.

Yet, here again, the case is not as simple as it first appears. It is an inescapable reality that surgery involves risk, and that part of surgeon's role is managing that risk responsibly. This involves learning how to recognise and deal with dangerous clinical situations, functioning as an effective team member under conditions of uncertainty, and coming to terms with the consequences of error. For a surgeon, encountering the unexpected or making a mistake can generate high levels of stress which in turn can affect judgement, performance, and effective communication.

If simulation is to be effective, it must somehow allow learners to 'experience danger safely' – not provide a setting where all semblance of danger has been stripped out. Unless this can be achieved, simulation will only offer a pale representation of the real world. Worse, it may encourage complacency and a misplaced overconfidence. This resonates with Meyer and Land's identification of *uncertainty* as a threshold concept within surgery (Chap. 6) – the need for continual reading and reframing of a situation as it develops.

3.5 New Directions for Simulation

Simulation offers the opportunity to abstract from a complex reality, to generalise from the particular, and to create conditions for repeated practice which minimise any potential for harm. Yet, common themes running through the arguments outlined above are complexity, nonlinearity, and the need to 'think clinically'. It follows that any simulation should recreate these conditions of clinical practice, helping learners to think like clinicians (not technicians) while preserving the centrality of the relationship of care. This is a tall order.

3.5.1 Placing the Patient at the Centre

When practising a procedural skill on an isolated benchtop model in a simulation centre or skills lab, it is extremely difficult to 'imagine oneself into' the clinical situation which this exercise represents. Partly, this is due to a lack of contextual cues – simulation centres seldom recreate the conditions of clinical practice in a way which appears convincing. But largely this is caused by the absence of a human patient. This absence places an inanimate model at the centre of the learner's focus.

Work by our group has developed the concept of hybrid or patient-focused simulation, where a simulator (usually a benchtop model) is attached to or aligned with a real person (usually a Simulated Patient or professional actor) (Kneebone 2009a; Kneebone et al. 2002, 2003, 2005, 2006, 2007). This brings about a powerful shift in perception, compelling the learner to relate to the patient as a human being at the same time as performing the procedure. By having to respond to the 'patient's' questions during a procedure, for example, the clinician has to bring into play a wide range of key skills and behaviours. This concept is described further by Nestel and Bentley in Chap. 9.

Initial work aligning existing models with Simulated Patients (SPs) was technically crude, though it provided surprisingly high levels of perceived realism and engagement. Yet there are obvious limitations to scenario design if models have to be contrived so as to conceal a join. Current work within our group is using prosthetics expertise from film and television to create 'seamless simulation' – highly realistic yet relatively low-cost models which are attached to a person in such a way that the join cannot be seen. Preliminary studies have demonstrated very high levels of engagement by participants and we are currently exploring this concept systematically.

3.5.2 Heightening Realism for Surgeons

A particular issue with surgical simulation is that current models and programs are seldom convincing enough to overcome the scepticism of participants. This is especially the case with experienced surgeons, who have already mastered the preliminary stages of technique and whose challenges have moved to a different level.

Historically, immersive simulation has been spearheaded by anaesthetists, for whom simulation-based crisis training has become an integral component of learning (Gaba et al. 2001, 1998/7; Gaba 2004; Gaba and DeAnda 1988; Holzman et al. 1995/12). For anaesthetic teams, the anaesthetic machine acts as a crucial mediator between the world of the patient and the world of the clinician (Goodwin 2008; Hindmarsh and Pilnick 2002, 2007). This is especially the case in scenarios involving a general anaesthetic, where many of the characteristics of authentic practice (including physiological monitoring and the administration of drugs) can be convincingly recreated by means of such a machine, in the absence of a real patient. In a sense, communication with the anaesthesised patient takes place 'through the machine', reflecting pathophysiological responses generated by a mannequin.

For the surgeon, however, the picture looks very different. As outlined above, dexterity and operative skill are key to a surgeon's professional identity. Crucially, these involve interacting with human tissue. Although effective team work is indispensable, the ability to 'do' the operation is a primary focus. Indeed, the operating theatre is designed so surgeons can give their undivided attention to what they are looking at, without having to raise their eyes from the brightly lit operative field. The special social practices of surgery allow the surgeon to demand an instrument and expect it to be placed in his/her hand immediately, bypassing completely the usual conventions of eye contact and polite phraseology (see Chap. 10).

If the surgeon's primary focus is the operative field, any simulation which does not recreate that field realistically will impose considerable demands in terms of willing suspension of disbelief. Yet, most current surgical simulators are strikingly unrealistic, both in appearance and behaviour. Inanimate models are insufficiently subtle to recreate the nuances of human tissue, while dead animal parts cannot recreate the characteristics of living organs. Crucially, perhaps, bleeding is usually absent and anatomical variation is seldom seen. Although in some countries, live animals are used for surgical training, in many parts of the world (including the UK) this is not possible. All too often, therefore, the impact of simulation is of a predetermined, formulaic exercise which is more realistic for other team members than for the surgeons themselves and which fails to capture the uniqueness of individual operations.

3.5.3 Creating an Effective Simulation

A central question is therefore *what* should be simulated and what level of detail is required in order to provide authenticity and to secure engagement. In many simulation centres (especially those catering to postgraduate surgical training), much attention is paid to the replication of a whole environment such as an operating theatre or intensive care unit. As many elements as possible of the original setting are provided, including operating lights and tables, anaesthetic machines and storage facilities. Such simulations allow clinical teams to take part in scenarios based around common or important clinical situations.

Yet, the central issue concerns function rather than structure. What must be recreated for the clinician is a sense of being involved in an operation. The challenge is to ensure that simulation *works* at the appropriate levels. From this perspective, simulation is more like a painting than a photograph, recreating those elements which are functionally most important rather than attempting to replicate every detail. In fact, attention is not uniform and unselective – clinicians see most clearly what is most important to them, and the rest becomes blurred. And where this focus is directed will depend on the clinician's specialty.

Elsewhere, the author has used an image of concentric 'circles of focus' to describe a gradient of perceived realism (Kneebone 2010). Applying this model to the surgeon, the primary focus of attention in the operating theatre is the operative field. In this central circle, every detail is of interest and importance. Around this is another circle – the setting within which the operation is taking place. Although this too is crucial, what takes place here registers at a lower level of awareness. This circle relates to *context* – the setting where the operation occurs and the people who take part in it. Within this second circle, a general sense of being in an operating theatre is supported by a complex combination of sights, sounds, and sensations – the noises of the monitor and the buzz of muted conversation; an awareness of the anaesthetic machine and the team around it; the bright light overhead; and the sensation of being gowned and gloved. Because the surgeon is focusing so intently on the primary circle, however, events and objects in this second circle are less distinct. This blurring is both physical and metaphorical. Components of this circle register at a less conscious level – some elements indeed are only noticeable if they are not there.

These two circles are embedded within a third – the wider picture of the clinical scenario that is unfolding, the tapestry of events from which the operation is constituted. Anaesthetic decisions are made, drugs are fetched and administered, instruments are requested – and sometimes problems arise and stressors are introduced. But again, this activity takes place outside the surgeon's primary focus.

If this model of circles of focus has authenticity, then, it can form the basis for a different approach to simulation design. Instead of simple *replication* of an operating theatre, the process becomes one of active *recreation*. And at the heart of this lies *selective abstraction*, the identification of what are the crucial elements required for belief in a simulation as a mirror of reality. In this way, resources can be employed selectively, achieving the greatest realism at the lowest cost.

3.5.4 Widening Access to Simulation Centre Facilities

Providing and maintaining dedicated simulation environments on a wide scale are costly, resource intensive, and probably unaffordable in the current financial climate. Largely because of their cost and scarcity, such centres are only available to a limited number of potential users. How then might immersive simulation be made widely accessible? One possibility is the concept of 'in situ simulation' – where simulators and simulated scenarios are taken to actual clinical settings (Allan et al. 2010; LeBlanc 2008; Rall et al. 2008; Weinstock et al. 2005, 2009). Although this approach offers obvious attractions and is gaining ground, the practical difficulties of aligning such simulations with service demands have led us to explore other avenues.

The selective approach outlined above has practical implications for simulation design and for addressing the challenges of making effective simulation available on a wide scale in austere times. We have developed the concept of *Distributed Simulation (DS)* (Kneebone et al. 2010). The underlying philosophy of DS is to provide simulation facilities that are 'good enough' to engage participants and achieve learning goals, yet are low cost, portable, and able to be erected in a variety of clinical or nonclinical locations. Using the principles outlined above, only salient features are selected and recreated.

Engagement within the first circle is achieved by creating realistic prosthetic models of human tissue, drawing advanced techniques from film and television.

The aim is to minimise the need for 'imaginative work' on the part of surgeons by creating tissues that look and feel as real as possible. In order to develop the DS framework for the outer circles of focus, a team of industrial engineers was given the brief of identifying and recreating key triggers for perceived realism from the surgeon's perspective. During an extended period of observation in actual operating theatres and in-depth discussions with surgical teams, the engineers (who had no previous exposure to clinical settings) selected key components which constitute a surgical setting (e.g., operating lamp; ambient sounds; monitor beep; anaesthetic machine; and equipment trolleys).

The first function was to establish a physical boundary. Drawing on terminology from theatre studies, we framed simulated clinical activity as taking place within a conceptual enclosure (a 'space'), which is independent of its actual geographical location (the 'place') (Balme 2008; McAuley 2000). In order to function effectively, this space must be delimited from its surroundings, so that those within it can perform without distraction from the world outside – as they would within the walls of a real operating theatre, where access is restricted and authorisation required. DS provides a portable simulation space which can be quickly erected in any available location, using an inflatable circular 'igloo' to 'shut out' external surroundings. This creates an 'impression' of a clinical environment which can then be populated by a variety of scenarios, people, and 'props', depending on specific need.

Next, this delimited space is furnished with simplified representations of equipment, for example, a lightweight, tripod-mounted operating lamp constructed from moulded plastic, and a life-size photograph of an anesthetic machine. Preliminary studies with surgeons confirmed our belief that equipment and activity beyond the first circle was perceived as real, even when represented by low-cost models and pictorial representations. Feasibility and validation studies have confirmed that the concept has potential, and further studies are in progress.

The creation of a convincing environment for simulated care, although necessary, is not a sufficient condition for authentic simulation. The next requirement is to provide *experiences* that reflect clinical practice, and allow educational goals and outcomes to be achieved. The construction of simulations (scenarios) must of course be based on actual clinical experience. As discussed above, this requires the relationship of care between patient and clinician to be established. But again, this is a process of recreation rather than replication – although in this case a functional rather than a structural recreation. Here, the process of selective abstraction results in a dynamic 'performance'. If successful, the means by which this performance is achieved will fall out of conscious awareness, and participants will experience it 'as if' it were the real thing (Dieckmann et al. 2007).

Current work is widening the focus to anaesthetists, using a similar approach to develop apt simulations which can recreate the key elements of the anesthetist's practice, while the theatre nurse's perspective forms another essential component of this complex picture.

3.5.5 Rehearsal

Much of the above discussion has focused on mirroring clinical performance, using simulation as a means of practising component skills. Yet, performance is more than the sum of component parts.

There are interesting parallels between instrumental musicians and surgeons, both of whom display high levels of dexterity within a complex matrix of other skills (Kneebone 2009b; Lehmann et al. 2007; Parncutt and McPherson 2002; Williamon 2004). Both professions require *performance* – an operation in the case of surgeons, a public performance in the case of musicians. Both professions rely on *practice* – in simulation centres in the case of surgeons, in solitary practice rooms in the case of musicians (Chaffin et al. 2002). But musicians – especially those playing in small ensembles – include an intermediate stage of *rehearsal*. Here, they come together as a group, having perfected their parts as individuals, to put together what they have learned. During rehearsal, they negotiate a shared interpretation of the piece, discuss issues of speed and timing, and work on how they want the music to sound before committing themselves in front of the public where there is no going back. The crucial elements appear to be the *context* of rehearsal (approaching it as if it were performance) and working with the *people* who will perform.

For surgeons, however, rehearsal is still relatively rare. Of course it is true that surgeons build up extensive experience through operating, but this does not provide the combination of safety and realism which rehearsal implies. In some centres, VR computer programs allow surgeons to 'run through' demanding minimal access procedures before the actual operation, using that patient's imaging data to recreate the conditions of surgery. But most surgical learning still takes place within performance, supplemented by increasing reliance on task-based practice in simulation centres. Newer concepts of contextualised simulation therefore offer opportunities for surgeons at all levels systematically to rehearse what they have practised before operating on a real patient.

3.6 Where Next?

It is tempting to speculate what the future may hold for simulation within surgery. In this chapter, some examples from the author's own research have provided a lens for examining current approaches. However, such ideas are constantly in flux. Moreover as highlighted in Chap. 1, predictions are likely to be proved wrong within the cycle of a book's production. As with any fast moving field where technology plays a major part, any discussion about simulation is doomed to seem quaintly outdated by the time it comes to print.

Yet, we seem to be on the threshold of major changes in how simulation is viewed and used, especially in a climate of increasing financial constraint. The low cost, portable yet immersive simulation environments described above raise the possibility of widespread access to immersive simulation within any hospital or institution, without requiring investment in fixed facilities or dedicated staff. This could change current approaches to simulation-based education, allowing static centres to focus on the activities that require full-scale clinical environments (such as anaesthetic team training) while opening up new possibilities at a local level. In particular, such developments could allow a shift in focus from tasks to the environment, exploring the notion of a ‘surgical ecosystem’ as outlined above.

Seen from this perspective, simulation offers a means of making visible the shared ‘atmosphere’ within which surgery takes place and which is essential for safe practice. An understanding of how this atmosphere works, of what is required to sustain it, and of how to recognise and remedy early signs of dysfunction is probably one of the most important attributes of any member of the surgical team. Yet a hegemony of the technical threatens to overshadow these crucial attributes.

3.7 Conclusion

This chapter started by proposing that simulation is much more than simulators. To be effective, simulation must capture the essence of real-world practice, with all its complexity and variation. The chapter outlined a theoretical model for the mutually dependent relationship between the simulated and the real, proposing that each can immeasurably enrich the other when the balance is right. After highlighting some limitations of current simulation approaches, the argument puts forward a case for heightening authenticity by actively and selectively *recreating* the settings of clinical care rather than simply *replicating* them.

Simulation seems set to play a steadily increasing role in surgical education. It is therefore crucial to retain a critical stance to what simulation can and cannot offer, using the tools of educational research and analysis to illuminate this challenging, complex, and underresearched field. Building a robust evidence base, grounded in methodologies which are both rigorous and apt, will develop a theoretical infrastructure which is sorely needed but often missing.

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