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Simulation, safety and surgery

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ABSTRACT

Objectives This paper explores the place of simulation in contemporary healthcare education and training, highlighting the challenges of recreating complex clinical settings which can support the development of competent, rounded and caring practitioners, and address issues around human factors as well as technical skill. It frames the relationship between clinical and simulation-based practice as a mutually dependent, two-way process.

Discussion According to this view, simulation is less like a photograph of clinical care than a painting of it—a process that requires selection and interpretation. The paper presents simulation as a canvas on which to paint this picture. To be effective, simulation must mirror the essentials of a clinical setting without reproducing every detail. After highlighting key issues with current approaches to simulation, the paper considers how authenticity and perceived realism can be heightened through innovative uses of technology and design, putting forward a conceptual framework based on the notion of 'circles of focus.' The paper then outlines the concept of Distributed Simulation, using low-cost, portable yet immersive environments to address limitations of access to dedicated facilities.

Conclusion The paper concludes by considering theoretical and practical implications of these innovations, focussing especially on surgery and other craft specialties.

INTRODUCTION

This paper explores the place of simulation in contemporary healthcare education and training. It highlights the challenges of recreating complex clinical settings which can support the development of competent, rounded and caring practitioners and address issues around human factors as well as technical skill. It frames the relationship between clinical and simulation-based practice as a mutually dependent, two-way process.

According to this view, simulation is less like a photograph of clinical care than a painting of it—a process that requires selection and interpretation. The paper presents simulation as a canvas on which to paint this picture. To be effective, simulation must mirror the essentials of a clinical setting without reproducing every detail. The paper will consider some theoretical and practical implications of this proposition, focussing especially on surgery and other specialties which demand high levels of manipulative dexterity.

BACKGROUND

In recent years, the landscape of clinical care has undergone profound upheaval. Time-honoured ways of thinking and doing are being challenged by

widespread change, with new techniques for investigation, diagnosis and treatment emerging constantly. At the same time, the duration of training programmes is being drastically reduced, and work hours restrictions are bringing about fundamental organisational changes on both sides of the Atlantic. One obvious effect of shortened training is a curtailment of opportunities for clinical experience, especially as shift working rather than continuous care becomes the norm.

The professional climate is also changing radically. It is no longer ethically acceptable (if it ever was) for clinicians in training to learn 'on' patients. This reduction in clinical exposure (previously built upon a prolonged apprenticeship extending over many years) poses obvious challenges. Already there is widespread concern that doctors completing their specialist training in areas such as surgery and the interventional specialties may simply not gain the breadth of skill and experience to deal confidently with any clinical problem they may encounter.^{1 2}

At first sight, simulation offers attractive solutions to many of these issues. Practising on inanimate models in the safety of a skills centre, the argument goes, allows learners at all stages to gain component skills without endangering patients. This argument is especially compelling in the face of dwindling opportunities for clinical exposure, framing simulation as an alternative means of gaining experience. The case is bolstered by clear parallels with other safety-critical professions, such as aviation, where simulation-based training is accepted as an article of faith.³ Simulation therefore offers a proxy for those elements of education and training which are no longer available within a clinical setting.^{3 4}

This line of reasoning is powerful, and simulation has now moved to centre stage in many countries. The UK's Chief Medical Officer, for example, explicitly states that simulation will be of central importance in healthcare education, especially for surgery and related craft specialties.⁵ Yet, on closer examination, the picture is less clear than it first appears. What exactly are the benefits and limitations of simulation? What is the evidence that experience gained within simulation is transferable to the real world? What might be the drawbacks of an increasing reliance upon simulation-based education? And if simulation is as valuable as it seems, how can it be made available to all those who would benefit?

A key issue concerns risk.⁶ For many people, simulation equates safety with absence of risk. This reflects a growing climate within healthcare of aversion to risk generally, and a philosophy of risk-free training. In reality, however, all clinical care entails risk, and its effective management is key to

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becoming a mature clinician. Understanding the impact of risk or danger on clinical judgement and skill is a crucial element of becoming expert.⁷ Yet if risk is stripped away from training, clinicians may be ill-prepared when things go wrong with their patients. To be an effective proxy for clinical experience, therefore, simulation should recreate the sensations and perceptions of danger while still ensuring that patients are not jeopardised. Achieving this balance poses considerable challenges.

This paper will explore these issues and put forward possible solutions. In it, I will argue that simulation's major benefit is as an adjunct to clinical practice, that its value and relevance depend upon a close alignment with the clinical world, but that the world of simulation and the clinical world it purports to represent are frequently divided. To be effective, simulation should:

- ▶ recreate authentic conditions of the clinical work environment;
- ▶ reflect the relationship of care between patient and clinician;
- ▶ address the needs of individual learners;
- ▶ be perceived as locally owned;
- ▶ optimise the level of 'imaginative work' required for effective engagement;
- ▶ allow participants to develop expertise while experiencing danger safely;
- ▶ contribute to personal development and professional identity.

PROBLEMS WITH CURRENT SIMULATION

Two approaches to simulation are commonly encountered. The first addresses so-called 'simple' procedural skills such as wound closure, intravenous infusion and urinary catheterisation. Elsewhere, I have argued that simplicity is in fact a contestable concept, and that the determination of what is 'simple' lies in the hands of expert clinicians whose conception of simplicity may be quite different from a novice's.⁸ The experience of working on a model arm, for example, is qualitatively entirely different from performing a procedure on a living person. For a novice, performing this apparently straightforward procedure clinically may in fact be extremely challenging, especially in the context of a sick or demanding patient where a variety of complex skills must be integrated under pressure.

Especially in the early stages of learning, students commonly focus on technical aspects such as needle placement and knot tying, using isolated benchtop models which are widely available in many institutions. Yet such practice overlooks the crucial importance of context in applying any skill. To be effective, simulation must be aligned with the needs of each learner and their level of development. If a simulation is too simple and undemanding, it will be perceived as irrelevant and of little value. If too complex and taxing, it may either overwhelm learners and damage their confidence, or waste resources by providing unnecessary sophistication. Yet this dynamic of adjustment is difficult to achieve, especially when dealing with large numbers of participants with varying levels of experience.

At the other pole lie complex, high-fidelity and immersive simulations, allowing clinical teams to practise managing emergency situations. Simulation of this kind was pioneered by anaesthetists, achieving high levels of realism and value for anaesthetic teams and allowing a range of complex or uncommon conditions to be addressed. In such simulations, the responses of a patient under general anaesthetic are conveyed by a mannekin connected to an anaesthetic machine. Patients and their pathophysiological responses are 'represented' by traces on monitor screens and haemodynamic responses to drugs, creating a highly engaging experience.^{9–12}

For anaesthetic teams, such proxies for a real person closely approximate the conditions of actual practice and provide high levels of authenticity. For surgeons, however, the picture is different. Existing models simply do not recreate the look and feel of living human tissue with a similar level of convincingness; this presents a real problem in terms of willing suspension of disbelief and the amount of 'imaginative work' required of participants.

AUTHENTICITY

How can we ensure that simulation mirrors real life for surgeons? As long ago as 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.¹³

For Wiggins, the notion of authenticity is central. Authenticity is about replicating the diverse and rich contexts of performance, meeting 'an obligation to make the student experience [...] tasks under constraints as they typically and 'naturally' occur, with access to the tools that are usually available for solving such problems.'¹³ Wiggins offers key characteristics of authenticity as:

1. Engaging in worthy problems and questions of importance;
2. Faithfully representing contexts encountered in the field;
3. Addressing non-routine and multistage tasks;
4. Requiring the student to produce quality performance;
5. Providing concurrent feedback and allowing self-adjustment;
6. Requiring trained assessor judgement;
7. Searching for patterns of response in diverse settings.

Although initially framed in terms of intellectual competence, Wiggins' arguments hold especial force for specialties such as surgery, where craftsmanship and workmanship are key to clinicians' identity as well as to the outcomes of their work. Sennett, for example, refers to craftsmanship as 'an enduring, basic human impulse—the desire to do a job well for its own sake',¹⁴ while Pye distinguishes between the 'workmanship of risk' (where the quality of the result is uncertain during the process of making) and the 'workmanship of certainty' (where the quality of the result is exactly determined in advance, as with a factory-made object).¹⁵ Clinical practice clearly involves workmanship of risk, whose outcome is the product of a dynamic relationship between clinicians (skilled craftsmen, in Pye's terms), a living patient and a complex environment with multiple variables.

ACHIEVING REALISM

So, how can such authenticity be achieved within simulation? A central challenge is how to recreate the essence of real-life experience. Clinical practice is built upon the relationship between two people—a patient and a clinician. The complexity, richness, uniqueness and challenge of clinical care depend on this human connection. And making sense of this complexity lies at the heart of being a clinician. If simulation is to engage with this complexity, it must somehow mirror the unruliness of real life—it must allow Wiggins' progression 'from a crude grasp of the whole to a sophisticated grasp of the whole'.¹³

A crucial distinction is between simulations (recreating a whole clinical event) and simulators (physical models, mannekins or computer programs). Often, both in simple and in

complex simulations, a simulator is the focal point of the experience. In this case, the primary relationship lies between a person (the learner) and a machine (the simulator). However sophisticated the machine, it remains a machine. This imposes inescapable constraints on authenticity.

HYBRID SIMULATION

So, how can this central relationship between two people (rather than between a person and a machine) be provided within simulation? A logical starting-point is to place a real person within the simulation. Of course Simulated/Standardised Patients (SPs) have been central to healthcare education for decades, especially when addressing consultation and history-taking skills. In such scenarios, trained actors play the role of patient. Until recently, however, invasive procedures were treated in a different fashion, placing inanimate models at the focus.

Work by our group has pioneered the concept of hybrid simulation, where inanimate models are aligned with SPs playing patient roles to create a setting which requires an integrated approach. Participants have to interact with the patient as they perform a procedure, avoiding any split between so-called technical and non-technical skills. This recreates the integrated nature of clinical care, where such splits are both artificial and unhelpful.^{8 16–21}

Our initial work aligned SPs with existing models, covering the joint with a drape (figure 1). Although technically crude, this 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 models which are attached to a person in such a way that the join cannot be seen (figure 2). Preliminary studies have demonstrated extremely high levels of engagement by participants, and further work is exploring this concept systematically.

SEQUENTIAL SIMULATION

Simulation activity typically revolves around a single encounter or episode of care. Yet, actual practice is a continuum. In surgery, for example, an evolving relationship is built up, which extends from outpatient referral, discussion of management options, preoperative assessment, the operation itself and postoperative recovery, to discharge into the community.

Within our group, the concept of sequential simulation aims to recreate this longitudinal aspect of care by sampling ‘frames’ from a patient’s trajectory. In the case of surgery, this might include a preoperative encounter between surgeon and patient (exploring options and gaining consent), an operation under general anaesthetic, and postoperative assessment and detection of complications.



Figure 1 Hybrid simulation using strap-on suture pad. (Posed by a model).



Figure 2 Hybrid simulation using seamless prosthetic wound.

Some, but not necessarily all, of these elements would involve a human ‘patient.’ During the operative phase, for instance, the anaesthetised patient might be represented by an inanimate model. At present, realistic models for operative surgery are conspicuous by their absence. Extension of our work with prosthetics is leading to custom made models aimed at surgeons and their immediate teams (figure 3).

WIDENING ACCESS

Most current immersive simulation relies upon dedicated static facilities which are scarce, expensive and resource-intensive, and which lie beyond the reach of many clinicians in training. In such centres, activities are driven by forces (such as ensuring sufficient throughput to survive financially) which may be out of alignment with the educational needs of those who attend. In consequence, there may be a built-in lack of responsiveness to individual learners and a mismatch with learning goals. This may result in a perception that simulation-based education is being imposed from without, rather than being ‘owned’ by participants themselves. The dominant agenda should therefore be clinical rather than organisational, framing simulation as a means of strengthening elements of clinical practice rather than functioning in a self-contained universe of its own.

If immersive simulation is to be of value, it should be available to all who need it. At present, however, immersive facilities are



Figure 3 Simulated laparotomy.

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restricted to a relatively small number of dedicated simulation centres, usually located in major cities. Such centres provide realistic, quasi-clinical settings which closely resemble real environments, while digital recording technology allows activities to be recorded and used for feedback and debriefing. In addition, specialised facilities such as control rooms and debriefing spaces allow activities that would not be possible in clinical practice.

Much attention is paid to the indiscriminate reproduction of a whole environment, ensuring that all components are provided. Such facilities commonly provide faithful reproductions of clinical environments (such as an operating theatre or ITU). As many elements as possible of the original setting are provided, including equipment such as operating lights and tables, anaesthetic machines and storage facilities. Based closely on real settings, these allow clinical teams to take part in scenarios based around common or important clinical situations.

Providing and maintaining such environments is costly and resource-intensive. Largely because of their cost and scarcity, such centres are only available to a limited number of potential users. How then might it be possible to retain the essence of immersive simulation, yet make it more accessible? An interesting alternative is 'in situ simulation,' where simulators and simulated scenarios are taken to actual clinical settings.^{22 23} Although this offers obvious attractions, the practical difficulties of aligning such simulations with service demands of the UK National Health Service have led us to explore other approaches.

DISTRIBUTED SIMULATION

We have developed the concept of Distributed Simulation (DS).²⁴ 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 non-clinical locations (figure 4). Instead of the faithful reproduction of an actual setting, only salient features are selected and recreated.

The first function of DS is to establish a boundary. To draw on terminology from theatre studies, simulated clinical activity occurs within a conceptual enclosure (a 'space') which is independent of its actual geographical location (the 'place').^{25 26} 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.

The concept underpinning DS is to separate space from place. A portable simulation space can be quickly erected in any available location, using an inflatable 'igloo' to provide a circular enclosure whose ambience provides an 'impression' of a clinical environment (figure 4). This can then be populated by a variety of scenarios, people and 'props,' depending on specific need. Having established a simulation 'space,' the next requirement is to determine what should take place within it and how this can be recreated as effectively as possible.

CIRCLES OF FOCUS

Attention is not uniform and unselective—clinicians see most clearly what is most important to them, and the rest becomes blurred. Where this focus is directed will depend on the clinician's specialty. An image of concentric 'circles of focus' is used to describe a gradient of perceived realism (figure 5). Applying this model to an operation, the surgeon's primary focus of attention is the operative field. In this central circle, every detail is of interest and importance. The clinical operating theatre environment is designed to support this heightened awareness—the field is brightly lit by multiple overhead lights which eliminate shadows; instruments are placed in the surgeon's hand by a member of the team without any need for distracting eye contact; every nuance of anatomy or drop of blood is sharply defined.

Around this central circle is another circle—the setting within which the operation is taking place. This too is crucial but takes place at a lower level of awareness. Here is the context of the procedure—the setting where it occurs and the people who take part in it. Within this second circle, a surgeon's 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 focussing 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.



Figure 4 Distributed Simulation showing inflatable operating theatre.

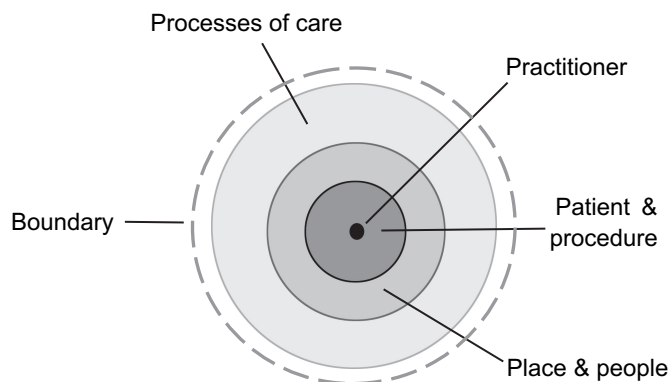


Figure 5 Circles of Focus.

REPRODUCTION, RECREATION AND SELECTIVE ABSTRACTION

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 reproduction of a operating theatre, the process becomes one of 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. Positioning these elements along a realism gradient becomes key to creating an effective simulation experience.

Paradoxically, however, the component that is of most interest to the surgeon—the operative field—is often the least realistically portrayed within current simulations. Models are crude and stylised; anatomical variation is absent; and tissues do not bleed. For the surgeon, therefore, the effort of believing in the simulation—the ‘imaginative work’ required—is unacceptably high. As described above, the introduction of prosthetics expertise promises radical changes, by creating models with high levels of perceived authenticity, in both look and feel.

In order to develop the DS framework, we gave a team of design engineers the task 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 (eg, operating lamp; ambient sounds; monitor beep; anaesthetic machine; equipment trolleys). Preliminary studies with surgeons confirmed our belief that equipment and activity beyond the first circle were perceived as real, even when represented by low-cost models and pictorial representations.

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 in 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 reproduction—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.²⁷ To return to my opening metaphor, they are seeing the painting itself rather than the canvas on which it is painted.

REHEARSAL

If we can create convincing simulated environments that allow authentic performance to be reproduced, how might we use these systematically in the service of clinical education? The concept of systematic rehearsal offers considerable potential, and there are analogies between surgical teams and ensemble musicians.²⁸

When starting to prepare for a public performance of an unfamiliar piece, musicians become proficient in their individual parts through solitary practice. Once they have mastered these parts, however, the players come together for rehearsal. This crucial stage allows them to work together in conditions that approximate those of the eventual performance. Here they reach a negotiated agreement of how they will perform as an ensemble, addressing issues of interpretation and integration as well as planning for possible mishaps on the night and ‘experiencing danger safely.’ By the time they come to the performance, where the piece must be played from beginning to end with no

opportunity for backtracking, the ensemble members are playing as a single unit.

In surgery, by contrast, most time is spent upon performance (the actual operation). Practice of component skills (in simulation and skills centres) is becoming increasingly evident. However, formal rehearsal is still conspicuously lacking. Part of the reason is that facilities for effective rehearsal are seldom available. By providing access to immersive yet low-cost simulation facilities, DS offers the potential for developing rehearsal as a key plank of healthcare education, allowing clinical teams to ‘experience danger safely’ and to build up a repertoire of authentic responses to complex clinical situations which will stand them and their patients in good stead (figure 6).

CONCLUSION

A simplistic perspective frames simulation as a means of gaining component skills (usually relating to invasive clinical procedures). A more nuanced view frames it differently—as a stepping stone to gaining mastery within a complex clinical world. This paper suggests how this might be achieved, exploring how a selective approach might allow high levels of immersion and perceived realism to be provided within the constraints of a resource-limited healthcare system. At the heart of this argument lies the relationship between clinical care and simulation.

Simulation should allow participants to behave not only as technicians but also as rounded clinicians, recreating the conditions of practice without imposing unnatural constraints. To achieve this, the artifice through which simulation’s illusions are achieved should fade into invisibility, leaving participants free to function authentically. To return to the metaphor of a painting, simulation should allow clinicians to see the picture, not just the canvas and the paint.

Considered in this way, simulation becomes not just an activity but a way of seeing, which can change how we perceive our clinical practice. Merleau-Ponty describes a parallel experience when looking at a painting:

I would be at great pains to say *where* is the painting I am looking at. For I do not look at it as I do at a thing: I do not fix it in its place... It is more accurate to say that I see *according to* it, or *with* it, than that I *see it* [my italics].²⁹

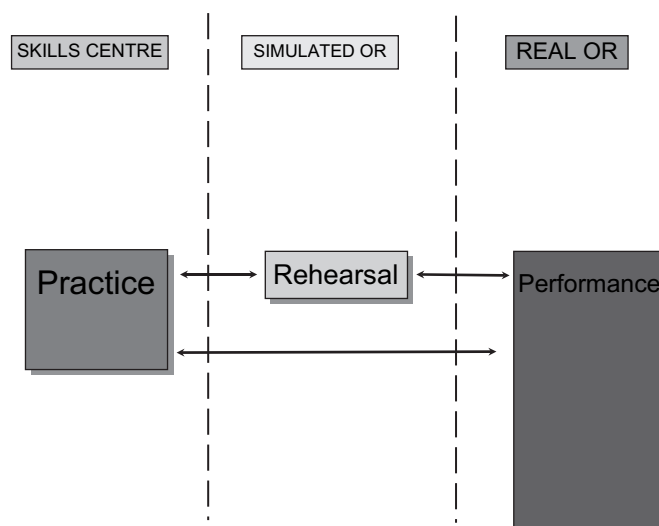


Figure 6 Three stage model for procedural training.

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Used imaginatively, simulation can serve a similar function, allowing us to see clinical practice according to what takes place in a simulated setting and vice versa. By using simulation as a lens for shaping our perception of clinical practice, rather than as an end in itself, we will ensure that caring for patients remains our primary concern.

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