A PRACTICAL GUIDE FOR MEDICAL TEACHERS

SIXTH EDITION

ELSEVIER

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A Practical Guide for Medical Teachers

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Learning in a Simulated Environment

Roger Kneebone, Debra Nestel and Fernando Bello

Trends

- Simulation is a means, not an end.
- Simulation must be authentic, reflecting and resonating at some level with the realities of the clinical world.
- Simulation does not need to be complex or expensive to be effective.
- Simulation technology will continue to advance rapidly, opening up further opportunities for education and training.
- Simulation can integrate 'communication' (simulated patients, clinical teams) with 'procedural' skills (technology).

Key concepts

- Simulated participants (patients) (SP): individuals trained to portray individuals in scenarios and to provide feedback to learners about their experience (Nestel & Bearman, 2015). Most commonly, the participants are in the role of patients.
- Hybrid simulation: a combination of simulation modalities to enable holistic practice of clinical skills (Kneebone et al., 2002), such as an SP aligned with a task trainer for performing a procedural skill.
- Simulation as design: a conceptual framework for simulation as design involves selection, abstraction, re-presentation and intensification (Kneebone, 2016).
- Hybrid simulators: a combination of a physical model with customized software and electronics/mechatronics, offering a range of interactive settings that support learning.

Introduction

Decades of debate about whether or not simulation 'works' have changed into discussions about how to embed and implement it. An initial preoccupation with high technology and a focus on anaesthesia and interventional specialties has broadened to include simulation at every level of clinical education. The question is no longer if we should use simulation, but how.

Yet confusion remains, and learning through simulation is often perceived as a specialized domain requiring dedicated facilities and complex equipment. Simulation is often framed as an end in itself, detaching technical procedures from their clinical context and presenting them as something that can be practised in isolation. Terms such as 'simulation centre' make simulation itself the focus, rather than addressing what is to be simulated and why. This historical association with expensive static facilities and high technology can mask the widespread usefulness of simulation at much simpler levels.

Unhelpful distinctions between 'technical' and 'nontechnical' skills compartmentalize educational practice (Murphy et al., 2019). This chapter resists such notions of separation, arguing instead for an integration of approaches and resources and asserting that simulation—like lectures, bedside teaching or any other educational approach—is a means rather than an end. Running alongside clinical practice, simulation offers a parallel resource to support learners as their clinical experience grows and develops.

Simulation can have a powerful impact on participants and requires specific considerations to ensure that this impact is positive, constructive and ethical (Park & Murphy, 2018).

Tip

Like other educational methods, simulation can support students in preparing them to learn in and from clinical practice.

This chapter is for the general medical reader rather than the simulation specialist. It sets out to give an accessible account of current developments and focuses on medical education rather than speciality training. Simulation, we argue, can happen anywhere—not just in simulation centres. A challenge is for clinicians and educators to take back control and democratize simulation, whether or not they have access to costly specialized facilities. We therefore start by going back to basics, asking what are the clinical and educational challenges to which simulation can offer solutions.

Background

We define simulation as a process where principles of design are used to integrate clinical care with education. The central focus is what takes place between two people—a clinician and a patient, or a teacher and a learner—held together in a relationship of care. Knowledge and skill must be applied within a context of trust, integrity and professionalism, and simulation must reflect this human relationship.

The acquisition of expertise requires sustained deliberate practice with the intention to improve, underpinned by feedback and critique in a supportive environment conducive to learning. The ability to pause, restart and replay a clinical encounter provides invaluable opportunities to apply educational principles to the clinical setting. It is also important for learners to experience failure, and to recognize when they are approaching (or crossing) the limits of their competence. Such ideals often conflict with the constraints and dangers of the clinical setting.

Simulation offers a solution to some of these challenges, identifying aspects of clinical care (with all the dangers and complexities which that implies) and transplanting those to a setting where the educational needs of learners are treated as prime and where no real patient can suffer harm.

Tip

Simulation offers learners the opportunity to rehearse elements of clinical care in patient-safe environments and to receive feedback intended to develop future practice.

We therefore argue that simulation is not an end in itself, but rather a means to support learning. In recent years, the emphasis has moved from practising so-called 'technical' skills on isolated models to a more comprehensive vision which encompasses the complex human context of unique individuals working together. This needs to take into account what educational theory can tell us about how people learn, especially under conditions of pressure and stress.

Earlier discussions centred on practical issues, such as the provision of simulators or the detailed recreation of clinical settings. The debate now is how to embed simulation most appropriately within the world of clinical practice, ensuring a proper balance between technicist and humanist perspectives. We cannot think of patients as depersonalized bodies and procedures as tasks performed according to a formula. Each encounter with a patient or colleague is unique.

This chapter challenges the notion that simulation requires costly static facilities. Developments such as 'in situ' simulation blur the edges between clinical care and education, by taking simulation into clinical settings. Our own developments of hybrid, distributed and sequential simulation (described later) offer further possibilities. More recently still, simulation has been used as a means of sharing the closed practices of healthcare with patients and those who care for them and with publics and society at large.

Simulation as design

Simulation can be thought of as a verb rather than a noun; an activity or method rather than a place or an array of physical simulators. Viewed as an activity, simulation is much more flexible than is commonly perceived and can be adapted, modified and shaped according to individual circumstances and needs. To do this, a conceptual framework is necessary. Framed as an active process, simulation involves the following elements (Kneebone, 2016):

- Selection from the complex world of what is to be examined, taught and learned. This requires dialogue between 'clinician,' 'educator' and 'patient' perspectives. For example, learning a bedside procedure (such as inserting a urinary catheter in a distressed elderly man with acute retention of urine following an operation) might be identified as a learning need.
- Abstraction of the selection, removing it from its original setting. This requires analysis of the key objectives in terms of clinician-patient interaction (including fine motor skills) and clinical learning. In the earlier example, inserting the catheter requires a combination of procedural skill (inserting the catheter accurately and safely) and interpersonal sensitivity (reassuring a distressed patient while working with a clinical colleague).
- Re-presentation of the abstracted selection. This provides the opportunity to carry out the task in question, performing the practical procedure on a model while engaging with the patient as a person. This may take place within a dedicated centre or in alternative venues, allowing selected aspects of clinical practice to be addressed within a safe yet realistic simulated setting. Such settings take the needs of clinicians, patients, learners and educators into account in designing apt environments for learning which balance challenge and support.
- Intensification is an outcome of this process. By stripping away what is inessential (such as distractions from other patients on a ward or other elements of real-world complexity), learners are freed up to focus on their individual learning needs at that moment.

Tip

A conceptual framework for designing simulations comprises selection, abstraction, re-presentation and intensification.

Simulated patients

This section outlines the pivotal role of simulated patients (SPs) in capturing the essence of clinical practice and implementing the 're-presentation' described earlier. At the core of healthcare practice is the communication between patients and healthcare professionals. Kneebone (2014) describes how this relationship of care is mediated by voice:

> *"[Voice]…is a complex concept that can be read in both literal and metaphorical terms. From this perspective, voice – extended to include facial expression, gesture, touch, even clinical interventions – is medicine's primary medium of connection. Making sense of voice involves the ability to transmit and receive simultaneously, continually modulating one in response to the other."*
>
> *Kneebone (2014)*

It is through this notion of voice that SPs make their contribution to medical and health professional education—as a proxy for real patients in this relationship of care.

Simulated patient methodology and trends in medical education

Since the 1960s there have been reports of SPs in medical and later in health professions education. The first documented accounts of SP work are attributed to Barrows (1993), a neurologist and innovative educator in the United States. Barrows experimented with teaching well people to demonstrate clinical signs to prepare medical students for clerkships. However, he was concerned with more than the clinical signs, coaching SPs to present the gestalt of the patient. Skilled clinicians were unable to detect that SPs were not 'real'. Although there was initial resistance by his peers, Barrows persisted and there is now a sophisticated global SP industry.

Fundamental concepts in simulated patient methodology

Although SPs are now described as well people trained to portray a patient in a healthcare scenario and to offer feedback to learners on how they were received or experienced (Nestel & Bearman, 2015), their range of practices varies tremendously. SP methodology refers to scholarship associated with SP-based practices for educational and/or research purposes. Here, the 'P' in 'SP' refers to patients, but it could quite easily refer to other participants, such as relatives, bystanders, healthcare professionals or others. We also use the term simulated rather than standardized (a common North American usage) to reflect our values about relationships of care and their portrayal by SPs.

An effective relationship is one in which the continual modulation of voice leads to respectful understanding. A tension in contemporary SP methodology is reconciling the standardization of SP portrayals required for Objective Structured Clinical Examinations (OSCEs) with the representation of the complexity of real clinician-patient relationships. Indeed, we value individual variation as a particular strength of SP methodology, capturing the uncertainties and unpredictabilities of clinical practice. This affords learners the opportunity to be immersed in SP-based scenarios, to reflect on what occurred and to share insights from SPs.

Discourses of clinical competence

International trends in medical education have influenced SP practices, especially the focus on medical competence and its shifting discourses as described by Hodges (2012). In SP methodology, the performance discourse is illustrated by providing the opportunity for learners to demonstrate their ability to perform a clinical skill with an SP (e.g., history taking, explaining a procedure). In the psychometric discourse of competence, all behaviours are considered to be measurable and as such translatable to numbers. Standardization and SP-based stations in OSCEs offer an obvious example. Standardization often reduces exchanges within the OSCE station to overly simplistic cues and responses that do not reflect real relationships but privilege specific clinical actions. This is a move away from Barrow's original concept. A more recent discourse of competence as reflection is represented by learners making meaning of clinical encounters through feedback from SPs. This feedback is intended to shape learners' future practices. A shift to a production discourse of competence focuses on quality outcomes illustrated by the Association of Standardized Patient Educators (ASPE) in developing standards for SP practices (Lewis et al., 2017). Each of these discourses of competence has varying degrees of presence in contemporary SP practices. It is important to reflect on these discourses as they influence the ways in which SPs approach their work. Finally, Bearman and Nestel (2015) note an emerging complexity discourse of SP methodology, a theme developed in this chapter.

Scope of simulated participants practice

SPs can contribute to a wide range of patient-based healthcare scenarios and be coached to describe symptoms and demonstrate signs, supporting the development of communication, professionalism and patient safety. SP-based scenarios enable learners to experience these core components of clinical practice in a patient-safe environment. Commonly, scenarios focus on exchanges between learners and SPs in clinical tasks, such as exploring patients' histories, negotiating management plans and sharing information. Specific clinical characteristics of illnesses and diseases can be portrayed, including acute and chronic conditions affecting any bodily system and age of patient.

Because SPs can look, sound and behave as real patients, they also contribute to the development of clinical reasoning, physical examination, investigative, procedural, operative and therapeutic skills through appropriate scenarios. Recent developments focus on interprofessional collaborative practice, placing SPs at the centre of team-based simulations. Although SPs usually work in simulated environments, they sometimes work in real clinical ('in situ') settings. An obvious advantage is the authenticity of the environment, reflecting the setting in which the learners are or will be expected to practice. A variation on in situ simulations is incognito or unannounced SPs, where the SP is functioning as a mystery shopper might in retail, but here the SP works in a clinical setting and makes judgements of learner performance and clinical processes in the workplace.

Hybrid simulations

The potential of SPs continues to expand, such as in mastering procedural skills. We have pioneered the concept of hybrid simulation, in which a simulator is placed beside an SP to enable procedural, operative and investigative skills to be practised and consolidated (Kneebone & Nestel, 2010; Kneebone et al., 2002). For example, a suture pad strapped to the arm of an SP to enable a learner to practise wound closure, a simulator arm positioned on an SP for learners to practise establishing an intravenous line, a virtual reality simulator placed at the end of an examination couch with the SP lying on their side with legs drawn up for learners to practice flexible sigmoidoscopy. Drapes, other props, make-up and moulage products create an illusion of seamlessness between the simulator and the SP.

We developed this approach to support learners in the challenges of integrating the complex sets of skills required for safe and effective care. Hybrid simulations facilitate this integration, and are suited to most clinical events in which the patient is conscious. Many manufacturers now develop simulators to accommodate hybrid simulations.

Patients' voices

Although these are exciting advances, much SP-based work is framed from clinician perspectives and the needs of the curriculum rather than presenting authentic patients' voices. Scenarios are often seen as 'a mirror for the teachers' preconceptions rather than as an authentic reflection of a patient encounter' (Nestel & Kneebone, 2010). It is common for clinicians to determine learning goals, design scenarios and direct feedback that inadvertently overlook patients' perspectives and experiences. Even the way we have described the hybrid simulations earlier privileges clinical tasks over patients' experiences. SP methodology offers unique opportunities to access the complexity of clinical practice, to explore the relationship of care and to examine the voices of learners and SPs in a particular place and time.

Tip

Simulated patients are proxies for real patients; portraying and offering feedback from patients' (not clinicians') perspectives.

When empowered, SPs can make a unique contribution by speaking for patients rather than for clinicians. Strategies include patient participation in all stages of SP methodology, from establishing learning goals to evaluation, and in selection, abstraction, re-presentation and intensification. Co-construction of scenarios by clinicians, learners and patients may ensure that all perspectives are valued in the process of learning about relationships of care. Although it may be impracticable to do this every time, it must happen often enough to ensure that learners learn what patients value (Nestel et al., 2018b).

Another strategy is to base scenarios on real patients' histories, an approach which is usually 'filtered' through clinicians' perspectives (Nestel et al., 2008). Inviting real patients to work with SPs is a seemingly obvious, but underused strategy. Of course, there are limitations with this approach. These include the willingness, ability and suitability of real patients to participate (one important reason for involving SPs in the first place), the impact on a real patient of an actor portraying their experience (a potentially confronting experience) and the sharing of personal information (issues of confidentiality). Locating the teaching of clinical skills as part of a broader arc of patient care (including discharge planning, say, or other follow-up care) offers more patient-centred approaches to learning.

Qualities of simulated patients

A spectrum of SP practices ranges from simple to complex, and this expanded scope of practice requires high levels of expertise. The demands on the SP in a scenario are varied, but usually require the ability to remain in role while responding appropriately to cues offered by the learner. SPs need to be able to recall what they noticed about what the learner was offering, what they themselves transmitted in response and why—all key constituents of feedback. Added to this is the emotional load of role portrayal, of many repetitions of a scenario, of working with a facilitator, and offering what is often trenchant feedback to learners. The SP will be expected to report on more than the words and gestures exchanged, perhaps including the way in which the learner used the environment or artefacts in the setting—the placement of medical notes, the positioning of chairs, the handling of medical equipment and more. Specialist language may be required to get at the essence of the relationship of care.

The role of the SP is extremely complex. A dramatic arts background offers a solid foundation, especially in managing the emotional work of role portrayal, and a deep understanding of educational principles is also essential. Performance and educational experience are required for successful work at the complex end of the spectrum of SP practices.

Supporting simulated patients in role portrayal and feedback

Two main types of support for SPs are required; in portraying roles (re-presentation) and in offering feedback (intensification). For role portrayal, commencing with character development rather than the clinical event is one way of focusing attention on the patient as an individual (Nestel et al., 2015). SPs are encouraged to focus on embodying the person whom they will be portraying—of considering who that person is outside the clinical encounter. Only after this is achieved does the training shift to placing the person as a patient in a clinical context. Scenarios usually incorporate a written briefing document or SP role that guides preparation and rehearsal. There may be safety issues to be considered in teaching SPs to portray clinical signs and for working in hybrid simulations. Where SPs are being prepared for OSCEs, training needs to focus on establishing the parameters for appropriate responses.

There are many approaches to managing feedback for learners. It is beyond the scope of this chapter to outline these in detail. Here we consider verbal feedback immediately after a simulation. Facilitator-led feedback should have an invitational quality, which empowers SPs to share their experiences. Observers (e.g., other learners) may experience the scenario differently to the learner and the SP. Being a participant within the scenario offers a different experience to looking in from the outside. Acknowledging and respecting this difference privileges the relationship of care.

SPs usually step out of role to offer feedback. They speak from their experience within the scenario drawing on their in-the-moment decisions. Learner and SP relationships offer a different dynamic to that which learners have with real patients. Although learners often report forgetting that they are in a simulation soon after it commences, the fact remains that it is a simulation. The power balance can shift in either direction, and in part depends on the commitment of all participants in the scenario to use the experience as a learning opportunity.

Simply providing the opportunity for learners to practise skills in scenarios is insufficient. Feedback (e.g., spoken, audiovisual, rating forms) from multiple perspectives (e.g., clinicians, peers and SPs), together with reflection by which the learner makes meaning for future practice is critical. This is the forum for the voices described earlier to be explored. It is important to share scholarly research on what comprises patient-centred care and associated clinician behaviours. However, SPs must be encouraged to make meaning of this research relative to their own experiences, the roles they portray and the settings in which they work.

Tip

By using the conceptual framework described earlier, SPs can contribute to all phases of simulation design and make truly patient-originating offerings to learners.

A key feature of simulation is that scenarios may be paused and the evolving clinician-patient relationship discussed. The learner can reflect on their progress with the SP and identify suggestions for development—a continual modulation of the participants' voices. When the scenario is resumed, new ideas can be tested out. Time can also be compressed or expanded to enable access to particular elements of the relationship (see Sequential simulation later).

Simulation technology

The discussion now moves to the other key element in simulation—technology. Simulation technology has benefitted from advances in materials science, virtual and augmented reality (VR/AR) computing, mobile devices, advanced human-computer interfaces and three-dimensional (3D) printing. Although there is no doubt that it can play an important facilitating role in the simulation as design process described earlier, there is also a real danger of technology dominating the simulation discourse, particularly with the current wave of fashionable technologies: artificial intelligence (AI), VR, AR, mixed reality (XR), and so on. It is therefore crucial to acknowledge that the educational value of simulation technology lies not on how technically advanced or sophisticated it is, but on how well it can support the learning outcomes of a particular educational encounter. Thus clear vision, an educationally sound approach and an understanding of the affordances and limitations of a specific simulation technology are essential to make use of its potential, ensure a balanced partnership between pedagogy and technology, and avoid the simulation agenda being driven by the naturally vested interests of simulator and simulation technology companies.

A key use of simulation technology is to enable the re-presentation of the abstracted selection in the simulation as design process (see earlier), through the development of simulators, defined here as apparatus designed for rehearsing selected aspects of clinical practice. We recognize three main types of simulators: physical models, immersive simulators and hybrid simulators.

Tip

Simulation technology benefits from rapid advances in many other areas, but its true value depends on how well it can support the intended learning outcomes.

Physical models

Physical or bench-top models are widely used at undergraduate and early postgraduate levels of training (Badash et al., 2016). Also known as task trainers, they tend to focus on specific skills, examinations or procedures, allowing novices to practise them repeatedly. Made from a variety of plastic, silicon and other materials, they aim to resemble the look and feel of real life tissues and organs, offering direct handling of instruments and interaction with real materials. Clinical procedures simulated include venepuncture, cannulation, urinary catheterization, basic suturing, bowel and vascular anastomosis, hernia repair, as well as other commonly performed surgical tasks and physical examinations.

Recent advances in materials science, 3D printing and cross-fertilization between model makers, artists and medical educators have resulted in extremely realistic, visually and tactile, as well as functionally complex bespoke benchtop models. Physical models are relatively cheap in comparison to the other type of simulators. However, major drawbacks include fixed anatomy, wear and tear and lack of facilities for formative and summative assessment. The majority of these models also tend to be used in isolation separate from their clinical context, which can lead to a reductionist approach to learning.

Immersive simulators

The last 20 years have seen VR technology used to recreate a wide range of surgical procedures with an increasing level of realism, allowing learners to interact with a high-fidelity computer-based simulator (Olasky et al., 2015). Minimal access interventions are particularly suited as manipulating objects at a distance with suitable instruments, while watching a two-dimensional (2D) screen, already reflects standard practice in minimal access surgery. Such simulators consist of a suitable human-computer interface resembling the instruments used, a screen to display the virtual environment, and a computer to run the simulation. Learners may choose procedures with varying levels of difficulty; performance metrics (e.g., time taken, economy of movement, errors made) and the procedure itself can be recorded automatically. Feedback based on these metrics is normally provided after the procedure, with or without a tutor's input.

Several generations of VR simulators have been developed. In the late 1990s, the first generation focused on training basic skills by performing isolated tasks (e.g., pick and place, navigation) using abstract scenes and 2D representations of geometric solids (e.g., MIST-VR). The early 2000s witnessed the second generation focusing also on basic skills, but attempted to achieve this by using more realistic procedural tasks (e.g., LapSim). In the mid 2000s, the third generation allowed entire procedures to be simulated, introducing a degree of anatomic variability to create a range of difficulty levels, moving beyond psychomotor skill and beginning to include decision making (e.g., LapMentor). The current fourth generation reflects progress in computer graphics, design, interfacing and visualization, as well as enhanced ergonomics, improved content and curriculum management, and better integration with simulated clinical settings (e.g., VIST-LAB). One of its aims is to offer patient-specific simulation that allows specialists to plan and rehearse challenging cases before an actual operation. Although minimal access interventions continue to dominate, the range of surgical and nonsurgical specialities supported has increased significantly (e.g., dentistry, endoscopy, orthopaedics, neurology, urology, gynaecology, ophthalmology). Integration of fully immersive VR, AR and XR is also being explored by various medical and surgical simulation companies (e.g., LapMentor VR).

Cost and the need for ongoing specialized support is one of the major drawbacks of immersive simulators. Their design and development demand considerable resources, whilst their wider adoption requires tackling a range of practical, administrative, educational and financial challenges (Olasky et al., 2015).

Hybrid simulators

In this section, we draw a terminologic distinction (based on usage in the literature) between hybrid simulators and the broader concept of hybrid simulation (outlined earlier). Hybrid simulators are a combination of a physical model with customized software and electronics/mechatronics, offering a range of interactive settings that support learning. They lend themselves well to supporting hybrid simulation through their use with SPs and have the potential for also supporting team training, moving beyond practicing isolated technical skills and recreating the context of clinical practice.

Hybrid simulators include full body mannikins able to provide tactile, auditory, and visual stimuli (e.g., Laerdal SimMan, CAE METIman). Such simulators present a range of pathophysiologic variables and can respond to the administration of drugs, as well as give immediate feedback to a range of interventions. Mannikins are routinely used for anaesthetic training and are becoming increasingly common in other domains. They may be used within a dedicated educational facility, but also in the field. Full-body simulation allows for basic procedural practice, as well as forming part of immersive scenarios where learners can perform and reflect on critical diagnostic, management, communication, organizational and multitasking skills.

Hybrid simulators also cover endoscopy, endovascular and urologic interventions (e.g., EndoVR, EndoSIM, VIST-C, URO MENTOR), combining an authentic interface (endoscope, catheters/guidewires, cystoscope) with a realistic VR display. Such simulators are able to mimic a range of diagnostic and therapeutic interventions, at different levels of difficulty, allowing learners to gain the basics of manipulative skill through repeated practice. Decision-making is enhanced by the display of vital signs, haemodynamic wave tracings, and patient responses that appropriately reflect relevant physiology. Performance metrics are captured and presented after each procedure. A range of pathologic conditions and technical challenge levels is also offered.

As technology continues to advance, hybrid simulators and immersive simulators are converging, offering a wider range of functionality, larger selection of procedures, more sophisticated interfacing, photorealistic graphics rendering, and a more holistic integration within clinical scenarios.

Tip

Simulators range from simple benchtop models to highly complex full body mannikins and highly immersive systems.

Current and future trends

Simulation-related technology has continued to advance rapidly. Further increases in computational power are accompanied by substantial progress in graphics processing, optics, sensor technology, touch enabled human-computer interfaces, mobile technology and materials science. Unified software development platforms that facilitate rapid prototyping and beta testing, as well as reutilization of software components, are emerging. All of these, coupled with the wide availability and cost effectiveness of 3D printing, progress in the fields of medical imaging, instrumentation, diagnosis and intervention, are resulting in a new paradigm where simulation technology can support training and practice across all stages of healthcare in a coherent and coordinated manner. Consultation, specialist diagnosis, preoperative planning, intraoperative guidance, postoperative recovery, discharge, reintegration into and care in the community can all now be taken into account. AI and data analytics are beginning to make inroads into simulation. Their use is being explored to support the underlying computer modelling, provide intelligent tutoring assistants which offer personalized and adaptive training opportunities, and generate sophisticated learning analytics.

Further improvements in the realism, functionality and available variability of physical models can be expected, with smart bench-top models incorporating sensor and actuating technologies to provide real-time feedback, reproduce physiologic behaviour, and support more complex interactions. Integration between physical models and advanced software simulations will continue, blurring the boundaries between simulator types. At the same time, software development will converge towards more powerful, unified development platforms borrowed from the gaming industry. This will set the scene for a more cost-effective VR simulation development model based around a 'Simulation App Store', where simulation users download simulator Apps that can then be tailored and executed on a common smart simulation platform, which in turn will result in more flexible and affordable simulators.

Tip

Further advances in simulation technology are expected to make simulation more affordable, more widely available and more adaptable

Simulation in the 21st century

The earlier discussions have outlined two distinct approaches to simulation—the humanist and the technicist. Historically, these have evolved along separate lines. We argue that much can be gained by aligning these traditions. In addition to our work on the concept of hybrid simulation described earlier, the following examples highlight such possibilities.

Distributed simulation creates 'realistic enough' clinical environments that are portable and relatively low cost (Kassab et al., 2011; Kneebone et al., 2010). Physical contexts of care are provided by lightweight backdrops, often presented within an inflatable enclosure to delineate a consulting room, ward, operating theatre or intensive care unit. A sense of authenticity is created by clinicians working together to enact pathways of care which they carry out in real life, using actual clinical equipment to treat the 'patient' (represented by SPs, physical models or hybrid simulation). This 'minimal necessary complexity' allows the most appropriate level of detail for the purpose at hand to be selected, adjusting this as appropriate for selected participants.

Sequential simulation moves beyond single episodes to portray sequences of care, highlighting connections between elements in a clinical pathway (Powell et al., 2016; Weldon et al., 2015). By concatenating a series of 'scenes' (for example a patient at home, in their community physician's consulting room, in an ambulance, a hospital ward, operating theatre or intensive care unit), a clinical trajectory of days or weeks can be condensed into half an hour or less. In addition to addressing skills within a given section of the healthcare system, this allows transitions between phases of care to be rehearsed and examined (Weil et al., 2018; Weldon et al., 2017, 2018). It also allows simulation to be taken into public spaces and other unorthodox venues to address societal issues, such as the rising incidence of knife violence among young people (Tribe et al., 2018).

The combination of distributed and sequential simulation opens opportunities for clinicians to engage with patients, their carers and the general public. By inviting nonclinicians to watch, take part in and interrogate pathways of care through simulation, healthcare professionals can widen their perspectives and gain valuable insights (Tang et al., 2013). By framing professionals, patients and publics as equally although different expert, simulation-based encounters can rebalance those inequalities in power which sometimes characterize clinical interactions, leading to 'reciprocal illumination' for all participants (Kneebone, 2015).

Integrated procedural performance instrument (IPPI) overcomes some of the limitations of OSCE-style assessment (such as an unduly formulaic approach based on learning prescribed procedures) by incorporating unpredictability within clinical scenarios (Kneebone et al., 2006). A series of stations integrates the humanist and technicist challenges outlined earlier (such as siting an intravenous line in a patient with visual disability, or giving an injection to an angry and abusive patient). Structured feedback from SPs and clinician observers acts as an aid to self-critique and reflection by learners.

‘Minimally expensive simulation’ offers an alternative approach to simulation design. By inviting clinicians and students to work with what lies to hand rather than relying on costly specialized equipment, participants’ imaginative powers and improvisational skills are brought to the fore (Harris & Rethans, 2018). This approach frames simulation as a creative process where teaching, learning and simulation design evolve in synchrony, countering an unhelpful tendency to separate the creation and manufacture of simulation from its educational application.

Summary

Simulation is central within contemporary clinical education and its role is set to expand. Yet simulation is often equated with costly, high-tech facilities dominated by a profitable industry. This chapter challenges assumptions about the need for cost, complexity and specialist expertise. In many cases, simulation is an activity which can be carried out anywhere, using what lies to hand, and does not depend upon elaborate or expensive facilities.

Of course, in many cases, sophisticated facilities remain essential. Simulation and its technologies have a crucial role in allowing procedural skills to be practised and assessed. As science and clinical care become ever more sophisticated, the need for specialized techniques to be practised in safety becomes increasingly evident. It is essential that emerging clinical techniques are accompanied by the means of learning to perform them safely and well. Technologic advances offer huge potential, especially in addressing the learning of 'unsighted' procedures mediated by touch, such as rectal or vaginal examination. Rapid advances in haptic simulation, AR and machine learning hold the promise of new approaches to multisensory learning.

Yet an emphasis on high technology for a specialized few can hide the benefits of simulation for the many. This chapter argues that much may be achieved by simple means; by using existing resources imaginatively, by thinking laterally and by resisting pressures from the commercial world to equate value with cost (Nestel et al., 2018a). The role of SPs in creating the human framework of care is crucial, whereas insights from experts outside medicine can enrich the ecosystem of simulation. Surprisingly much may be achieved with surprisingly little.

By framing simulation as an educational approach rather than a fixed product (a means of learning, not an end in itself) we can harness the creativity of patients, clinicians and all those who teach and learn. By doing so we can ensure that the relationship of care—in education as much as in clinical practice—remains at the centre of everything we do.

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Independent Learning and Distance Education

John Sandars and Kieran Walsh

Trends

- Independent learning is essential for postgraduate medical education and continuing professional development, with learners taking responsibility to effectively meet their learning needs that are identified from daily professional practice.
- Independent learning is developmental and requires the development of self-regulated learning attributes through teacher guided active learning opportunities during basic medical education and postgraduate medical education, such as problem-based learning and flipped classrooms.
- Technology provides increasing opportunities for distance learning, with access and creation of a wide variety of learning resources outside the traditional classroom.
- Evaluation of learning resources and digital literacies are essential for independent learning and distance education. This is a challenge for both teachers and learners.

Key concepts

- Independent learning: a learning process with a shift in the control and responsibility of learning from the teacher to the learner.
- Distance learning: learning which occurs away from the confines of the traditional classroom, enabled especially by the use of technology.
- Self-directed learning: a learning process in which the learner takes full control and responsibility for their own learning.
- Self-regulated learning: a cyclical learning process to plan, self-monitor and dynamically adapt motivation and learning strategies to ensure effective learning.
- Ubiquitous learning: learning occurs at any time and in any location, and is enabled by ubiquitous technology, which is available on any device, at any time, in any location, and in any format.

Introduction

All learning has an outcome, such as the acquisition of new knowledge, skill or perspective, but an important consideration for all medical teachers is the process by which the outcomes are achieved. The process can be highly dependent on the teacher, with the teacher having control over both the outcome and the process. For example, the content of a lecture may be entirely determined by the teacher with no opportunity for the learner to be actively involved during the lecture. In contrast, the process can be highly dependent on the learner, with the learner taking full control over their learning, making decisions about the content and how this content will be acquired. Between these two extremes, the extent to which the teacher and learner determine the content and process of learning can vary. For example, the teacher may facilitate the learning by providing directions to content that is expected to be accessed before a lecture or small group session (however the learner will also be free to explore other content related to their own learning needs).

There is a wide variety of medical education content that can be easily accessed by learners, and increasingly, this content is both accessed and provided using technology. For example, smartphones can provide rapid 'one click' access to a range of learning resources—from mobile device applications (apps) to social media (such as Twitter and YouTube) to websites. This content also has a spectrum of teacher and learner control in its creation. For example, social media may be entirely learner created but websites, such as online learning modules, are often developed by teachers and replicate lectures. The ubiquitous nature of technology has led to a revolution in distance learning, which occurs away from the confines of the traditional classroom, to become increasingly integrated with a range of teaching and learning approaches. For example, a small group teaching session with specific online content on a website provided by a teacher can be integrated with collaborative learning through social media interactions between learners before, during and after the session.

In this chapter, we will discuss the terms that describe learning across the range of learner control, the importance of learners taking control of their own learning, the main characteristics of learners who take control of their learning, and how to develop learners so that they can take control, including the use of technology to enable distance learning. The main principles span the continuum of medical education.

The terms that describe learner control of learning

"The term 'independent learning' describes a shift in the control of and responsibility for learning from the teacher to the learner."

Higher Education Academy (2019)

The World Federation for Medical Education, which informs national policies on basic medical education, postgraduate medical education and continuing professional development, uses the same term to describe this essential aspect of medical education and highlights the importance of progressively increasing learner control over the continuum of medical education (World Federation for Medical Education: London, 2015).

Independent learning is a key feature in the literature on childhood education but the important role of the teacher in guiding the learner towards meeting specified learning outcomes is emphasized because it is considered that children have not fully developed their capacity to be independent learners (Meyer et al., 2008). The importance of the teacher for independent learning is also recognized in the Association of American Medical Colleges (AAMC) Curriculum Inventory, with teacher guided learning outside formal medical education settings, such as classrooms, but it also refers to independent study and preparation for formal learning activities, such as problem-based learning or team-based learning sessions (AAMC, 2016).

The literature on adult education has a focus on 'self-directed learning', with the learner taking full control and responsibility for their own learning (Brockett & Hiemstra, 2018). The AAMC Curriculum Inventory similarly recognizes the importance of self-directed learning for lifelong learning but considers it to be distinct to their definition of independent learning, with its greater guidance for the learner (AAMC, 2016).

Although there are differences in the use of the term independent learning and self-directed learning in medical education, we will use independent learning throughout this chapter to describe a broad process in which the learner takes control and responsibility for their learning, especially because the key skills required by learners are identical. An important aspect of basic medical education and postgraduate medical education is the development of learners so that they become increasingly responsible for their own learning, which is essential for continuing professional development.

Importance of being an independent learner

The ultimate aim of medical education is to ensure high quality and safe care for patients. This requires doctors to take individual responsibility for not only the care of their patients but also their own learning to ensure that knowledge, skills and professional attitudes are constantly updated in response to the needs of patients. The adoption of this independent approach to learning is essential for continuing professional development.

> *"Research has shown that doctors respond to the wide range of problems, from clinical to ethical and legal to administrative, that they face in daily professional practice by identifying their own specific learning needs."*
>
> Slotnick (2001)

These learning needs become specific learning goals and these are met by a variety of learning resources. The new learning is then directly applied to current and future practice. Increasingly, responding to specific learning goals is by just-in time learning, and this is enabled by ubiquitous technology, which is available on any device, at any time and at any location.

Independent learners have increased intrinsic motivation, with learning driven by internal reward, and become more actively engaged in the process of learning. This has important implications for the provision of basic and postgraduate medical education, especially because developing high intrinsic motivation is essential for lifelong learning.

Characteristics of independent learners

There are two essential characteristics of being an independent learner. The first is the identification of the need to learn and the second is effectively meeting this need.

Identification of the need to learn

During the performance of any academic or clinical activity, the independent learner may become aware of a feeling of uncertainty or surprise when there is a difference between the intended outcome of their performance and the actual outcome. Internal feedback on performance through self-monitoring and awareness of the level of performance can be difficult for many learners, especially low performers who tend to overestimate their level of performance. However, research has consistently shown that external feedback provides an important stimulus for learning (Hattie & Clarke, 2018). Feedback can be obtained from a wide range of sources, from patient comments to formal assessments, and an independent learner is highly motivated to both seek and respond to feedback. This motivation is intrinsic and has internal rewards, such as increased satisfaction by performing to the best of their ability. This is in contrast to dependent learners who seek external rewards, such as approval from others.

Effectively meeting the learning need

The process of effectively meeting the identified learning need requires the learner to have high abilities in self-regulated learning (Schunk & Greene, 2017). Self-regulated learning can be described in three phases:

Phase 1

It is important for the learner to set clear and specific learning goals to meet their learning needs, such as information seeking from a particular resource or developing a skill.

Tip

Research in both academic and clinical contexts has consistently shown that setting learning goals is essential for effective learning.

Goal setting not only directs the learner to a specific learning activity but also motivates the learner to actively engage in the learning activity to ensure that the goal will be achieved. Effective learners choose the most appropriate learning strategies from a range of different strategies, such as note taking to maximize information retention or searching the internet for relevant information.

Phase 2

While pursuing the learning goal, it is essential for the learner to maintain their motivation and to constantly self-monitor the extent to which their chosen goals and strategies are meeting their intended learning outcomes. Effective learning requires making modification to motivation, goals and strategies through a constant 'fine tuning' process.

Phase 3

Effective learners reflect by using both internal and external sources of feedback on how they have attempted to meet the identified learning need during Phase 1 and 2 so that they can be more effective when they approach learning in the future. An important aspect of effective learners is that their attribution beliefs about success and failure to achieve their intended outcomes have a focus on factors that are controllable by the learner, such as their approach to learning, instead of factors that are uncontrollable by the learner, such as chance or the intelligence of the learner. This has implications for future motivation of the learner because uncontrollable beliefs lower motivation.

Although the main focus on self-regulation has been on the individual learner, there is increasing interest in the importance of the influence of other learners and the context on the extent to which the individual learner is a self-regulated learner and an independent learner. Individuals are rarely isolated in their academic or clinical practice and frequently they are members of a group or team. These situations create opportunities for individual learners to seek external feedback during all of the phases of self-regulated learning. The context is also a major influence, especially by means of institutional and curriculum approaches to education.

The challenge of developing independent learners

Research suggests that the development of self-regulated learning and independent learning for an individual learner is progressive across the basic medical and postgraduate medical education phases of medical education. There is an essential role for the teacher in this developmental process, acting as a facilitator to guide the learner in both how to self-regulate their learning and how to find appropriate learning resources. The involvement of the teacher should progressively diminish as the learner becomes more independent.

Important approaches for facilitating development include

Providing opportunities for specific advice and support on developing the key attributes required for self-regulated learning and independent learning

The initial development of self-regulated learning is often provided through study skills sessions, with a focus on goal setting and seeking feedback, but an essential time for increased provision is during remediation for underperformance, both academic and clinical. It is essential for teachers to remember that all interactions with learners should have the aim of developing self-regulated learning and independent learning. There is a temptation to take control when the learner appears to be struggling and, instead of providing information, the focus should be on how to find the required information.

Promoting the development of self-regulated learning and independent learning through the delivery of the curriculum

Tip

The curriculum has a major influence on the development self-regulated learning and independent learning, especially the approach to teaching and assessment.

There is increasing use of more active approaches to learning; from problem-based learning to team-based learning to flipped classrooms. These approaches require learners to meet their learning goals through a variety of learning resources, and many of these will be internet based. However, an important challenge in basic medical and postgraduate medical education is the frequent high stakes assessments that have a major focus on the acquisition and demonstration of specific competences. There is a tendency for learners to only prepare for an assessment and teachers are frequently requested by learners to provide teaching with only this focus.

Developing essential skills for evaluating learning resources

An important responsibility of teachers is their evaluation of learning resources regarding their suitability to the learning needs of learners. With independent learning, this responsibility is transferred to the learner and developing the essential skills for evaluating learning resources is a key factor in the selection of appropriate resources, especially when there are a vast number of resources from which a choice has to be made. All learning resources should be evaluated to ensure that the content is up to date, there are details of the author to ensure that the content can be trusted and is without bias, the content is justified, such as links to a journal article or expert opinion, and the source should be verified, because many resources have commercial sponsorship and the main purpose might be selling a product.

The digital world and distance learning by the independent learner

Tip

There are a very wide range of opportunities for distance learning by the independent learner, which occurs away from the confines of the traditional classroom or lecture hall, using the enormous variety of learning resources that are enabled by technology in the digital world.

Most learners have a smartphone that can easily access a vast source of content that is widely dispersed across numerous learning resources. Increasingly, learning is just-in-time and occurs as a response to learning needs that are identified through educational experiences, such as small group sessions, or through interactions with patients. This ubiquitous learning, at any time and in any location, is enabled by ubiquitous technology, using any device, in any location and in any format. Learning with technology rapidly moves the control of learning from the teacher to the learner, especially the pace of learning, but often the teacher will continue to create content, such as apps or websites. In ideal circumstances, online learning resources will enable learners to put their self-regulated learning skills into action for the purpose of more effective and more efficient learning.

Apps

This technology is designed to be run on a mobile device (including smartphone) and many can also connect to websites that offer a wider range of content. The variety of content in apps is huge, from interactive educational games to clinical decision support tools to interactive resources, such as anatomy and clinical skills revision aids.

Social media

This term includes blogs and microblogs (such as Twitter), internet forums (many of which are hosted by professional organizations), content communities (such as YouTube and Instagram) and social networking sites (such as Facebook and LinkedIn). Most of these social media resources have content that is created by learners and an important aspect of social media is collaborative learning, with sharing information and opinion, but also learners have the opportunity to validate their current knowledge against their peers.

Most learners who use social media will regularly follow the content that has been posted to a particular social media site. These resources provide useful up-to-date links to current new information and opinion across a broad range of topics. The content is often provided by an 'influencer' who has expertise within the topic and is followed by many learners, often in their thousands. Finding and following social media can be greatly helped by sites that identify current trends, such as the Symplur Healthcare Hashtag Project, and by using aggregators, such as Feedly.

Free open-access medical (FOAM) education has become increasingly adopted in postgraduate medicine and continuing professional development in emergency medicine, anaesthetics and paediatrics. Each discipline offers a range of separate sites and the FOAM education sites contain a range of content, including blogs, podcasts, online videos, photographs, text documents and online quizzes.

Websites

The internet can provide a vast learning resource of over 2 billion websites, with content which can be potentially created by anyone with internet access, and can be accessed by a variety of search engines. The vastness of this potential learning resource, and its variable quality of information, requires learners to have well-developed self-regulated learning attributes to ensure that independent learning goals are met but also skills to evaluate learning resources are essential. It is essential that the learner does not drown in a sea of learning resources.

Some websites have been created by teachers and online clinical decision support tools are increasingly being used in postgraduate medical education and continuing professional development. This resource enables learners to formulate a clinical question, find an answer to that question, and put their new learning into practice for the benefit of their patients. An ideal clinical decision support resource will enable learners to find an answer that is evidence based and continually updated but is also highly practical. Clinical decision support resources enable learners to mainly access knowledge online but other forms of online learning resources can enable learners to achieve other learning outcomes, including skills and behaviours. These online resources usually have a multimedia approach, including video and text-based materials, and can support learning of communication and procedural skills. They can also enable behaviours associated with effective team working or quality improvement. Online resources are frequently based around clinical cases, with real life clinical scenarios to help learners think through how they will put their learning into action in the real world. Many such resources also have an assessment at the end to enable learners to self-assess that their learning goals have been effectively met.

Learners increasingly expect to be able to keep a record of their online learning, including their internet searches, especially for sharing with their supervisor or appraiser, or claiming continuous professional development credits as a result of their learning. However, many regulators of continuing professional development operate a system that captures learning in a time-based manner, where learners claim credits on the basis of the number of hours that they spend learning. However, newer systems will be required that recognize how technology is transforming learning, with capture of their online activity.

Digital literacies for independent learning and distance learning

"There are numerous definitions of digital literacies but all have a focus on the learner having specific abilities to enable them to take maximum advantage of learning with the wide range of potential learning resources in the digital world."

Health Education England, London (2018)

The main literacies include:

- Technology literacy: the ability to proficiently use a range of different technologies, from devices to applications to networks.
- Information literacy: the ability to effectively retrieve, interpret, evaluate and curate the vast amount of information available across multiple sources.
- Media literacy: the ability to effectively produce, disseminate and curate a wide variety of content that can be enabled by technology, including photographs and videos.
- Communication and collaboration literacy: the ability to effectively and collaboratively communicate across the multiple opportunities that can be enabled by technology, including social media and online discussion boards.
- Identity management and security literacy: learners' ability to effectively maintain personal information about themselves and others.

Although there is an increasing emphasis on developing digital literacies whilst at school before commencing basic medical education, many learners will need to further develop both the range and depth of abilities. This also applies to many teachers in medical education.

Future trends in independent learning and distance learning

Technology will continue to evolve and be adopted for independent learning and distance learning. Machine learning to develop self-regulated learning attributes in basic medical education and the integration of learning and clinical systems for postgraduate medical education and continuing professional development are already on the near horizon. Personal learning environments for individual learners will be required to provide a focus for independent learning, with components that can record the learning process and curate the learning resources.

Performance assessment and feedback in medical education has a predominant focus on competence outcomes but there is increasing interest in the process by which a learner achieves these outcomes. Self-regulated learning can be assessed using microanalysis and this can inform feedback, such as in making a diagnosis or performing a technical skill (Leggett et al., 2019). In addition, the use of technology and learning analytics can track how a learner attempts to meet their learning needs across a variety of learning resources on the internet. This approach can be useful as evidence of engagement, especially in continuing professional development.

Tip

Although the focus of self-regulated learning and independent learning is on the individual learner, there is increasing interest in coregulation by groups of learners.

This trend is associated with the increasing interest in multidisciplinary learning and interprofessional education across the continuum of medical education, from basic medical education to continuing professional development.

Tip

A major challenge for both teachers and learners is the development of the essential attributes related to the evaluation of learning resources and digital literacies.

Increasingly, both teachers and learners will also need to collaboratively curate learning resources, with the development of online systems that can rapidly access a wide variety of evaluated learning resources that can be used to answer a specific learning need.

Lastly, it is important to remember that this is a fast-moving field. Ten years ago, teachers might have been justified in saying that online distant learning is effective in certain domains (e.g., learning knowledge) but not in others (e.g., in learning procedural skills). However, the advent of virtual reality means that learners can learn certain procedural skills online (Bernardo, 2017; Pfandler et al., 2017). Similarly, the culture of using online mobile learning resources in the workplace is changing. In the past, healthcare professionals in training might have felt uncomfortable about using their mobile phone in the workplace but increasingly, it is viewed as just another tool (Joynes & Fuller, 2016; Patel et al., 2015)].

Tip

In a time of rapid technological and educational progress, both teachers and learners should continually question their approach to teaching and learning, especially because younger learners have grown up with technology and they increasingly see that using technology is simply another way that they can learn.

Summary

Independent learning is essential for postgraduate medical education and continuing professional development, with learners taking responsibility to effectively meet their learning needs that they identify from daily professional practice. The aim is to ensure that doctors have the appropriate knowledge, skills and professional attitudes that are required for safe and high-quality care. Independent learning is developmental and requires the development of self-regulated learning attributes through teacher-guided active learning opportunities during basic medical education and postgraduate medical education, such as problem-based learning and flipped classrooms.

Technology provides increasing opportunities for distance learning, with access to and creation of a wide variety of learning resource outside the traditional classroom. There has been increasing use of free open access learning opportunities, such as FOAM education. Increasingly, ubiquitous learning occurs at any time and in any location, and is enabled by ubiquitous technology, using any device, in any location and in any format.

A major challenge for both teachers and learners is the evaluation of learning resources and digital literacies that are essential for independent learning and distance education.

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21

Digital Technologies in Medical Education

Rachel H Ellaway

Trends

Much of our lives are mediated by the use of digital technologies. This has impacted both medical education and medical practice. This chapter considers four areas of technology use in and around medical education:

- Medical teachers are making need to know why, where, when, and how to best use these technologies, as well as why, where, and when not to use them.
- Medical education and practice need to be appraised and aligned with the presence of technology in all aspects of modern life.
- Medical teachers need to prepare their learners to use digital technologies for healthcare, as well as educational purposes.
- The data generated from using digital technologies can be analysed to guide education practices and thinking.

Key concepts

- Analytics: the use of data, both educational and noneducational, to inform learning and teaching strategies and outcomes.
- Digital professionalism: medical professionalism in the context of the use and presence of digital technologies.

Introduction

Medical education has always used educational technologies; books, buildings, photography and models have each played a critical role in shaping the practices and possibilities of medical education. Nevertheless, when we think about technology, we tend to focus on digital technologies; the computing devices, software, services, and network infrastructures that pervade and underpin so much of what we do. Arguably, there is little in the modern world that is not touched by digital technology now that the worldwide web, mobile technologies, and cloud computing are the default media for so much of our everyday lives. Medical education has not been immune from this shift.

Digital technologies are not just a means to an end in medical education, they can change us and they can change the ends we are seeking to achieve. It is important therefore that medical teachers appreciate when and how to use (and not to use) digital technologies in their teaching practices. They also need to appreciate how their learners, their working environments, and their societies are being shaped by digital technologies.

There are many textbooks that describe different kinds of educational technologies, how to use them, and the impacts these technologies can have on teaching and learning (Clark & Mayer, 2008; Horton, 2006). Rather than reprising their ideas here, I will focus on four ways in which technology both shapes and can be used by medical teachers: technology as medium; technology as context; technology as outcome; and technology as intelligence.

Technology as medium

Technologies have little value unless they are actually used. Medical teachers should therefore know how to use digital technologies to support and enable what they do. They also need to be prepared to make use of the many possibilities of using digital technologies and not be limited to their original intended uses.

In terms of what medical teachers may draw on, the list of technologies used in contemporary medical education is long and is growing longer all the time. Resources, such as multimedia learning packages, podcasts and videos can be used in support of instruction, both in the classroom and for independent study. Online simulation resources, such as virtual patients, can be used to practice and hone skills, such as clinical decision-making. Teachers and learners can communicate and collaborate with each other on educational projects and activities using a wide range of media (social media, webinars, wikis etc.), and they can publish the outputs of their work through blogs, websites, and open media sites, such as YouTube. Reference materials, such as drug databases, clinical handbooks, and the research literature, can be readily used in classroom, bedside, and independent learning activities, and the results of learning activities and participant reflections on those activities recorded in clinical encounter logging systems and portfolios. Technologies for formative and summative assessment, such as online quizzes and formal computer-based proctored exams, can track and analyse learner performance. Curriculum maps can support curriculum planning and audit. Indeed, almost every aspect of contemporary medical education practice does or can involve digital technologies.

Digital technologies act as mediating artefacts; they provide the medium for undertaking particular kinds of activities. Indeed, it is this mediating role that makes them both essential and peripheral to the focus or the outcomes of the activities they support.

Why use digital technology?

Clearly there are a great many ways in which digital technologies can be used. But why use technology at all? Are there any activities in medical education where using educational technologies are the best way to teach or learn? The gold standard for education typically involves face-to-face individual tutoring with little or no technology mediation. Moreover, there are few, if any, learning theories that are predicated on the use of technologies. So, again we can ask: why use technology at all? The answer can be found in the transforming nature of digital technologies, which I have grouped into the following domains:

- Exponential connectivity: Digital technologies allow us to access content, services, and people in unprecedented ways. Where once we might have had to go to a library or sought out a face-to-face meeting with a subject expert to get the answer to a question, we can now access a multitude of online materials and opinions, and we can more easily associate individuals, materials and perspectives than ever before.

- Accelerating speed of action and response: Digital technologies can make communication, action and reaction much faster. Things that may otherwise take days or weeks without digital technologies may take just moments when using them. However, this can also mean we give ourselves less time to reflect on the consequences of our actions, and we may develop a lower tolerance for delays or things that take time to develop and mature.
- Defeating geography and temporality: Digital technologies can significantly extend the reach of our actions. For instance, geographically distributed learners can study together and patients and physicians at different locations can interact using telehealth networks. Interestingly, one reaction to this extended reach has been a tendency for students to value face-to-face encounters more than online ones.
- Massive integration: Digital technologies can be used to integrate a variety of services and information, reflected for instance in the use of learning management systems that integrate educational content, logistics, and communication into a single platform. However, integration also means more interdependence between system components, which can in turn make systems more and more vulnerable to errors and failures.
- Panopticism: Digital technologies can track and record almost any action their users make. While this provides the ability to provide rich feedback and modelling of learner behaviours it can also reduce learners' autonomy to explore and their freedom to express themselves without being overseen and judged for it. I will return to this point in the Technology as intelligence section.

In essence, the affordances of digital technologies let us change the rules regarding how we work and how we interact with information and each other. The affordances of digital technologies can help teachers and learners to save time and effort in remembering, repeating, finding, recording and structuring information and knowledge. These affordances can expand the reach of teaching and learning beyond physical limitations (potentially engaging more learners distributed across multiple locations). They can expand interaction beyond temporal limitations (teaching can be asynchronous—happening whenever is convenient rather than setting a single time for everyone). These affordances can also help us to organize and connect learners and teachers in support of a multitude of learning activities, and they can record and track teacher and learner actions in these activities. If you need some (or indeed all) of these advantages then technology can be useful in mediating your activities, if you do not need them then digital technologies may not play much of a role in your teaching practice.

"Digital technologies let us change the rules regarding how we work and how we interact with information and each other."

Technology and instructional design

Using technology in medical education may happen relatively spontaneously but it is far more common (and advisable) for medical teachers to design and plan their use of technologies, and to blend them into their teaching practice. This is called instructional design (Richey et al., 2011), which involves designing things to use (tools, materials) and designing things to do (activities) by considering:

- Who are your learners and what learning processes work best for them? Not all young people are keen on using digital technologies; there are likely to be learners who are very interested in using technology and others who are not. Medical teachers should be clear what technology use works best for their learners.
- In what contexts will technologies be used? The efficacy of using digital technologies depends on the context in which they are used. For instance, medical educators need to know whether there is adequate network and electrical power for their learners' devices, what the expectations are regarding what constitutes appropriate and inappropriate uses of technology, and how to be a digital professional (see later section in this chapter).
- What content will be involved, how should it be structured and sequenced? Designing things to be used should draw on learning theories (such as those pertaining to sequencing and cognitive load) and empirical evidence (Mayer, 2009). Other considerations include the testing and ensuring the usability of learning resources (making sure that their design and presentation is clear, unambiguous and accessible), and making sure that copyright and other licensing issues are addressed. The latter can be particularly daunting, and help from your library or other institutional supports may be advisable or even required.
- What instructional and noninstructional strategies should you use? Medical teachers need to decide what learners and teachers will be asked to do. Activities are typically based on an existing repertoire of approaches the teacher is familiar with and that are likely to afford the desired learning outcomes for the specific learners and learning contexts. It is beyond the scope of this chapter to describe the multitude of ways in which activities can be built around or using digital technologies. However, as other chapters in this volume explore the many dimensions of contemporary medical education the use of technologies is present, both explicitly and implicitly, throughout. One particular advantage to using technology is that it can extend the traditional repertoire of medical education activities to create new and hybrid activities. For instance, a lecture is 'flipped' when the didactic materials are prerecorded and put online for learners to study before class and the face-to-face time used for application and problem solving. Medical teachers are encouraged to think of activities and the uses of technologies as patterns that can be combined and recombined to create innovative and effective responses to novel learning situations (Ellaway & Bates, 2015).

- Consider what media and delivery systems you are going to use. Medical teachers need to select which tools and devices will be used, and this often involves a compromise between the ideal and the practical. For instance, the cost of developing bespoke software to meet a specific teaching need means that this is rarely the path medical teachers take (although it is not unheard of). Medical teachers tend to only use those technologies that are immediately available to them. For instance, most schools have some kind of online learning management system that provides generic course tools, such as file repository, discussion and calendar functions. Other generic educational tools and systems (Clark & Mayer, 2008; Horton, 2006) include online portfolios, evaluation systems, clinical encounter logging, and assessment systems. Noneducational tools can also be used, such as wikis for collaborative writing, blogs for reflective writing and webinar tools for small group work. Tools and systems that are specific to medical education (Ellaway, 2007) include virtual patients, online reference materials, and streaming procedural skills videos.

"There are two distinct kinds of practice: e-teaching (what the teacher does) and e-learning (what the learner does)."

The role of the medical e-teacher

The use of digital technologies for education is usually defined and led by teachers rather than learners. It therefore helps to separate out two distinct kinds of practice: e-teaching (what the teacher does) and e-learning (what the learner does). Medical e-teachers select the technologies they use, they facilitate their learners' activities through and around these tools, and they use them to evaluate and appraise their students' performance.

It is an ongoing challenge that the best learners tend to make use of every opportunity afforded them whereas less able learners tend to avoid them. If the goal is to help these less able learners, then the use of technology needs to align with their needs and they ways that they approach their learning. Simply making something available may increase the gap between the most and least able rather than closing it. For instance, self-diagnostic quizzes with targeted feedback can often help less able learners or those struggling with certain core concepts much more than multimedia rich resources can.

It is also important for medical teachers to ensure that their technology-enabled activities are integrated into and aligned with the curriculum. If e-teaching is not in alignment with the rest of the curriculum, then it introduces dissonance and confusion for the learner, as well as sending mixed messages regarding what is and is not important. Using technology for teaching should also better prepare teachers for more traditional face-to-face teaching practices.

Teachers' and learners' experiences of using any given technology may be quite different. For example, the way a teacher uses PowerPoint or a learning management system is very different from the way their learners use these tools. Some technologies, such as tracking and analytics, are almost exclusively used by teachers or course leaders, whereas others, such as educational apps and virtual patients, are almost exclusively used by learners. Moreover, not everyone uses technology to the same extent. In every class, there will be students who are less interested in using digital technologies, as well as those who actively embrace them. The contemporary medical teacher clearly has to encompass variation in technology use in many dimensions.

In conclusion, digital technologies can provide a wide range of media that can be used for many different medical educational applications. However, the selection and function of any given technology is perhaps less important than the use of good instructional practices and a focus on the needs of different learners and the intended outcomes of your educational activities and programmes.

Technology as context

Whether or not a medical teacher does or does not use digital technologies in their teaching, it is very likely that they are working in environments that are to some extent mediated by digital technologies. After all, almost everyone has a cell phone or smartphone, and most learners and teachers also use laptops, tablets, and other digital technologies throughout their working days. It is important therefore for medical teachers to understand and ground their practices in this increasingly ambient use of digital technology that forms much of the context for medical education today.

Using digital technologies in medical education is not solely about adding their advantages to what we do. There are also drawbacks and problems that can arise from the use of digital technologies, and to that end, medical teachers should be aware of the less desirable implications that accompany the benefits of using these technologies. We can frame this in terms of the formal, hidden, informal and null curricula of technology use in medical education (Ellaway et al., 2013):

- The formal curriculum of digital technology use tends to be small and often consists of no more than instructions to learners as to what they must do, what they may do, and what they must not do with their digital technologies. Medical students' appropriate use of social media is a growing topic of concern but has not, so far, become a core part of formal medical curricula.
- The hidden curriculum of digital technologies reflects the unspoken institutional expectations and cultural norms that influence their use. First and foremost, it is reflected in the expectations that: (a) learners and teachers have the appropriate digital technologies to let them perform their roles, (b) they know how to use these technologies appropriately, and (c) they know how to maintain them. Even though they are not formally taught or assessed, anyone who does not meet these standards quickly finds themselves at a disadvantage. There is also an equity issue in terms of who pays for the devices that learners use. Most schools now have a 'bring your own device' (BYOD) policy that shifts responsibility and costs for these devices to the learners.
- The informal curriculum of digital technology use reflects the individual perspectives and expectations of teachers and preceptors that shape and direct technology use. This may include situations where a teacher or preceptor is particularly keen on using technology in support of learning (such as where a preceptor trades tips on apps and mobile devices with their students) or is against the use of technology in learning situations (such as where a preceptor forbids the use of mobile devices in front of their patients).

Clearly, although there may be relatively little explicit attention paid to the use of digital technology in medical education, a great deal depends on it, and medical teachers should carefully consider the different messages and expectations of technology use they and their learners are exposed to, provide guidance where necessary, and identify and address equity issues appropriately.

Dependency and digital technology

Given that digital technologies have an increasingly ambient presence in contemporary medical education, medical teachers also need to consider the ways in which they depend on digital technologies, and the consequences of these dependencies. From one perspective, we can consider what the effective use of digital technology in medical education depends on. I have illustrated this by adapting Maslow's hierarchy of human needs (Fig. 21.1).

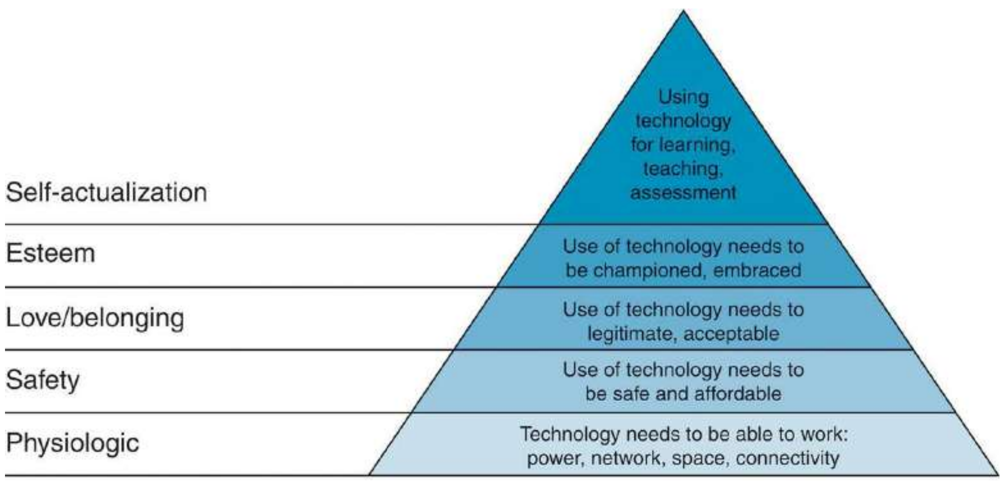

FIG. 21.1 Using technology for learning, teaching and assessment depends on underlying contextual affordances. Failures or challenges at lower levels can undermine higher levels. This helps to explain why it is that the same technology may be more or less effective or viable in different contexts.

A second perspective on dependency focuses on the extent to which technology directs and shapes what we can and cannot do, what we pay attention to and what we ignore, and what we value and do not value. For instance, most digital devices (laptops, smartphones, tablets, etc.) are designed for one person to use them at a time. This means that these technologies constrain and shape how their users interact and how they work with and around these technologies. For example, groups of people tapping away at their personal devices rather than talking to each other is a growing cliché of this modern age. Sociomaterialist theories of technology use, such as 'activity theory' (Engeström et al., 1999), reflect this shaping and mediating perspective, as does affordance theory (the range of actions that learners' and teachers' perceive as available to them when using different technologies).

A third perspective on dependency reflects the risks and liabilities associated with using digital technologies in medical education. For instance, data security and confidentiality have become critical issues for all organizations, with more and more resources required to protect against attacks and breaches. Even if system integrity is maintained, there are still risks related to the extent to which key events or activities depend on a given technology working. For example, moves to using online assessment have been somewhat limited by network and platform limitations. Paper-based examinations, despite being slower and more expensive to run, may prove to be more resilient and reliable. Medical teachers may well therefore elect to use simpler, more reliable and less dependent technologies rather than the more alluring but riskier digital tools available to them.

Finally, we can consider dependency in terms of technologies changing over time. Digital devices and tools do not last indefinitely; they are frequently updated or superseded. Medical teachers should not overcommit to or let themselves become overdependent on a particular tool or platform. Instead, they should be mindful of how they could shift their teaching between tools and platforms when the need arises, and how they can continue teaching when their tools fail or are discontinued.

> *"Digital devices and tools do not last indefinitely; systems and tools are in a permanent state of being updated or superseded by newer alternatives."*

Digital natives

Medical teachers need to appreciate the roles and identities their learners may adopt when using digital technologies. There has been a tendency over the last decade, particularly in the media, to equate youth with greater computing skills and abilities than their seniors. Labels such as 'digital natives' or 'net generation' have become a powerful meme that has persuaded many learners and faculty (Ellaway et al., 2015). This is problematic for a number of reasons. Although some learners have certainly embraced a digital lifestyle, others have not, often for perfectly sound and defensible reasons. Any group of medical students will typically have some students who make extensive use of digital technologies and others who have little interest in using them. This asymmetry can be exacerbated by learners' generally poor assessment of their ability to use digital technologies, particularly for those who have greater confidence than competence. Teachers on the other hand may have less confidence than competence in using digital technologies in their work, and they may perceive greater risks in using technologies than their learners, and they may as a result cede control of the digital to their learners on the (perhaps mistaken) belief that they are better able to make appropriate decisions in this regard (Beetham et al., 2009).

Technology as outcome

Although most technology use in contemporary medical education is about mediating learning activities, there are some aspects of medical education that focus on preparing learners for using technology as clinicians. From this perspective, technology use can be both the medium and the objective of training activities.

Preparing for e-health

Physicians increasingly use digital technologies in their clinical practice (e-health and telemedicine in particular). Physicians therefore need to know how to use tools, such as electronic health records (EHRs) and electronic medical records (EMRs), imaging (picture archiving and communication system [PACS]), laboratories, order entry and prescribing, point of care information, decision support and guidelines, logistics (scheduling, organization, management), and digital tools for communicating with patients and colleagues. Medical applications of digital technology should be taught across the curriculum, where possible using the technologies and tools that will be used in practice. For instance, an EMR could be populated with patient cases for problem-based learning or clinical skills sessions. However, as the specifics of these technologies typically vary by context, it is usually more important to teach the principles of e-health rather than the specific operations of a particular platform or tool. While the specific e-health competencies required of graduating doctors is still debated, there are models that can be used to guide education practice (Ho et al., 2014).

Digital professionalism

The use some of tools and systems, such as social media, has allowed individuals to say or do things in public forums that impact their own reputations, as well as those of their institutions and professions. Although there have always been indiscretions in medical education, the difference with social media is that it makes these indiscretions far more public. Whereas some institutions have responded by punishing or proscribing the use of social media, others have tried to take a more positive approach.

> *"Digital media are not an intrinsic threat to medical professionalism. Professionals should use digital media for positive purposes in ways that support principles of patient care, compassion, altruism and trustworthiness. Professionals should be aware of the shaping nature of their relationships with digital media and they should maintain the capacity for deliberate, ethical, and accountable practice."*
>
> *Ellaway et al. (2015)*

There are three dimensions to what we call digital professionalism:

- Proficiency: Professionals should be able to use technology effectively and safely, without making inappropriate use of time and resources, while avoiding unnecessary risks and distractions. This includes selecting and using technologies safely and efficiently, and making appropriate use of training and support resources.
- Reputation: Digital professionals should behave appropriately and respectfully in all venues with all media at all times; they should refrain from disclosing anything in any medium that they would not be comfortable defending as appropriate in a court of law or in front of a disciplinary panel.
- Responsibility: Digital professionals are responsible for their actions; they should seek to develop and maintain positive and effective behaviours associated with using digital media. They should model positive behaviours in using digital media to others including their students, peers and patients.

Medical teachers should incorporate digital professionalism within broader professionalism training and assessment activities in the curriculum, they should clearly connect the use of technology with the principles of professionalism, and they should model good digital professionalism to their students and colleagues.

Technology as intelligence

The final broad area in which digital technologies can be used in medical education focuses on using the data generated by digital technologies used in educational activities to guide future education practices and thinking. Collectively known as 'analytics', this is enabled by our interactions with our digital technologies leaving a broad trail of data in their wake. For instance, the longitudinal microassessments that are collected and analysed to track resident performance and progression towards completing their required competency milestones, can also be analysed to consider preceptor behaviours, and other differences and variances according to location, time of day or year, and so on (Chan et al., 2018). We do not need to limit our analyses to data deliberately generated from educational activities (such as test scores or evaluations), we can consider any data for analysis that can tell us something useful about our learners. However, accessing these data can be problematic, as much of what learners do in the digital realm remains invisible to their teachers. For example, although some social media data are easily accessible (e.g., Twitter) most are not. Much as analytics shows great potential for informing educational practice, the utility of analytics is limited by data accessibility, data quality and data utility (Ellaway et al., 2019). For instance data may be compromised through inaccuracies, absences, under- or oversampling, and so on. No data are perfect, and it is important therefore that the quality of the data is well understood and any inferences drawn from the data proportional to their quality. Even if you have good data, they might not be able to tell you much. Data from educational technologies generally reflect machine-level events, primarily cursor clicks and key presses; they can tell you what happened and when it happened, but they usually cannot tell you why something happened or what educational consequences were. Education analytics is an emerging area of activity at the time of writing this chapter and it is unclear at present quite how much and in what ways this will become part of the medical education mainstream.

Another emerging and related concept to analytics is that of 'big data', the parsing of very large datasets to identify patterns and variances that can then be mapped back to phenomena that would otherwise go unnoticed. The primary challenges in big data science are the volumes of data to be parsed, the velocity at which the data are generated, the variety of different data and sources of data to be considered, and the veracity of the data available. It is unclear how much real operational utility big data will be able to afford medical education practice.

Education analytics and big data also pose a number of ethical challenges, not least of which is the extent to which they represent a surveillance culture, one where learners and teachers are constantly being tracked and evaluated on their every action. This raises many other concerns, not least of which is the opportunity this creates for inappropriate and unethical decisions to be taken on what the data seems to be showing. Thus while the ambient collection of education data could indeed be used for intelligent and beneficial purposes, it could also be used for less desirable political or ideologic purposes. It is unclear at the present time where we will draw the line in monitoring and controlling our learners and teachers through the data they generate.

The final emerging technology that has great potential to both aid and disrupt medical education is artificial intelligence (AI), 'computer software that are designed to mimic and extend human rational thinking and actions' (Masters, 2019). AI is already being used in some aspects of medical practice in support of tasks where computers may be more accurate or less prone to mistakes than human beings. The ethics of using AI in medicine are still being debated, but their use in medicine has implications for teaching (in particular diagnostic and reasoning skills) and for the role of physicians in general. Although the use of AI in medical education is at present relatively rare and low key, the potential for intelligent agents and systems to augment teaching and learning in medicine should not be underestimated.

Summary

Medical teachers have access to an unprecedented range of educational technologies to support their teaching, and they need to be able to function in a range of different digitally enhanced environments. They need to be able to appreciate the dynamics of such environments and select those tools and processes that best meet their needs. All medical teachers are therefore to some extent medical e-teachers. This chapter has set out a series of concepts around educational activities that should allow both learners and their teachers to make much better use of their various technologies. The greatest promise of the digital may and probably should be to enhance and improve traditional models rather than to simply sweep them away. Future editions of this book will have the benefit of hindsight to validate or challenge this perspective.

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Medical Education in an Era of Ubiquitous Information

Johmarx Patton and Chuck P Friedman

Trends

- Information is available more and more in digital form.
- Biomedical knowledge via the Internet is making point of care reference easier.
- Learning health systems are enabling healthcare to continuously improve, reducing quality improvement latency by years.
- Because new evidence is being generated in real time, clinicians need to be able to deal with uncertainty of evidence when making decisions.
- Comfort with clinical reasoning and decision aids must continue to increase.

Key concepts

- Digital learner: regardless of generation, digital native or digital immigrant, learners will use digital methods for information acquisition and knowledge supplementation that teachers need to be prepared for.
- Computable biomedical knowledge: in addition to human readable knowledge pertaining to health and healthcare, knowledge representations that can be consumed, interpreted and displayed by machines aid in knowledge acquisition and decision making by skilled users.
- Application Programming Interface (API): a computing interface that defines interaction between multiple software intermediaries.

Introduction

In the modern world, health information is everywhere. Increasingly, this information is in digital form, which makes it accessible not only to people but also to devices that can store it and add value to it through computation. Information is available to everyone who participates or has an interest in health and healthcare, including health professionals and their patients, organizations that pay for healthcare, educators, as well as researchers and quality improvement specialists.

Perhaps the greatest change in recent years is the availability of health-related information to the general public, including both their personal health data and general medical knowledge. Patients as recipients of healthcare have access to data about them generated by healthcare, and, increasingly, they are capturing their own data through sensors and mobile devices.

Information is a resource that can lead to better health and healthcare, but this does not happen automatically. All participants in healthcare must learn to be careful generators, skilled navigators and discriminating users of information. They must approach information with a healthy scepticism about its accuracy. They must know how to filter information to avoid what has been called ‘drinking from a fire hose’ (Friedman et al., 2016).

Data, information, and knowledge

Understanding the distinction between data, information and knowledge allows us to develop different strategies to teach learners to interact in the digital healthcare environment. 'Information' is typically used as an umbrella term for the continuum of data to knowledge, and we follow suit in this chapter. Anchoring the continuum on the data side are the strings of symbols that we are familiar with as raw data. Anchoring the continuum on the knowledge side are rules and hypotheses that help us analyse complex situations. In our current environment, it has all become ubiquitous as it is increasingly stored in a digital format.

> *"Perhaps more than any other recent advance, health information technology (HIT) is rapidly becoming a key foundation for all aspects of patient care. As the complexity of healthcare increases, so does the complexity of collaboration needed between different members of the healthcare team. To evaluate the effectiveness of new treatments and the quality of care in specific populations, individual providers or the team as a whole must be able to rapidly and efficiently collect, analyse, and select intervention and performance data. Regardless of their chosen field, all medical students will have to manage vastly increased amounts of biomedical and clinical data."*
>
> *Triola et al. (2010)*

When knowledge is in a computable form, it can also advise us as to what course of action to take. Knowledge has existed for decades in the form of journal articles and other tomes. Although available, it is not easily accessed and its ability to give on-demand advice is nonexistent. In the last decade, we have seen digital knowledge being leveraged in the form of risk prediction calculators and computable clinical guidelines. The ability to access this knowledge in the moment is a competency that will increasingly be necessary for clinicians.

The ability to access the right information, about the right patient, at the right time to deliver quality and effective care is a benefit that electronic health records (EHRs) give to healthcare providers across the globe. The generation of data by the patients themselves, in addition to all of the data generated by the healthcare system, and the continued explosion of medical knowledge at exponential rates has created a dynamic, fluctuating information environment in healthcare. As clinicians, the ability to recognize what medical knowledge needs to be intrinsic to one's self, what knowledge can be obtained when needed and where to obtain that knowledge becomes another waypoint that must be navigated. The partnership between people and technology is continuing to develop and can fulfill this need. As educators, we must ensure that our learners are able to maximize the partnership between themselves and digital information resources.

Healthcare in the digital age (and biomedical knowledge in the cloud)

In the digital world, information can easily be moved from where it is to where it is needed. The current healthcare environment is evolving to supply data and information from EHRs, emerging knowledge from the learning health system, and biomedical knowledge repositories in the cloud. As these technologies take a foothold, they have effects on medical education, and we will explain the impact of each of these in turn. Increasingly, in this digital environment, and with the explosion of biomedical knowledge, information technology will be required in addition to the decision-making done in clinical practice. This will require a shift on the part of the profession to recognize that best practice will begin to increasingly rely on aids to clinical reasoning and decision making, such as clinical decision support systems.

Electronic health records

A multitude of global sources predict that the movement of healthcare documentation from analogue to digital will continue to evolve, and at a rapid pace. EHRs have been abundant in the United Kingdom since the 1990s, and the continued adoption of digital documentation for acute care continues. Northern European nations, such as Denmark and the Netherlands, have converted to nearly digital systems. A nationwide implementation of the open source VistA EHR occurred in Jordan in 2009. In developing nations, such as Malawi, that are still implementing critical infrastructure, efforts to implement EHRs at the point of care have created networks of healthcare information that improve the quality of care for patients. This continued evolution from paper records to digital ones has several benefits, including increased access for authorized individuals and the ability to perform analyses with greater ease.

In addition to providers who benefit from increased access to their patients' digital information, there are two additional beneficiaries—other providers on a national or international infrastructure, and the health system itself. As the exchange of health information from one location to another becomes more seamless, having a fuller picture of a patient available to them, physicians on the other side of a country or on the other side of the world are able to provide the best possible care to a patient with increased precision.

Learning health systems

This same information is available to the health system at large, allowing it to study and improve itself. The concept of the ‘learning health system’ is continuing to grow in the United States and in Europe. This infrastructure affords simultaneous virtuous learning cycles on a variety of specific health problems. A learning cycle consists of three key phases: (1) the aggregation and analysis of data; (2) the creation of knowledge and its application to change clinical practice; and (3) recording the results of the application and continuous improvement thereafter. The learning health system has a large number of uses, from public health tracking and managing epidemics to the surveillance of drugs newly released to market, to the discovery of new best practices for the treatment of common diseases such as asthma.

"A more efficient, effective, and safe healthcare system requires a more rapid progression of knowledge from the lab bench to the bedside."

Friedman et al. (2010)

Biomedical knowledge in the cloud

As this new knowledge is generated, it is often digitally available before it reaches print, if it ever reaches physical print at all. As both biomedical information (general information about the human body and health) and knowledge (in the form of checklists, best practice guidelines, models and algorithms) become available on the internet, it can be represented in both human readable and computable forms. Both formats will give rise to the 'knowledge cloud', available anytime and anywhere with a connection to the internet. Over the coming decade, the ability to pose biomedical questions to the knowledge cloud, or for the cloud to offer clinical decision support based on the best available evidence will emerge as the best clinical practice.

Aids to clinical reasoning and decision making

Even in the present day, clinical decision support from local systems serves as an aid for the brain capacity of physicians. This, however, is not a new concept. Handbooks are a common item found in the laboratory coats of physicians across the world. The amount of information that one is required to remember to deliver immediate care versus what can be referenced has long since been recognized. The dilemma we face at the present day, and will continue to face in the future, is that the volume of information that we will have to store external to our own brains will continue to increase. The medical profession will need to be ever more comfortable with relying on external sources to provide it with the information needed to deliver effective and safe care to patients. As educators, it is equally important that we are comfortable with this mode of patient care. We must recognize our own biases and current practices. This will aid us in helping our learners develop their own practices based on their innate abilities; understanding what they need to know and what they need to know how to retrieve. This changes the lens with which we examine our learners' performance and the expectations we have for them and that they have for themselves.

"It must be acknowledged, first, that the development of health information technology will require (or enable) cognitively-based physicians to delegate many tasks that

they previously held closely."

Blumenthal (2010)

The digital native learner

Many educators will assume that because our younger learners have grown up with Google and smartphones that they will instantly have proficiency with the digital tools that we supply to them. This is far from true and is a pitfall that many of our colleagues fall into when approaching the so-called digital native learner.

Research has yet to show that the generation that has grown up with digital tools is at large competent with those tools or that those competencies transfer to the academic environment (Gallardo-Echenique et al., 2015). Because these learners are not as competent as you may anticipate, it is important to at first ensure the baseline competencies necessary to engage with digital healthcare environment.

It is probably best to begin with understanding how comfortable your learners are with technology. From an experience of teaching a classroom of younger learners in the same age range, chapter author Patton found the learners' facility with the tools provided to them to be widely variable. Although a few of the learners could easily access a virtual private network and log on to the simulated EHR, other learners had difficulty just logging in to the computer itself. This was Patton's first indication that a section on this topic would be necessary. Before this, he had been quite presumptuous in the learners' collective ability to successfully navigate commonplace technology.

We recommend that, as a baseline, learners will need to be competent in computer and mobile hardware; have facility with accessing the Internet and other digital resources; and be capable of rudimentary searches. Developing the basic information retrieval competencies of our learners may not be so easy. Thompson (2013) found that although learners are facile with rapid communication technologies like text messaging, their ability to perform deep, meaningful searches was lacking. The first step then would be to build up the learners' ability to create search terms that will be appropriate to yield valuable information. This will be covered later in the chapter.

The generational differences that we assume between the ‘digital native’ learners and the ‘digital immigrant’ faculty are an artificial boundary created by our assumptions of the environment that our learners born after 1980 have grown up in, and reinforced by, the popular media (Gallardo-Echenique et al., 2015). As educators, we should instead focus on ‘digital learners’, regardless of the generation they belong to. This allows us to engage with physician learners across the spectrum of their career, and focus on what a digital learner needs at baseline to be successful in acquiring the competencies we will outline in the second half of this chapter.

Three key competencies at a time of ubiquitous information and educational strategies to support the digital learner

A medical education curriculum at a time of ubiquitous information requires changes or additions to current educational goals and strategies. We introduce three key competencies for physician learners, along with the accompanying strategies for curriculum design, delivery and assessment. These are our suggestions to effectively prepare physicians for the information-based future of clinical practice in 2020 and beyond.

Metacognition and sensing gaps in one's knowledge

In the age of ubiquitous information, it may be more important for a physician to know whether their approach to and knowledge about a clinical situation are correct or incorrect rather than it actually be correct. If their assessment of the situation is flawed, and the physician is able to recognize that it is flawed, their ability to access and interpret knowledge from sources external to themselves proves invaluable and they are able to course correct. Physicians who believe that they are correct will not routinely consult available resources. Their unaided actions could presumably put patients' health and wellbeing at risk. The first competency that we are recommending is that the competent physician must be aware of what they do and do not know, and have some insight into how they process information; they must know when to ask for help when making clinical decisions in real time because they have reached the limit of their knowledge about the situation. Collectively, these skills and attitudes fall into the realm of metacognition.

Metacognition

Metacognitive skills are the hallmark of a learner that will be capable of lifelong learning. Mark Quirk (2006) describes the five key metacognitive skills of the physician learner to be: (1) definition and prioritization of goals, (2) anticipation and assessment of their specific needs in relation to the goals, (3) organization of their experiences to meet their personal needs, (4) definition of their own and recognition of differences in others' perspectives, and (5) continuous monitoring of their knowledge and problem solving. The fifth skill, continuous monitoring of one's knowledge, plays a critical role in the day to day of clinical practice. Not discounting the other skills, which are necessary for professional development over one's lifetime, helping learners develop the ability to appraise their knowledge level in the moment could potentially prove to be lifesaving. By providing an environment that allows learners to acquire and utilize these skills, we allow these future physicians to develop the confidence that they will need to act decisively in difficult situations.

Confidence calibration

Described by Friedman et al. (2016), the Confidence Calibration Matrix (Fig. 32.1) displays what happens when a clinician is correct or incorrect when their appraisal about their knowledge is correct or incorrect. The physician is typically safe when they are properly calibrated and appropriately access information. There is the possibility, however, that suboptimal use of information resources results in the clinical assessment switching from correct to incorrect. Using the strategies outlined later we can guard against this.

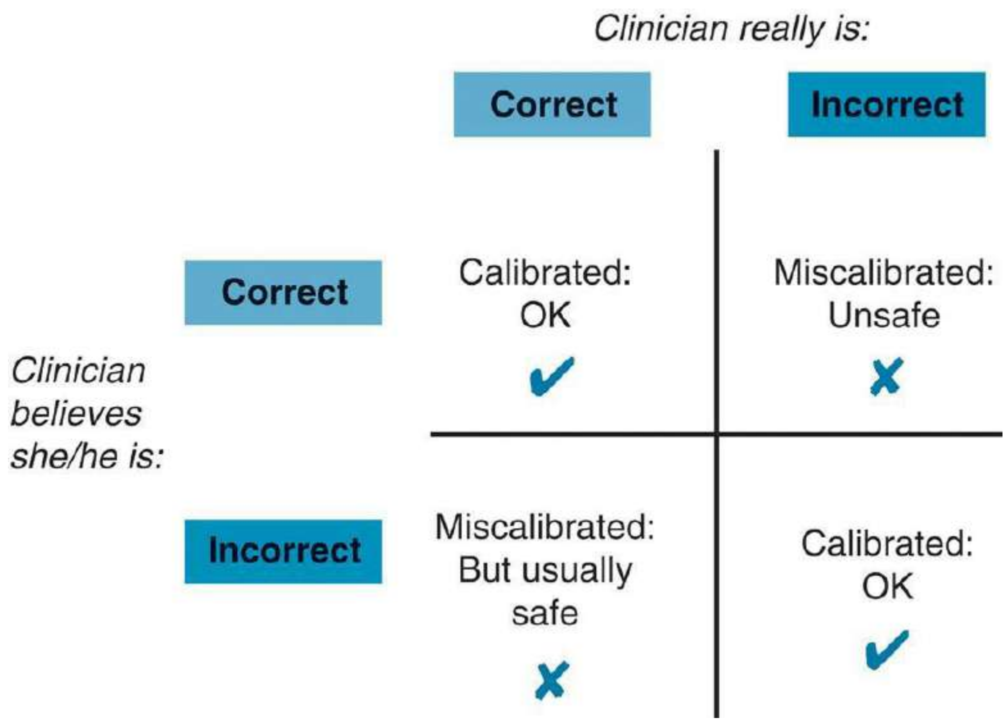

FIG. 32.1 The Confidence Calibration Matrix. (From Friedman et al., 2016.)

The first type of miscalibration occurs when a physician is correct but believes that they are incorrect. Although typically safe, this form of miscalibration results in slower clinical decision making, which could be hazardous in some clinical situations. The second type of miscalibration occurs when the physician is incorrect but believes that they are correct. This is the most dangerous situation because the physician will not seek assistance from the appropriate information resources. Even when decision support tools sense a problem, this physician will likely ignore the advice.

It is difficult to guard against this second type of miscalibration. Individuals in this state will not seek help, and others will only recognize their deficiency once a medical error is made. Preventing learners and physicians from entering this state by reinforcing the following point is the best cure for this ailment.

The salient identification for medical teachers is the learner that is incorrect and recognizes that they are incorrect. This requires a change in culture where not knowing the answer but recognizing one's knowledge gap and knowing how to bridge the gap in one's own knowledge is equal to or greater than having the right answer. The learners that meet this competency will be able to understand their own thought process and knowledge; access and retrieve available resources; and use those resources to make corrections to their thoughts and actions.

Demonstration and assessment of metacognition

A strategy to have learners demonstrate this behaviour could be used during rounds when learners are presenting on patients, or similarly in small groups discussing scientific principles. Preceptors should routinely ask the learners about their level of confidence in the assessment they have made and what evidence brought them to that conclusion. This promotes the behaviour of consciously considering one's confidence level. With habituation this will be a routine inner dialogue for the learner—to evaluate their confidence about the assessment of a clinical situation.

To reinforce this approach, practicing physicians should model these same types of behaviours. As medical educators we will need to become more introspective about, aware of, and willing to discuss our own confidence and levels of calibration.

Tip

The value of reflection continues to be questioned by learners. Be certain to help them understand the value of such activities to create buy-in and allow them to do meaningful work.

Reflection of this type is a good way to assess this metacognition competency. Through carefully designed guided reflections, learners will be able to self-monitor and receive feedback from others (Sandars, 2009). Assessment of the reflection should include comments on the depth of reflection, examination of one's own perspective, and inclusion of the perspective of others.

Information retrieval and the ability to form an appropriate question

Whereas the first competency addresses the ability to recognize gaps in one's knowledge, the second competency ensures that the skills are in place for the learner to frame a good question and access available resources to improve their incomplete knowledge. However, to know where to look, there must be some basic understanding of the subject at hand.

To illustrate the point, consider three potential states of being for the learner or physician before interacting with digital resources (Fig. 32.2). In the first state, the individual has insufficient knowledge about the problem of interest to frame an appropriate question. The learner in this state will not be able to obtain assistance from any resources and will be unable to address their current situation. In the second state, the learner has partial knowledge about the problem of interest and will be able to frame a good question. In the third state, the learner's personal knowledge is already complete. In this final state consultation with information resources is not needed; however, as the volume of biomedical knowledge continues to explode, learners are unlikely to reach this state by the end of their careers.

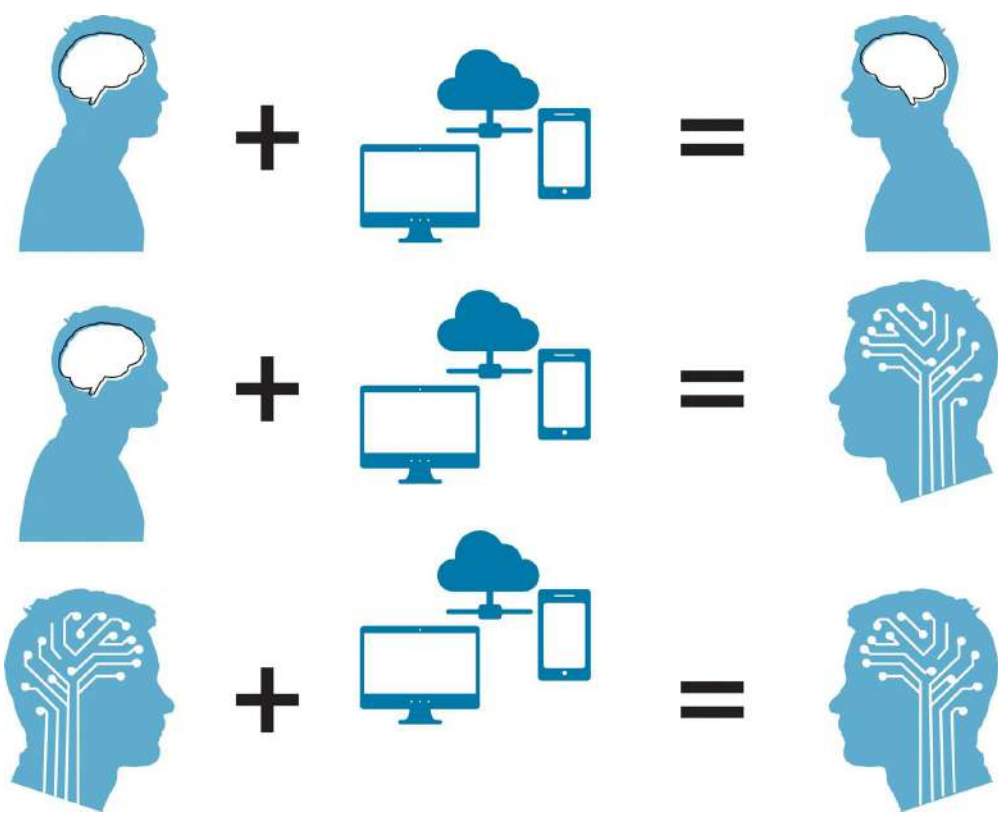

FIG. 32.2 Effects of ubiquitous information on different states of knowledge. *Top:* With insufficient knowledge, the person cannot frame a question and does not increase their

knowledge. *Middle:* With partial knowledge, the person can pose questions to the available resources and increase their knowledge. *Bottom:* With (nearly) perfect knowledge additional information is not needed. (Modified from Brain by Wes Breazell from the Noun Project; Cloud Server by Creative Stall from the Noun Project; Computer Icon by Creative Stall from the Noun Project; Mobile Phone by Cengiz SARI from the Noun Project.)

Foundational, advanced and specialized medical knowledge

Delivering this competency to learners requires a shift in focus from providing every possible piece of knowledge to learners before they exit our doors to one of learning what they need to know to frame an appropriate question. This educational approach places an emphasis on the organization of knowledge in curricula to adequately describe what is truly foundational knowledge for learners, compared with what would be advanced knowledge or even specialized knowledge. This is a departure from teaching a large volume of knowledge and a shift to teaching foundational knowledge that serves as a scaffold to prepare learners for advanced, and subsequently specialized, medical knowledge.

Tip

Curriculum inventory software, including several free to use packages, simplifies the task of compiling curriculum data. Sharing, making visualizations, and deriving meaning from the data become easier.

Cataloguing the existing curriculum is the first step in reorganizing it to effectively deliver the right knowledge to the learner at the right time. Many schools are beginning to inventory what they teach and where, documenting learning objectives for each session that they give to their learners (Dexter et al., 2012). To fully realize the potential of what has been collected, tagging content according to its level of abstraction from facts to high-level principles will help filter what must be taught from what can be sought by the learner. Once this inventory is available it becomes relatively easier to restructure the curriculum to deliver foundational scaffolding knowledge to early students, advanced knowledge to your more senior medical students, and supply specialized knowledge to those who will need it in their practice.

Framing an appropriate clinical question

Informationists and librarians play a key role in educating physician learners about framing an appropriate clinical question. Once an appropriate search has been devised, assessing which sources of information can best answer that question can be guided by the librarian. Librarians use heuristics like reputation of source, methodology of creation and date of publication to help them make recommendations. Learners and medical teachers can also use these heuristics to evaluate sources of information.

Physician learners will require practice in formulating good questions to prepare them for the digital information supported practice of the future. To accomplish this, information retrieval sessions could use currently available versions of cloud knowledge resources that are mature enough to provide valid advice—even if these tools are not yet mature enough to be deployed in clinical practice. In doing this, we can take advantage of the fact that simulated clinical problems posed in the classroom mirror future practice. Even though this technology is still being developed, it can be used in these situations to help learners develop skills they will need in a future when that technology is more mature and widely deployed. In general, the curriculum should challenge learners with problems that require use of the digital information resources, whatever the state of those resources might be at that point in time.

Assessment of information retrieval and analysis

To assess the ability to frame an appropriate question and retrieve the appropriate information, examinations should allow learners to demonstrate this competency via 'open book' exams. This shift from 'closed book' exams aligns with the shift from learning a large fund of knowledge to knowing what you need to know to learn more. Given the ubiquitous nature of information in the digital age of healthcare, there is little justification to continue the custom of 'closed book' exams at the level we currently practice.

Enacting this assessment strategy can be accomplished using a modification of the triple jump exercise introduced at McMaster University (Smith, 1993) (Fig. 32.3). The first pass is a closed book examination based on the learner's personal knowledge only. This first pass provides a 'scaffold score', which assesses their foundational knowledge. In the second pass, the learner can access information resources to provide a refined answer to the problem at hand. This second exercise provides two scores: a 'process score' related to how well they were able to use the available information resources and an 'examination score' of how well the learner was able to perform assisted by the information in their environment. In the final jump of the assessment, the learner presents their findings from the second exercise to an assessor that can interrogate the learner's knowledge and process in the moment. The final jump verifies the learner's ability to access knowledge and understand their thought process in real time.

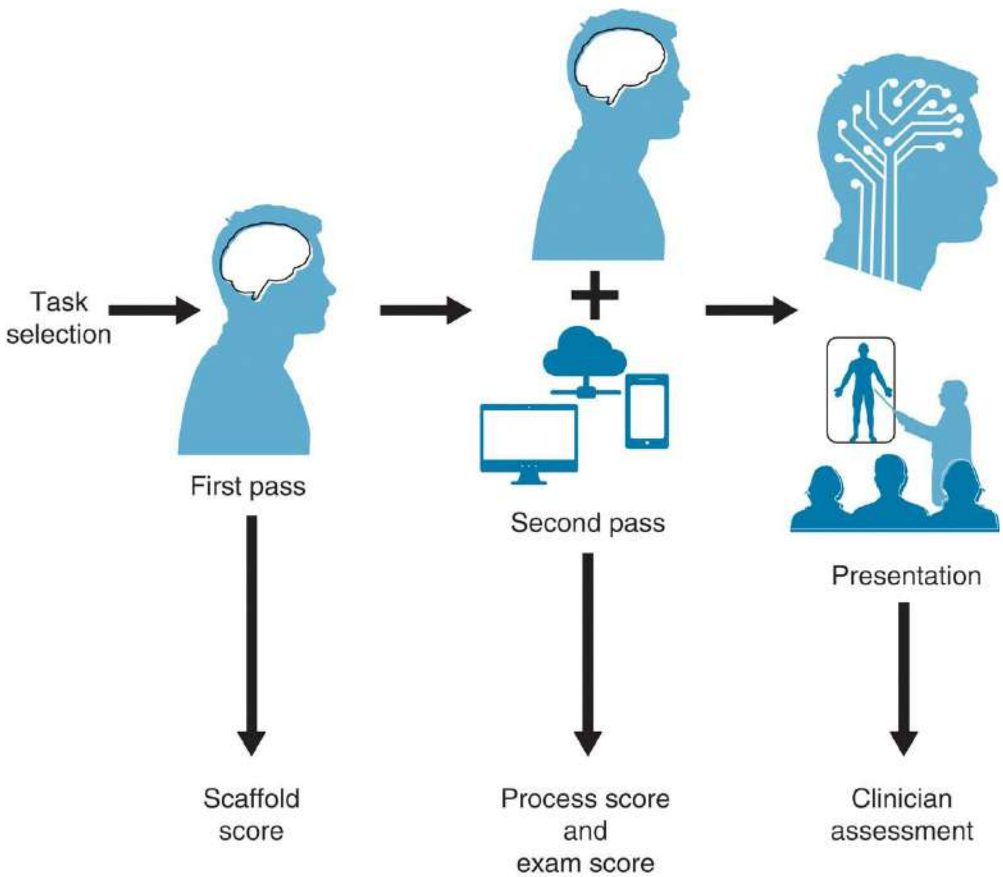

FIG. 32.3 The triple jump exercise in the era of ubiquitous information. (Modified from Brain by Wes Breazell from the Noun Project; Cloud Server by Creative Stall from the Noun Project; Computer Icon by Creative Stall from the Noun Project; Mobile Phone by Cengiz SARI from the Noun Project.)

Tip

Following the learner's digital trail, collection of experience data can be achieved via the Experience API (application programming interface [xAPI]) and a Learner Record Store. http://experienceapi.com/overview.

Evaluating and weighing evidence to make decisions; recognizing patients and interprofessional colleagues as additional sources of information

A discriminating user of all the information resources and knowledge repositories of our digital healthcare environment must be able to deal with and handle uncertainty. The third competency ensures that learners will have the knowledge and skills to evaluate, include/exclude and weigh all available evidence. Some of the evidence will come from clinical guidelines and e-textbooks. Real-time evidence will be generated from the learning health system, and the responses that the system generates will be accompanied by confidence measures for the results. In many scenarios, clinicians will be faced with incomplete and/or conflicting information. Therefore part of the knowledge scaffolding of the physician in the digital age must relate to decision making under uncertainty.

Tip

Rather than teaching evidence-based medicine as a block early or late in a programme, consider threading it through every year.

To achieve the delivery of this competency to learners, increased curricular attention must be given to topics like formal decision modelling and analysis; evidence-based decision making; critical evaluation of the literature; metaanalysis; and data mining and signal detection. In recent years, medical schools have begun to introduce to the topic of evidence-based medicine to our learners, and it has become more prevalent in clinical practice. It has been a struggle to make this appear relevant to learners and practising physicians alike. The need for this competency across the continuum of learners will become increasingly apparent as we continue to move into the era of ubiquitous information.

Assessment of uncertainty/shared decision making

Objective Structured Clinical Examinations (OSCEs) can be designed to assess for this competency. A complex clinical case, with a patient that has several social or cultural considerations involved as determinants of the decision, would serve as an excellent example. Learners would need to demonstrate their ability to gather the necessary information and incorporate statements about their confidence in the knowledge they have, or have obtained, into the explanation of their decision.

Tip

How learners weigh evidence and handle uncertainty can be incorporated into Mini-CEX (clinical evaluation exercise) assessments.

Summary

It is an exciting time in healthcare as more of the information about patients and medical knowledge become available digitally. Although there are baseline competencies required for practice in this new era of ubiquitous information, the three key competencies we have outlined will be critical to the success of physicians in clinical practice beyond the next decade. The ability to sense the gaps in one's knowledge will serve to reduce medical errors by improving the confidence of physicians in their medical knowledge. The ability to quickly form appropriate clinical questions and access relevant, reliable sources of information will prevent physicians from becoming overwhelmed by the large volume of information at hand. Finally, the ability to evaluate and weigh the available information will help physicians handle the uncertainty that exists in their environment.

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