

Twenty-First Century Immersion Technologies in Health Professions Pedagogy



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INTRODUCTION

“Life is not a problem to be solved, but a reality to be experienced.”

Søren Kierkegaard (1813-1855)

The justification of pedagogy in the context of Extended Reality (XR), which encompasses Virtual Reality (VR), Augmented Reality (AR) and Mixed/Hybrid Reality (MR) has become an ongoing source of complex ambiguity over the last decade, that the COVID-19 pandemic has only served to exacerbate (van der Niet and Bleakley, 2021). Ensuring the validity and reliability of XR experiences within health professions education remains central to the potential to rule out technologies as adjuncts to optimal pedagogic practice as an authentic means of providing insight and illumination of medical contexts, scenarios, and disease processes (McGrath et al, 2018). For the purposes of this chapter there will be four fundamental operationally definitive terms of what the umbrella term XR encompasses, firstly VR refers to the use of computer technology in the creation of simulated learning environments. Secondly, AR pertains to the addition of computerised content as an overlay to reality, which means that learners can actively interact both with real world and augmentations of it at the same time. Mixed or hybrid reality refers to the transection of virtual worlds and actual worlds, where physical and computerised objects can interact and exist concurrently. XR encompasses all of these and as a collective they have revolutionised health and medical training, particularly in relation to the practise of risk management and professional role identity in life and death situations, for example obstetric emergencies, as reported by Hayes, Hinshaw and Petrie (2018).

Training for the strategic management of risk in healthcare practice in situated contexts of healthcare provision has been a key focus in the use of XR in practice (Hilty et al, 2020). Not only does it involve rational aspects of cognitive knowledge or the purist demonstration of psychomotor skills and affective domain learning (Zulkifli, 2019). It also encompasses the intuitive, tacit and largely intangible intellectual instincts that develop with sustained experiential learning (Humpherys, Bakir and Babb, 2021). One of the key issues has been the challenge of assessing the last of these, what XR has enabled is the benchmarking of perceived levels of interprofessional and multi-disciplinary teamwork, where intuitive knowledge can be used to measure risk, regardless of the level of the organisational hierarchy within which personnel are employed (Goh and Sandars, 2020; Hayes, Hinshaw and Petrie, 2018). This chapter will explore the key epistemologies or ways of knowing, from a theoretical perspective, that can be used to ensure the level of authenticity necessary to highlight the pedagogical shifts in the application of

DOI: 10.4018/978-1-6684-7366-5.ch023

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learning theory which now characterise responsive curriculum design and adaptation to accommodate XR in practice.

BACKGROUND

The ongoing pandemic, which on February 14th, 2023, had reached 755,703,002 confirmed cases and 6,836,825 million fatalities, has not only changed the world of education in its current form, but it has also likely altered its mechanism of delivery for the foreseeable future (WHO International Data, 2023). In practice the pandemic has seen universities close, a switch to hybrid models of learning and education, a social science, depleted in terms of its capacity to engage people in face-to-face meetings (Okoye et al, 2021). The plethora of academic articles surrounding online learning is phenomenal, but few address how a fundamental paradigm shift in Higher Education is implemented methodologically (Luctkar-Flude and Tyerman, 2021). What is usually described is a narrative description of the processual use of technological intervention, rather than any degree of alignment in terms of underpinning theoretical justification for implementation, or indeed the constructive alignment demonstrating best how processes of assessment can effectively be driven by complementary processes of teaching and learning (Moreira, 2020). The physicality of learning has also been altered beyond recognition, seeing people as upper torsos and faces has changed everyday interaction in the situated nature and context of learning, yet minimal evidence exists as to the long term impact of this on motivating, engaging and sustaining active processes of learning, teaching and assessment on an individual level (Park and Kim, 2020). By over reliance on the physicalism of the articulated voice and postural positions of the upper torso, executed in an atmosphere of scrutiny, learners have had to change their interaction so that their degree of interaction is heavily influenced and constrained (Obrad, 2020). Whilst predicting how global disease and inequality will influence the future of education, it is impossible to ignore potential challenges that lie ahead for Higher Education (Bevins et al, 2020). It is possible to inferentially predict that COVID-19 may be one of the first of a new generation of global pandemics that will need to be dealt with alongside dramatic changes in overall global warming, which will also ensure that populations which are densely populated suffer most severely (Negev et al, 2021). Alongside the issue of pandemic disease is the prospect of global catastrophes and natural disasters occurring far more frequently and necessitating support and address now. The progressive redevelopment of existing technology to accommodate this is more than apparent, so that learners can engage physically in medical and healthcare settings with less extensively sized equipment and a greater capacity to seamlessly integrated extended reality into all practice (Yigitcanlar et al, 2020). Geographically there are other issues at play, in terms of the accessibility of technology across global outcomes, with the result that some countries cannot be guaranteed adequate internet access, bandwidth or the cost of the technology products may simply be prohibitively expensive (Horton, 2021). Being cognisant of this necessitates ensuring both affordability and accessibility across the globe if the differential inequity between countries is to be addressed on an ongoing basis. Being able to standardise and regulate experience for learners is also of fundamental importance if equity and parity of experience are to be assured across these programmes (Crouch et al, 2021).

Pedagogical design and its address within the context of Higher Educational institutional curricula often places processes of curriculum justification and design under scrutiny (Annala et al, 2021). This is largely attributable to the complex ambiguity that curriculum designers have to contend with, in terms of the technical capacity of XR equipment and the accompanying resources they necessitate (Aebersold and Dunbar, 2021). A key example of this is the multi-disciplinary perspectives that designed scenarios must authentically represent within the context of health and medical education, where XR is implemented in practice (Antoniou et al, 2020). Because of this, the concept of experiential learning has become a focus for the opportunity of ensuring that XR is relevant to real world application in practice, with the introduction of its continuum's integral parts (AR, VR and MR). The published evidence to date demonstrates that XR training has been shown to improve learner performance skills across an array of learning domains (cognitive, affective, and psychomotor) within the context of instructional simulation (Tabatabaei, 2020). Having moved firmly from proof-of-concept pilot studies, XR as an embedded part of health and medical curricula is being used across a wide variety of simulated contexts (Tang et al, 2020). In comparison to traditional didactic teaching methodologies the benefits are seen within the areas of student motivation, confidence and the capacity of learners to take measured risk within the context of a consequence free facilitative environment where constructive feedback on performance can inform reflexive praxis around complex ambiguity and clinical decision making. Acclimatisation to new contexts and settings, for military learners, for example is invaluable, where introduction to new unfamiliar climates and contexts is undertaken via constructivist experiential learning opportunity in interactive immersive scenarios, where the pace and timing of exposure can largely be controlled in line with learner need (Cobos, 2020). The addition of iteratively increasing levels of complex ambiguity as skill increases is another opportunity for the formal scaffolding of learning within customised immersive experiences (Orr et al, 2020). Depending on whether learning is about the magnification of micro- theoretical concepts such as, for example atomic level particles, blood corpuscles or synaptic junctions or whether learning is centred around macro social constructs such as social justice and equity in different contexts of culture or climate, immersive technology with XR has the potential to extend the reach within and between academic pedagogies and disciplines and as a direct consequence impact on the capacity and capability of multi-disciplinary and interdisciplinary professional working at the front line of patient care (Mitchell and Boyle, 2021). Confidence underpins learner motivation and in turn elevates levels of competence, which ensure this iterative cycle continues (Owens, 2021).

Roussin and Weinstock (2017) detailed the pedagogical challenges faced by educators and trainers leading simulation-based training in the context of healthcare and medical services. In relation to the theoretical underpinning of their work, they presented the complexities of managing programmes in relation to single and double- loop experiential learning and the impact of organising organisational hierarchies in relation to the need to gain experiential learning in practice. Whilst their work omits specific reference to the implicit value of tacit knowledge in crisis situations, the functional insight they provide in relation to situated learning is invaluable in relation to the overall administration of optimal multidisciplinary and interprofessional teamworking scenarios. Most significantly their research demonstrated the application of scaffolded learning to the point of autonomy, consistent with Vygotsky's Zone of Proximal Development (1978) but also Argyris' acknowledgement of the relevance of single and double loop learning and the need to challenge and reconcile assumptions relating to the acquisition of knowledge through experience. Both raise important issues in terms of the longitudinal provision in education with XR, in relation to the phasing and iterative presentation of learning outcomes,

each serving to consolidate consequent stages of learning within and between cognitive, affective and psychomotor learning domains.

DRIVING AUTHENTIC LEARNING VIA PEDAGOGICAL JUSTIFICATION

Pedagogical design of the blurring of where reality and actuality co-exist within the context of digital immersion underpins the concept of validity in XR. While pedagogical research and applied praxis are still at the mercy of technology to a certain extent, as the virtual world becomes progressively more advanced, then so too will the capacity and capability for authenticity and validity within medical and healthcare education and training (Ligtart et al, 2021).

It is useful here, to consider the degree to which VR, AR and XR have been integrated across the health professions within differing signature pedagogies and the cognitive, psychomotor and affective learning domain skills necessitating address. It is here that some healthcare professions can be delineated in terms of their functional involvement in patient centred care. For example, dentistry and physiotherapy have relatively functional interventions, whilst the work of a podiatrist, due to the ergonomic positioning of a practitioner, entails more of an opportunity to engage psychosocially with patients during their appointments (King et al, 2018). Indeed academic debates have historically been posited about the functional basis of such healthcare professional roles as dentistry, since they are so functional in nature that people queried whether they could actually be regarded as a profession at all (Welie, 2004). The other implication is the stage of learning that medical and allied healthcare practitioners have reached in their career trajectories, where VR, AR and XR may be implemented most appropriately. The majority of published literature to date focuses on learning ‘in situ’ whereas the assessment of learning longitudinally in the context of real life praxis, is often evaluated with a degree of tokenism by those whose initiatives have introduced simulation in the first place.

The operationally definitive terms of VR, AR and XR are significant when considering the nature of the artificial environments that are created in the exploration of potentially risk filled scenarios, which emulate the real world (Alnagrat, Ismail and Idrus, 2021). This is primarily in relation to how artificial intelligence can be embedded within the context of virtual and simulated learning experiences, which also have to be optimally facilitated by staff skilled in the field of clinical simulation (Abbas, Kenth and Bruce, 2020). Central to progression in these aspects of a pedagogical paradigm shift, is the need for active dissemination and sharing of knowledge creation and acquisition that happens at the front line of medical and healthcare education where simulation in the context of XR are the expected and anticipated norms of undergraduate and postgraduate academic curricula across HEIs (Luo et al, 2021).

IMMERSION IN LEARNING EXPERIENCE

AR and VR enhance health professions education via immersion in learning experiences, positively influencing levels of engagement and motivation and by creating an atmosphere of interactive dialogue, which in terms of social inclusion can have a direct impact on the reduction of learner stress and anxiety (Brandon, Freiwirth and Hjersman, 2021). Encompassed by the umbrella term of XR, AR, MR and VR all bring a signature technological approach to applied praxis in the context of healthcare professions. In instances where different levels of sensorial intrusion are now widely used to extend the reach of pedagogic practice in medical and healthcare education and training, this has broad ramifications, not only on the

practical delivery of emergent technology in practice but on their pedagogical theoretical justifications as well (Robert, 2021). In instances where the affordability and hence the extent of digital technology available determines accessibility in practice-based settings. In terms of a hierarchy of availability, AR is perhaps the most widely available and least invasive of all XR and can be easily accommodated by readily available display systems (Suryanti et al, 2020).

In instances where the need for the relevance of space and situatedness and context is of fundamental importance, then MR is the best platform for integration into available physical environments. In this sense MR fills the gap that VR leaves, in permitting users to physically interact with pre-identified physical spaces (Silén et al, 2008). Dimensionality is also of key importance in terms of whether the ability to facilitate visualisation in 3-D is something which can actively contribute to the acquisition of tacit knowledge and actively contribute to a more finely tuned intuitive response to any given scenario in medical and healthcare practice (Gerup, Soerensen and Dieckmann, 2020). MR effectively bridges the gap between AR and VR as a consequence of the development of the hardware capability of display screens and visualisation resources (Juraschek, 2018).

Research into XR pedagogical initiatives and methodological designs is usually characterised by relatively small-scale case studies, focused on the collection of qualitative data rather than tangible quantitative evidence about the impact of XR in practice (Hamilton, 2021). Those which have succeeded in this, tend to focus specifically on psychomotor skill or level of cognitive improvement rather than affective domain learning. The concept of tacit knowledge is also one which remains relatively underexplored and which remains almost a hidden bonus in developing the confidence of collective team hierarchies in clinical and medical practice. making generalisability of findings to other contexts and settings. Whilst this is a disadvantage, the potential for transferability of findings within and between similar situational contexts and settings across the global can be quite high in terms of overall content validity (Levitt, 2021).

The majority of XR technologies now extends the bridge between simulated environments and their polar opposites in physical reality. The rate of progressive developmental platforms has been amplified and magnified by the global COVID-19 pandemic, which has contributed to a paradigmatic shift in learners centred hybrid and hyflex learning and teaching opportunities across the medical and healthcare professions pedagogies (Acharya, 2021). As signature disciplines, these professions have maintained a certain degree of reticence to engage fully immersive technology within the context of clinical healthcare practice, since this completely detaches the clinician from their normal parameters of visual capacity. Whilst lenses are acceptable, they also permit and maintain human characteristics and gestures such as established eye contact and that degree of connection, which patients deserve and need (Jongerius et al, 2020). This has been particularly evidenced within the context of brain and cardiac surgery, both of which have optimally utilised these technological advances for the patients they serve.

TRADITIONS IN MEDICAL AND HEALTHCARE EDUCATION

Across the continuum of signature pedagogies that contribute directly to medical and allied health education, it is anatomy and mathematics which arguably transcend most disciplinary boundaries (Hayes and Capper, 2020). The visualisation techniques, which both permit and facilitate enhanced pedagogical teaching methodologies respectively appeared first in the context of simulation within the aviation industry at the beginning of the 20th Century. Their developmental progression over the last century and the early part of the 21st Century has ensured that levels of complex sensory and visual experience have now become a mainstay of medical and healthcare education and training programmes (Jentsch

and Curtis, 2017). In the sense of providing students with the opportunity to undertake complex and risk inclined procedures, simulation is an invaluable resource. Within the context of safety, processes of experiential learning from practice can be fully exploited without there being any tangible, negative consequences in reality, so that unwanted outcomes can be illustrated and acknowledged without them actually ever having to come to fruition to do so.

Resources and student access to them have been a key issue during the pandemic, particularly for health and medical students for whom access to real- life anatomical models and cadavers may have been completely negated (Hilburg et al, 2020). For these students XR has ensured an opportunity for continued engagement with the discipline of anatomy and physiology across a range of contexts and settings. Since learning is extensive in relation to the need to develop a 3-D knowledge of bodily organs and systems, then the spatiality that XR offers also permits dynamic interaction, which otherwise would not be possible. In relation to the functional role of bodily organs and systems, XR has the added advantage that simulation of the dynamic motion of the body can be visualised as a learning resource, in contrast to cadavers, which are obviously non-functional (Ziker, Truman and Dodds, 2021). Within this simulation, it is also possible to identify, isolate and examine the individual functionality that specified aspects of these systems perform via repeated familiarisation. Ensuring learners iteratively progress from novice to expert within the use of XR of this nature, also ensures that learners can work in a risk free environment, which nevertheless serves to introduce them to the experiential learning which can form a solid foundation for their future professional careers in healthcare and medicine. In terms of pedagogic design and academic rigour the use of XR also provides an ideal opportunity to benchmark functional skills acquisition, alongside the real-time assessment of clinical practice and the opportunity for them to be exposed to sensory feedback from the situated learning they undertake (Kang et al, 2021).

BUILDING CAPABILITY FOR CLINICAL EDUCATORS WITH XR

The education and training of future medical and healthcare staff is not only dependent on disciplinary expertise but also the capacity to provide optimal learning experiences which in turn drive processes of assessment which are authentic and have real world validity and credibility (Voštinár et al, 2021). Future practitioners of all disciplines across the health and wellbeing continuum not only have to use evidence-based practice to discern clinical decision making, they also have to continually use scientific published evidence to iteratively update their continuing professional development in practice (Agha, 2021). As methodologies of pedagogic practice have become progressively more student there has been increasing emphasis on a move away from traditional rote learning to mechanisms of interactive, engaging processes of learning, which ensure deep rather than superficial learning across all aspects of education and training. Alongside this, is the recognition that learning driven purely by pressure to ‘perform’ within the context of examinations is futile in the truest sense of meaningful learning opportunity. In order to achieve this, XR can be regarded as a significant tool in the armoury of medical and healthcare educators who use this form of specialist resource to reinforce, motivate and enhance learning opportunities through authentically, strategically and constructively aligned academic curricula in Higher Education (Howell and Mikeska, 2021). Future practitioners also need the capacity to be educated in authentic situated learning contexts which are:

- Based on principles of diversity, equity and inclusion in terms of both optimal provision and optimal service to global, national, regional and local practice areas.

- Built on an ethos of compassion for all recipients and a respect for human life and wellbeing.
- Co-constructed with medical and healthcare service users and their families and carers.
- Designed on the basis of evidence-based healthcare practice and evidence-based processes of educational provision.
- Drivers of high quality multi-disciplinary and interprofessional patient centred teamworking.
- Effective in their capacity to drive education in relation to health and medical outcomes for patients at the front line of clinical care.
- Globally responsive and globally focussed
- Pedagogically designed and responsively designed on the basis of need and healthcare priorities in applied practice.
- Responsive in their capacity to dynamic and iterative change in healthcare landscapes.
- Specifically designed to value and promote autonomous learning, capacity for teamwork and proactive higher order critical thinking in relation to problem solving in health and medical care practice.

Within the context of XR integration, each pose individual challenges in relation to ensuring that digital technology is only ever seen as an adjunct to medical and healthcare education for the human race, not merely a functionalist or solely objective driver of it (Gandolfi, Kosko and Ferdig, 2021).

EXPERIENTIAL LEARNING THEORIES

The grander philosophical debates of perceived versus actual reality on an individual and collective basis are central to the processes of teaching and learning with XR. As a tool for the enhancement of understanding, meaning making and then critical reflection on practice, digital technology is invaluable as an adjunct to the human facilitation of knowledge, skills, attitudes and behaviours (Logeswaran et al 2021). The philosophical underpinning of experiential learning has its origins in constructivism, which is central to the acknowledgement of truth, either perceived or actual, and the capacity of all individuals to construct a perspective on truth based on their immersion in experience and the meaning they make of it (Koufidis et al, 2021). In this sense education is an entirely different experience for everyone who experiences the same phenomena and it is this individual experience and perspective meaning making, which lies at the heart of both collective and personal processes of transformation. The construction of a version of reality ensures that different perspective lenses can be applied to the same phenomena, so that scrutiny from several sources of triangulation can take place. Whether the experience differs collectively between adults and children in terms of capacity for meaning making through experiential learning was the source of seminal debate in the late 20th Century, with Knowles assertion that there was a distinction between andragogy, in terms of ‘adult’ ways of knowing and that of ‘pedagogic’ or child-based learning. What is arguable more relevant is the concept of lifelong learning, across which learning takes place from the cradle to the grave, as a temporal mechanism of integrating the prospective with the retrospective and making inference from it as part of the integral processes of reflection and reflexivity (Loeng, 2021).

THEORETICAL UNDERPINNINGS OF XR PEDAGOGY

Experiential learning has become a byword for the placement experiences that medical and healthcare students undertake as an integral part of their undergraduate studies with patients, whose consent, briskly acquired provides novice learners with an opportunity to build confidence and be guided by an ever vigilant and highly respected disciplinary expert observer. In instances of postgraduate study, it may conjure the image of a professional moving from competence to proficiency and consequent mastery of their specific field of disciplinary context (Mortimore et al 2021). Medical training to the uninitiated is instilled with the imagery of cadaveric dissection as a means of visualising what lies beneath the skin that is to be negotiated across a respected lifelong career. In contrast to practice-based experience at the front line of patient care in the context of care provision, though, the two are very different. It is here that whilst disciplinary knowledge and skill are invaluable to the expert educator, that skills of pedagogical praxis are equally important if the acquisition of knowledge which will underpin this lifelong career is to be assured and validated in practice. The theoretical underpinnings of learning and teaching have resonance in relation to the eventual capacity of medical and healthcare students not only to make meaning of experience but also to question that which cannot be taught, the tacit and reflexive response to intuition, which can only be derived from inner conscience and derived from processes of experiential learning in the psychomotor, cognitive and affective domains of learning, which can be tangibly assessed and used to benchmark fundamental knowledge and skills acquisition (Birt et al, 2018). Similarly, the capacity to transfer knowledge from the context of learning to the real world with patients who have an immediate need for assessment, diagnosis and consequent management is highly relevant to the potential to scaffold knowledge as clinical learners each move from the state of disciplinary novice to expert (Durning & Artino 2011)

MEANING MAKING IN HEALTHCARE PRACTICE

At the heart of capacity to learn and build on pre-existing experience is the theory of constructionist philosophy which when integrated alongside sociocultural perspectives from processes of active participation lies at the heart of all learning. The delineation between and linkage across theory and practice has become a fundamental goal of all involved in workplace education and training (Dennick, 2016). Since learning is both an individual and collective experience in the same sense as learning. What the Covid-19 pandemic detracted from was the fact that education is a social science, wholly reliant on interactivity and the derivation of meaning from multi-faceted and complex situational specificities, which when grouped as a collective constitute human experience. Being able to understand and frame the margin between knowledge and research entails a consideration of both the origin and consequent history of learning (Ten Cate and Billet, 2014). Alongside this, it is also necessary to consider how knowledge acquisition is gradually scaffolded through experience from novice to expert and to value those contributors to pedagogic practice who have acknowledged and formally recognised this (Graf et al, 2020). Whilst Kolb is often regarded as the seminal theorist of experiential learning, however there are several others of direct relevance to the pedagogical implementation of XR (Heong et al, 2020). Rooted in constructivist perspectives, Kolb's is of relevance since its focus lies in the translation of experience from external sources into epistemic cognition and meaning making on an individual basis. Kolb's theoretical perspectives are of importance when considering the processes of experiential learning, which in turn contribute to elements of subconscious bias that inevitably contribute to the profes-

sional identity of educators from specific signature pedagogies and disciplines. Social learning theory also plays a significant role in the development of experiential learning. It is a perspective upon which health and medicine have drawn heavily upon in the shaping and framing of new pedagogical perspectives. It frames learning outcomes in the context of their impact in applied praxis rather than in terms of their individual impact and acknowledges that these are often a natural by-product of distinctive social cultures and contexts. This also aligns with the concept of lifelong learning within which there is the acknowledgement that learning is dependent on levels of increasing experience (Hartman et al, 2020).

SCAFFOLDING LEARNING

XR provides an environment where the context of safety ensures that learners can iteratively be scaffolded through processes of knowledge acquisition and the basis of psychomotor skill competency and eventual mastery can be gained and evidenced in practice (Adefila et al, 2020).

One important aspect of the integration of XR though, is the degree to which it increases non-patient-based learning and the potential impact of this in relation to a lack of authentic human interaction across health and medical curricula. What this debate highlights are the significance of strategic curriculum design and justification across all programmes, where pedagogical constructive alignment is pivotal to outcomes-based assessment techniques and the credibility of their implementation. Similarly, where variations and combinations of XR are integrated across academic and clinical curricula then the technology selected ought to be aligned with the need for the acquisition of specific skills and techniques. The integration of XR and its components does ensure, however, that during the process of learning and the acquisition of new knowledge, skills and behaviours that ensure:

- Aims and objectives can be aligned with the opportunity for ongoing feedback and the opportunity to rehearse and develop new skill sets from novice to expert.
- Benchmarking of learner performance can be isolated into specific learning domains and assessed accordingly, with the potential of identifying individual learning need.
- Interruption and hence unnecessary and unwanted distraction, during the process of learning, can be avoided
- Patients can avoid any risk in terms of discomfort or the need to move regularly, as learners iteratively develop and refine new skills, where they can focus on domain specificity until a level of competency and eventual mastery is reached.
- That individual learning styles can be accommodated and encouraged by constructively aligning individual learning outcomes within each teaching session, where time permits.
- That psychomotor tasks can be repeated so that exposure, practical viability and accuracy can be iteratively increased.
- The opportunity for focused learner reflection on specific aspects of knowledge and skill acquisition and a reflexive approach for the address of individually recognised shortfalls.
- The theory-praxis gap can be gradually reduced by scaffolding learning and gradually increasing exposure to real life contexts where patients and their families are an integral part of authentic learning.

Non-technical skills such as interprofessional working and multi-disciplinary team working and the clinical attributes they necessitate in terms of optimal interpersonal communication and the management

of the clinical environment characterise the skill sets necessary to ensure the achievement of holistic learning in proficient practice (Dehghani et al, 2021). Examples where this is now integrated in practice are in the skills and drills training, where it is also possible to integrate aspects of complex ambiguity and stress into situations, where a clear integration of psychomotor skill, affective and cognitive domain knowledge and application are necessary within any given scenario (DeMaria and Levine, 2013). It is these learning needs that high-fidelity clinical simulators address, so that once basic competence in a skill has been achieved then additional emotional stress and the need for instantaneous clinical decision making can be assessed. Whilst simulation is not an active replacement for the adrenaline rush faced, it does offer an insight within learner centred experiential learning of the potentially uncertain scenarios that health and medical professionals often face in the real world. The portability of simulators such as ‘SimMan’ and ‘SimMom’ also provides the opportunity for context specific training opportunities where situated learning can become an integral part of strategic curriculum justification, design and delivery (Vigliani, 2021).

SUPPORTING CHANGE IN GLOBAL HEALTHCARE WORKFORCE PROVISION

Despite being one of the most needed and often underacknowledged parts of the global workforce, healthcare workers have virtually all been exposed to traditionalist mechanisms of education, which in terms of educational delivery have remained pedagogically unaltered for the best part of half a century (Karunathilake and Samarasekera, 2021). XR, as an integral part of a new technological age has been embedded within existing educational infrastructures, where traditional instruction mechanisms have shaped its implementation in relation to the pre-existing array of subject areas and academic disciplines represented by HEIs across the world. Stemming from the traditionalist apprenticeship models of learning, these learning approaches have been shaken to the core by a global pandemic that despite being predicted, came as a complete shock to global academic communities where health and medical education had to continue, despite education as a social science being altered beyond recognition in a space of six months, when national lockdowns shaped altered approaches to educational affordance and opportunity to learn (Chan, 2021). Whilst medical publications have an average currency of five years, clinicians of health and medical practice work for an average of forty years on the foundational knowledge attained almost half a century before. It is perhaps no surprise to learn then, that medical errors have become a progressively iterative problem across global health and medical practice, in situations where technology has developed to such an extent that new interventions are often almost obsolete before their initial implementation at the front line of patient care (Melnik et al, 2021). Whilst these issues are concerning, they also pose the greatest opportunity for processes of progressive change for health and medical students whose curricula will inform the complex and ambiguous territories of professionalism that they will need to negotiate over the forthcoming years. This is an opportunity not only to focus and stabilise the quality and optimal provision of education for the next generations of healthcare practice, but also to ensure that medical education becomes more accessible, cost effective and most importantly places patients at the heart of compassionate human care. Exponentially in response to these challenges there has been a progressive switch to Problem Based Learning pedagogical approaches to medical and healthcare curricula across the globe. The immediacy of feedback and impact of professional facilitation of learning is central to the success of this approach in practice and ensures that the mindset of a critical enquirer is entrenched in learners who one day will become the next generation of medical and healthcare providers.

The integration of patients and their families and carers, within the context of patient and carer public involvement (PCPI) initiatives is now an integral part of most health and medical school curricula (Ocloo et al, 2021). Whilst they are invaluable in relation to the development of affective domain learning and interpersonal and effective communication skills, the fact that these skills are inseparable from highly attuned cognitive and psychomotor skills in practice still exists. Where they are therefore of value is in the integration of these skills in conjunction with high fidelity simulation equipment, so that psychological fidelity can also be integrated into the acquisition of psychomotor technical skills training (Johnson et al, 2020; Hayes and Graham, 2020). This is of value in the transitioning between specifically designed learning environments, within which simulated learning takes place, and the eventual ‘real life’ praxis that students face. In terms of recreating learning environments which also reflect the multi-disciplinary and interprofessional working contexts within which health and medical staff find themselves daily, XR provides a useful mechanism of ensuring the psychological fidelity of scenarios used in learning. The origins of human factor analysis and historical emergence of XR training are well documented within the aviation industry, where contexts of flight simulation and the selective integration and conditions of flying can be reconstructed in terms of variability (Hawkins, 2017). One distinct variation in terms of the potential transferability of learning to ‘real life’ though, is the complex ambiguity and unpredictability of working with humans, whose predictability far outweighs anything an aeroplane, however complex can reflect. Unlike flying, therefore, those assessments regarded as ‘high stake’ in terms of potential outcome and risk, cannot be conducted with medical simulation equipment because of their relative potential variability in pathological and physiological status (Spurgeon et al, 2019).

Using teaching and learning to drive assessment is an acknowledged feature of student centred learning but we must never lose sight of the fact that XR, whilst being an adjunct and embedded part of health and medical curricula must never become the driver of learning in itself, lest the most important learning opportunities and factors may be lost to the prioritisation of technology over human need. Similarly, some higher education institutions aspire to owning the latest equipment, which is often declared obsolete before it can be pedagogically integrated with any degree of credibility across those academic curricula for which it was originally purchased. The focus of curriculum design and how teaching and learning ought to drive assessment rather than vice-versa must be advocated if the overall resultant levels of quality in patient care are to remain optimal (Burgess et al, 2020).

FUTURE RESEARCH DIRECTIONS

Within the context of the assessment of healthcare and medical students, formative assessment that is subject to the regulations of Professional and Statutory Regulatory Boards such as allied health and medicine programmes, there is also the opportunity to effectively moderate assessment within and between educational institutions in terms of the parity and equity of assessment mechanisms. Where clinical educators and academics must evidence the objectivity of processes of assessment, then XR will become an invaluable resource in terms of being able to standardise approaches to both formative and summative assessment techniques and their respective outcomes in educational practice (Wilson and Shankar, 2021). The COVID-19 pandemic has seen an exponential rise in the delivery of blended synchronous online and face to face teaching, which has been termed a hybrid learning approach. However, a newer term is the hyflex curricula which have permeated the educational marketplace, with tailored offers of

individual flexibility in learning patterns, which can accommodate more diverse student cohorts. These curricula represent the future of research for these disciplinary fields of praxis. Instructional resources delivered by XR are often an integral part of these flexible offers and it can be an optimal way of managing learning time for those adult learners who have additional family or working commitments to fulfil (Gagnon et al, 2020). Operationally defined, hyflex models also adopt a hybrid approach but offer the opportunity to study flexibly rather than at a pre-set time. Delineating between models of actual attendance on campus is often indicated by the term hybrid, whereas the actual curriculum model is termed blended and provide a fundamental platform for future pedagogical research.

CONCLUSION

Progressive innovation across medical and healthcare professions is something which challenges traditional, conservative approaches to pedagogy, which ultimately contributes to the life and death decision making of clinicians at the front line of care. In this regard, it is important that technology is seen as a driver of pedagogic practice, rather than a methodology in itself. In this sense uptake of these new adjuncts is wholly dependent on medical and healthcare educators being open to change in approaches to education of subsequent generations of students and an acceptance that iterative and ongoing professional skills development is an integral part of adopting technology in practice. In practice this also necessitates the recruitment of staff with specialist technical skills who are responsible for the operationalisation of equipment, but who may not necessarily have specialist pedagogical skills in terms of curriculum design and implementation. So collaborative teamwork in the context of operational delivery of teaching sessions is pivotal. This investment, in terms of financial cost, collaborative working and mandatory iterative skills development for both academic and clinical educators, ensures that learning in a context safe from real-life risk with the potential for benchmarking the acquisition of knowledge and skills, is made possible in practice. The ongoing global COVID-19 pandemic has caused huge global disruption to traditional medical and healthcare education. Innovative responses in digital and technological tools have been quickly implemented with the aim of ensuring that learning can be maintained and sustained to ensure sufficient medical and healthcare graduates continue to qualify each year. Whilst change continues to ensure transformative approaches in those countries who can afford the fiscal implications of these developments, the gap between training providers globally also has the potential to widen in relation to optimal quality of medical and healthcare education. This is an obvious area for address if there is not to become a skills deficit in those countries where the affordance of digital technology as standard for learners and their academic and clinical teachers, is not yet possible. It is the acknowledgement and address of these key challenges which has the potential for a truly authentic paradigm shift in the application of XR in pedagogic design, scholarship, and implementation to be achieved.

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KEY TERMS AND DEFINITIONS

Augmented Reality (AR): Is a technology capable of superimposing or overlaying a computer-generated image across a visual projection of the real world, providing a composite view of the two.

Extended Reality (XR): Is the term given to all real-and-virtual combined environments and human-machine interactions, which are functionally digitally generated by technology and wearable accessories.

Health Professions: Is the term used for workers who have been formally trained in the application of medical and healthcare principles underpinned by the core principles of care, compassion and evidence-based approaches to the care of people whose health necessitates assessment, diagnosis, or management.

Hybrid Curriculum: Is the term used to describe how online learning is integrated with traditional face to face learning and teaching.

Hyflex Curriculum: Is an adaptation of hybrid learning where each class session and learning activity is offered in-person, synchronously online, and asynchronously online. With this approach learners make the decision of how they will participate with the learning opportunities afforded to them.

Immersion Technology: Is the digital equipment which provides the perception of being present in a created and non-physical world.

Mixed Reality (MR): Is the merging of virtual and actual reality to provide new mechanisms of visualizing given scenarios. The physical objects and digital objects can interact with each other in real time.

Paradigm: A set of concepts or thought patterns, incorporating specific theories, designated research methods, hypotheses, and typical standards of what is a legitimate claim to contribution to a specific field of theory or practice.

Pedagogy: Is the methodological process and study of applied teaching and learning within specific subjects and academic disciplines.

Sensory: Relates to the experience of sensation via the physical senses in terms of either perception or transmission.

Simulation: Is the integrated use of a computer model, which imitates reality in the context of study, where risk can be eliminated as part of initial scaffolded learning.

Virtual Reality (VR): Is the digitally generated simulation of a 3-D image or situated context or learning environment, within which a learner can be placed and with which they can interact by wearing electronic accessories such as eye goggles or gloves with sensors.