Integrating Immersive Virtual Simulations into Pharmacy Training in Hong Kong: Insights and Reflections

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Abstract

Virtual reality (VR), an immersive, digitally simulated environment, whose appearance Changes in response to user interaction, has become progressively relevant in teaching and learning in medicine and pharmacy. This technology allows learners to repeat clinical procedure simulations and visualize intricate physiological processes, which is safer and more flexible than the conventional hands-on training. Practical involvement is crucial in pharmacy education, as it allows developing critical pharmaceutical skills, such as communication or decision-making, however, real-world practice is frequently limited by institutional policies and practical restrictions. In order to fill this gap, one of the universities in Hong Kong adopted VR-based learning units in an undergraduate pharmacy program. This report describes the form, incorporation, and effects of VR tools incorporated to improve the capacity of students in the areas of clinical reasoning and interaction with patients. It has presented the possibilities and challenges with integrating VR into academia and can advise researchers looking to integrate these advancements into pharmacy education.

Keywords: ***Pharmacy training, virtual simulation, immersive learning, digital pedagogy, experiential education, clinical skill development.***

1. Introduction

Virtual reality (VR) has become one of the most powerful instruments of modern education, as it provides digitally created, interactive space, which involves several senses seeking to recreate real-life conditions. VR, according to Merriam-Webster (2020), is defined as a virtual environment that is manipulated using computer-based stimuli and has experienced fast growth in all fields, including healthcare and medical education. Such an increase is indicative of the ability of VR to facilitate learning through repetition and practice in risk-free immersive environments (Ramnanan & Pound, 2017; Cao & Cerfolio, 2019). Specifically, VR presents an opportunity to visualize any anatomical structure and simulate various clinical conditions, which makes this medium particularly attractive in terms of professional training (Yu et al., 2019; Siyar et al., 2020).

VR has a huge potential in the area of pharmacy education where clinical experience and decision-making are central elements(1). The conventional education system is based on the lectures and restricted real-life practice which is not necessarily sufficient to make students ready to work in the dynamic healthcare setting. Direct patient exposure may be challenging to attain because of constrains at clinical locations, considerations of patient privacy, and resource shortages (Wartman, 2019; Shrestha et al., 2020). Such obstacles may interfere with the acquisition of critical skills by students, including patient counseling, interprofessional communication, and clinical reasoning.

In response to these issues, educational facilities are considering the virtual simulation as the supplementary method to traditional teaching. There is an increased use of simulated patient cases, which are presented using VR platforms, to offer students a practical learning experience devoid of the limitations of live clinical settings (Kurup et al., 2017; Silva et al., 2019). The technologies are designed to develop problem-solving ability and extend theoretical knowledge in the interactive and interesting form.

This report describes our experience of integrating VR-based learning activities in undergraduate pharmacy curriculum at one of the universities in Hong Kong. We describe the process of development, strategies of implementation, and student feedback that was gained during two academic years. It is expected to present experiences and practical suggestions about the use of VR in pharmacy education and to speculate on how these innovations can reduce the dividing gap between classroom education and clinical practice.

2.Implementation Framework: Digital Simulation Technologies in Pharmaceutical

Curriculum

What are Immersive Educational Technologies?

In the modern learning environment, the use of advanced technological solutions becomes more and more prominent as a way to facilitate better performance and engagement in learning. One of such emerging technologies that can be described as a game-changer in the field of experiential learning is immersive digital environments. Computer-generated simulations of this nature are able to build artificial environments that dynamically react to user input actions and as such afford learners with never before seen capabilities of interacting with otherwise complex material by multi-sensory stimulation. Their introduction into the curriculum of higher educational establishments is representative of a wider pedagogical move toward student-centered learning that emphasizes active learning methodologies as opposed to themore passive models of instruction(2).

2.1 Medical education has evolved with the digital innovation

Healthcare education is one of the fields that have experienced tremendous change due to the orderly incorporation of the latest technological innovations. Digital simulation platforms have gained popularity in medical training institutions across the world as a solution to long-standing problems in clinical education associated with exposure to patients, ethical issues in training cases, and a standardized learning experience. They have been especially useful in pharmacy education where students need to acquire complex competencies that cut across pharmacological knowledge, the ability to communicate with patients, and clinical decision-making. The repetitive practice that can be facilitated by the reproducibility of digital simulations would give learners a chance to perfect their skills, avoiding risks to patient safety and without using large institutional resources.

2.2 Modern Pharmaceutical Education Problems

Contemporary pharmacy education presents complex problems, which cannot be effectively resolved by the traditional methods of teaching. Students in pharmaceutical degrees are expected to acquire complex scientific knowledge and at the same time, gain practical skills, which they will use in the profession. The multidimensionality of the drug-disease interactions, pharmacokinetic principles, and therapeutic decision-making process demands novel pedagogical strategies which are potentially able to interconnect the theoretical background with the practical skills. In addition, there is also a tendency in healthcare education to rely more on collaborative, interprofessional models of learning that equip students with the team-based patient care settings. These dynamic educational needs require dynamic, flexible teaching strategies that will be able to suit most learning styles and preferences.

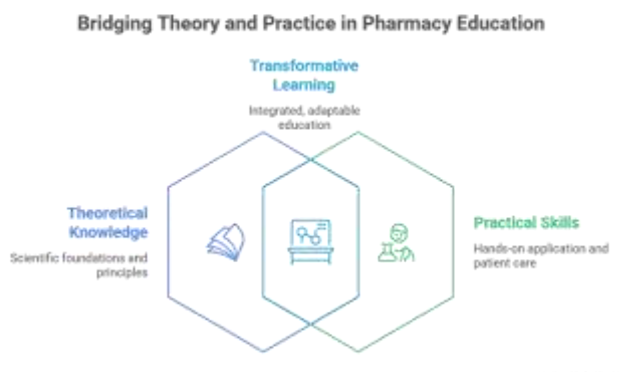

FIGURE 1 Bridging Theory and Practice in Pharmacy Education

2.3 Professional Development Experiential Learning Requirements

Practical learning experiences are major elements of the full pharmaceutical education programmes. These simulation experiences allow students to apply the theoretical learning into practicable clinical skills and become confident in patient-interaction cases. But, educational institutions face great logistical problems in ensuring that students get proper experiential learning opportunities. Clinical placement sites are frequently unable to accommodate large numbers of student learners and student access to realistic healthcare settings may be inhibited by patient privacy concerns and institutional policies. Moreover, the inconsistency of the learning experience that might be caused by the variety of real-world clinical environment may lead to the fact that not all students will face the same educational situation. Such limitations have motivated instructors to consider new ways of providing significant experiential learning experiences.

2.4 Technological Solutions to Educational Development

The shortcomings of traditional experiential learning methods can be overcome by the new and advanced simulation technologies. Digital mediums have the ability to simulate life-like healthcare situations in addition to offering controlled learning conditions that enable students to rehearse skills, err, and get instant feedback without any negative ramifications(3). These technological applications allow teachers to make the learning experiences more standardized so that every student is exposed to similar educational material that is irrespective of other external factors. Additionally, the simulation-based learning enables the generation of unusual or complicated clinical cases that may be difficult to come by in therealclinicalenvironment, and thus it increases the scope of learning cases that the students can be exposed to.

Included in this curriculum design are the Immersive Technologies that will be integrated into the curriculum design.

Immersive educational technologies can be successfully implemented only with the proper attention paid to pedagogical goals and curricular integration approaches. Successful implementation of technology in education entails aligning digital technologies with particular learning outcomes and at the same time demonstrating consistency with the overall educational objectives. Technological investments should be examined on their cost-effectiveness; institutions should determine the cost of the initial implementation as well as the maintenance needs. Moreover, faculty development programs will also be critical in making sure that the teachers have the needed skills to use these Sophisticated teaching aids. Institutional support structures such as technical infrastructure, equipment management protocols and student training programs are also part and parcel of the integration process.

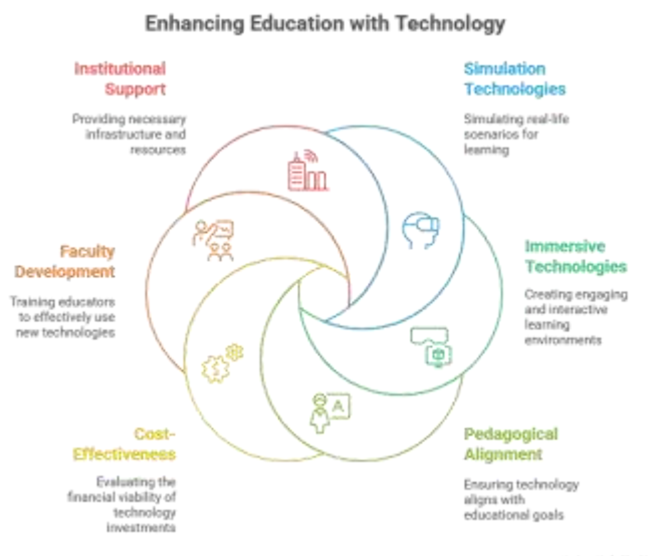

FIGURE 2 Enhancing Education with Technology

2.5 Adaptive technologies: Meeting Diversity in Learning

Modern student populations have variation in learning preferences, technological ability, and educational baggage that affects the way they connect with digital learning environments. The immersive technologies are particularly beneficial in addressing these diverse learning styles because they allow a broad variety of information processing and skill-building modalities. Visual learners would find value in the lifelike 3 dimensional display of anatomical systems and pharmacological actions and reactions, whereas the kinesthetic learners would be involved in the manipulation of the virtual reality environment. Such adaptive features make possible individualized learning experiences which can be tailored to the needs and preferences of individual students and which may lead to better overall educational performance.

2.6 Educational Technology of the Future

The further development of immersive technologies suggests an even bigger potential to improve pharmaceutical education. Recent advancements in artificial intelligence, haptic feedback devices, and augmented reality platforms could additionally widen the potential of developing advanced education experiences(4). The emerging technologies might permit more sophisticated modeling of patient interactions, multifaceted laboratory processes, and clinical decision-making situations. The growing accessibility and affordability of these tools may result in their expanded use as a part of the routine educational processes, and eventually, a revolution in the very paradigms of healthcare education provision.

Evidence-Based Implementation and Research Imperatives

The scientific examination of immersive technology efficacy is still of high importance to guide the evidence-based education. High fidelity research designs have to look beyond student satisfaction and involvement and show objective increases in knowledge retention, skill acquisition and the development of clinical competencies. Longitudinal studies which follow student performance following exposure to technology, into professional practice may also yield valuable information as to the long-term value of such educational innovations. The result of such research work will inform the future decision-making in the adoption of technologies and the best practices that maximize educational returns on investment.

3. Outcomes Assessment and Educational Impact Analysis

3.1 StatisticalValidation and Quantitative Learning Improvements

The overall analysis of digital simulation technologies demonstrated the significant changes in the learning outcomes of the students in terms of the several assessment dimensions. The use of validated measurement tools in the form of pre- and post-intervention assessments showed statistically significant knowledge improvements across all of the intended clinical areas. The scores in the understanding of heart failure rose at post-intervention level of 3.58 1.00, which was a significant change upon the baseline scores of 2.82 0.77, with a nearly significant difference ($p < 0.01$). Likewise, knowledge tests on acute myocardial infarction indicated the presence of a significant improvement in the initial scores of 2.87 0.81 to the increased performance levels of 3.46 1.03 ($p = 0.04$). Understanding of thromboembolic disorders showed similar results, as the post-baseline values rose significantly (3.03 0.82 to 3.55 0.97, $p = 0.04$), proving theeducational potential of technologyenhanced learning methods.

3.2 Development of professional competencies and improvement of confidence

In addition to the knowledge gaining, the adoption of digital simulation technologies demonstrated a quantitative increase in the professional competency formation and self-confidence rates among the students. Skills in patient consultation had improved considerably, with the ability evaluations rising in score since the beginning of the interventions 2.76 0.85 to the end of 3.36 0.96 ($p = 0.02$). This progressed was an indication of how students were now more comfortable and proficient in how to interview a patient and compile the relevant medical history as well as offer the proper pharmaceutical advice(5). The confidence levels during patient consultation situations showed even greater increments, as the baseline values of 2.66 0.75 improved to higher scores of 3.27 0.94 ($p = 0.01$). These results indicate that the use of technology enhanced learning experiences not only led to better technical knowledge but also to higher levels of professional self-confidence necessary to practice in a clinical setting successfully.

Learning outcomes of digital simulation technologies

Characteristic	Knowledge Improvement	Professional Competency	Confidence Level
Heart Failure	Significant	N/A	N/A
Acute Myocardial Infarction	Significant	N/A	N/A
Thromboembolic Disorders	Significant	N/A	N/A
Patient Consultation Skills	N/A	Improved	Improved

FIGURE 3 Learning outcomes of digital simulation technologies

3.3 ELGaps and Technology ELGaps and Technology

It was evaluated that there were serious deficiencies in the previous clinical exposure of the students that were solved using digital simulation technologies. According to the survey data, more than 75 percent of the student participants had never had the opportunity to talk to patients directly in the hospital settings, and over 90 percent had never communicated with physicians about prescription choices. This restriction of real-life healthcare encounters proved to be a significant impediment to professional growth which could not have been sufficiently compensated by the conventional classroom training. The digital simulation experiences allowed students controlled chances to rehearse professional skills that are crucial to their development, such as medical record interpretation, eliciting patient history, and communicating with other members of the health care team, thus filling key gaps in experiential learning.

3.4 Compare and Contrast Analysis with Traditional Instructional Methods

The results of the research proved the existence of specific benefits of technology-mediated learning in contrast to traditional education methodologies. The knowledge acquisition that was taught in traditional instructional formats was limited as the methods of practical skills and professional competence needed to enter clinics were not developed(6). The digital simulation technologies allowed students to experience lifelike clinical situations that could not be made possible by the traditional classroom-based learning or by studying lifeless case studies. These experiences were interactive, students were thus able to make decisions, experience the consequences and learn mistakes in safe, controlled settings that did not put learners or patients at risk of negative consequences.

3.5 Professional Readiness and Skills Training

The technology-mediated learning experiences supported total skills development in several competency areas of professional practice of pharmaceutical nature. Repeated exposure to a variety of clinical situations enabled students to demonstrate better skills in clinical reasoning, therapeutic decision-making and communication with patients. The simulation realism of the digital simulations allowed the students to train the necessary skills such as symptom examination, medication history-taking, and treatment plan analysis without the limitations and dangers of real patient interaction. Such practice opportunities were especially beneficial in gaining confidence in professional interactions and setting the basic competencies needed to be successful during clinical rotations and future professional practice.

3.6 Wider Educational Framework and Incorporation of Technology

The effective introduction of digital simulation technologies in pharmaceutical education is an indication of the bigger trends in use of technology enhanced learning in healthcare professions. Simulation based learning is gaining currency in medical education as a means of acquiring clinical competencies whilst overcoming some of the ethical and practical constraints inherent in traditional experiential based methods of learning(7). The results are adding to the rising body of knowledge that shows the promise of immersive educational technologies in improving student learning outcomes, developing professional confidence, and readying graduates to meet the requirements of modern healthcare practice.

3.7 Long-term Effect and Career Growth

The reactions of the students demonstrated that they valued the technology-enhanced learning experiences greatly and believed that such educational interventions would be useful in future professional practice. Participants acknowledged the importance of simulating clinical encounters in life-like situations prior to their exposure to real patients in the clinical rotations and practice(8). The chance to encounter a wide variety of clinical manifestations and decision-making procedures under the controlled conditions helped students to be better prepared to the complexity and challenges of the modern pharmaceutical practice. Those experiences also contributed to the increased knowledge of interprofessional collaboration and a pharmacist role in healthcare teams.

3.8 Continuous Improvement and Quality Assurance

The assessment procedures included extensive feedback gathering systems to provide the continuity of quality assurance and constant development of technology-enhanced learning projects. Digital simulation experiences were iteratively improved based on student feedback about content accuracy, the degree of realism in the scenario, and the educational value. Periodic evaluation of the learning outcomes would give objective indicators of the education impact whilst determining areas that needed to be improved or changed. Such a systematic quality assurance approach guaranteed that technology investment did generate significant educational value and at the same time remain relevant to the curriculum goals and professional preparation needs.

3.9 Evidence-Based Educational Innovation

The results of the research represent helpful data in pursuing the argument of implementing digital simulation technologies into the study programs in the field of pharmaceutical education. The shown gains in student knowledge, skills, and confidence confirm the educational investment in technology-enhanced learning methods as well as indicating the best practice implementation and optimization guidelines. These results form part of the increased evidence pool of the beneficial nature of novel educational approaches and serve to inform other institutions looking to undertake technology adoption initiatives of their own.

4.Conclusion and Future work

Educational Technology Efficacy and Verified Results

The thorough exploration of digital simulation technologies in pharmaceutical education has presented the strong evidence of their strategic embedment in the modern curricula. The observed growth of the student knowledge acquisition rates, professional competency building, and the self-confidence levels testify to the quantifiable effectiveness of technology-mediated learning methods. These results support the significant institutional costs necessary to implement technology as they offer empirical evidence to extend digital simulation program to other learning areas. The observed statistically significant increases in several dimensions of assessment provide reassurance that properly built technology interventions might be efficient in solving long-lasting issues in healthcare education, especially those associated with the Experiential learning constraints and Clinical preparation needs.

Innovation to Solve Basic Educational Problems

The immersive learning technologies application was able to mitigate a number of serious challenges that were inherent in the conventional pharmaceutical learning methods. The recorded disparity in student clinical exposure in which more than three-quarters of the respondents had never interacted with patients in a hospital setup is a major hindrance to professional preparedness that cannot be addressed sufficiently using traditional instructional approaches. Digital simulation technologies offered systematic experience to the students in acquiring the necessary clinical skills, experiencing professional communication, and gaining confidence in healthcare settings without affecting the safety of patients or necessitating huge resources of clinical placement. With this new method, it can be seen how technology can help fill the gap between theoretical and practical knowledge in healthcare education.

Resource Planning and Institutional Implementation Considertations

Institutional planning needs to go beyond the initial purchase of technology to support, maintenance and faculty development needs, to be successful in implementation of educational technologies. The results of the research support the crucial nature of the iterative refinement processes, which addresses the user-feedback and maximizes the educational efficacy and feasibility issues of practical implementation. The strategies related to the careful evaluation of resources allocation, such as the hardware infrastructure, software licensing and technical support services, and faculty training programs need to be considered at the institutions contemplating similar technology adoption projects. The proved necessity of the constant content updates and further scenarios development requires the sustainable funding mechanisms that could ensure long-term technology projects instead of one-time implementations.

Curriculum Integration and Pedagogical Alignment Strategies

Successful implementation of digital simulation technologies should not involve adoption of technology just because it is technology but must be closely harmonized with identified pedagogical goals and curriculum structures. The study proves that integration is successful when technology acts as a supplement to current education objectives, instead of acting as a substitute to the basic instructional strategies. Technology integration course selection ought to be based on student learning requirements, curriculum deficiencies, and exact competency building prerequisites, instead of being led by technological possibilities. Such strategic perspective would make technology investments generate significant educational returns and remain consistent with the larger program goals as well as professional preparation expectations.

Sustainable Implementation Models and Scalability Frameworks

The move between pilot testing and large-scale implementation uncovered some valuable lessons when considering how to design scalable educational technology programs. The change between fully immersive headset-based experiences and available panoramic video content teaches the lesson that the balance between educational soundness and practical limitations and resources should always be considered. More sustainable models of implementation have to fit in different institutional capacities, technical infrastructural capabilities, and budget constraints without compromising on the main educational gains. Production of versatile technology tools capable of fitting the various institutional settings increases the chances of widespread adoption and sustainability in diverse education settings.

Professional Education and Health Labor Forces

The achieved increases in student professional skills and confidence rates bear important implications on the healthcare workforce preparation and quality improvement agendas. The resulting outcomes related to the patient care and the healthcare system efficacy are directly connected to the increased capability to perform patient consultations, process the clinical information, and coordinate the actions with the other members of the healthcare team. Professional schools must take responsibility in ensuring the production of graduates who are ready to contribute to the delivery of health care services as soon as they step into professional practice and technology-enhanced learning methods are some of the useful means that can be used to realize this goal. The educational technology investment will eventually contribute not only to the students and institutions but also to the healthcare system and the patient groups.

The priorities of Evidence-Based Educational Innovation and Research

Findings of the research add to the existing evidence of the importance of innovative approaches in education as well as outlining the significant fields of further research. Such longitudinal studies which follow student performance since exposure to technology until the professional practice would help to shed some light on the long-term effects of educational innovations on the career growth and on the maintenance of professional competency. Moreover, the findings of comparative research studies of various methods of technology implementation might serve as the guidelines of best practices in balancing educational efficacy and the minimum level of resources prerequisite to achieve it. The systematic review of educational technologies however remains critical in providing assurance that institutional investments lead to significant returns as well as help in guiding the decision-making processes using evidence.

Evolution of Technology in Future and Education

Even more potential to improve healthcare education in the future years is ensured by the rapid development of educational technologies (artificial intelligence, augmented reality, and haptic feedback systems). Institutions have a challenge of crafting strategic planning models that project the evolution of technology, at the same time keeping their eyes on the educational goals and student learning outcomes. The adoption of any emerging technology ought to be driven by pedagogy and empirical data, as opposed to novelty of the technology itself. It can be expected that future advances in educational technology will permit even more realistic simulation experiences, individualized learning progressions, and adaptive evaluation methods that will yet additional increase the effectiveness of education.

Educational Leadership Strategic Recommendations

Educational leaders contemplating technology adoptions projects ought to place a preference on methodical needs analysis, stakeholder involvement, and the use of evidence-based decision-making procedures. Digital simulation technologies cannot be successfully adopted without the institutional commitment that would not only go beyond a financial investment but also cover the aspects of cultural shift, faculty training, and continuous quality assurance measures. Partnership among educational technologists, clinical practitioners, pedagogical experts assures that technology solutions sustain real educational problems and are consistent with requirements in professional preparation. By instituting evaluation and ongoing betterment cycles and processes, institutions can also fine-tune their technology investments and be able to show their educational stakeholders and accreditation agencies the results and outcomes of technology investments and use..

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Conflicts of interest

The authors have no conflicts of interest to declare

References

1. Lin M, Hsu C. Self-efficacy and readiness for practice among Taiwanese Pharm.D. versus B.S. graduates. Am J Pharm Educ. 2020;84(6):1120–1128.
2. Chang C, Lee W. Confidence and competence in pharmaceutical care: Comparing Pharm.D. and B.S. graduates in Taiwan. J Formos Med Assoc. 2019;118(4):762–769.
3. Wu J, Huang H. Educational outcomes of Pharm.D. and B.S. programs: A comparative study. Taiwan J Public Health. 2021;40(3):345–351.
4. Tsai Y, Kuo F. Readiness for advanced practice among Taiwanese pharmacy graduates. Int J Pharm Pract. 2020;28(3):210–216.
5. Chen YL, Liao C. Differences in clinical preparedness between Pharm.D. and B.S. graduates. Curr Pharm Teach Learn. 2018;10(2):239–246.
6. Wang C, Yu J. Evaluating pharmacist competence using self-assessment tools in Taiwan. J Eval Clin Pract. 2021;27(5):1074–1081.
7. Huang L, Wu S. Self-perception of skills in clinical settings among pharmacy graduates. Asian J Pharm Educ Res. 2019;8(4):33–39.
8. Lai P, Lin H. Bridging the gap: How Pharm.D. and B.S. graduates view professional readiness. Res Social Adm Pharm. 2022;18(6):3115–3121.