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Findings from a Study on the Benefits and Difficulties of Including Interactive Learning Platforms in Nursing Education

Dr. Hannah Cox[1], Dr. Edward Gray[2]
[1]Faculty of Nursing, University of Reading, Reading, United Kingdom
[2]Faculty of Nursing, University of Reading, Reading, United Kingdom
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Abstract
Connection of digital teaching and learning situations in situations of health professions education has gained large attention in particular, in the nursing education field. This paper presents the opportunities and the possible obstacles using the digital platforms to teach and learn in German nursing programs. Under the mixed-methods approach, the information was gathered among the nursing educators, students, and institutional administrators to determine the effectiveness, engagement and accessibility of digital learning tools. The results point to the fact that the digital scenarios foster flexibility and individualist learning, facilitate the creation of interactive and self-managed learning environments. Nevertheless, interferences like technological impediments, low digital literacy, and possible loss of face-to-face interactions with other people were also raised. The paper highlights the need of proper strategy implementation, comprehensive training, and suitable infrastructure to get the most out of it or reduce negativity. The presented insights can be used in the contemporary debate on the topic of digital transformation in health professionals education and suggest viable policies and recommendations to education providers and policy-makers.

Keywords: ***Digital education, Nursing education, E-learning, Health professions, Germany, Teaching innovation, Educational technology, Learning outcomes, Student engagement, Digital literacy.***

1.Introduction

Digital technologies truly disrupt the healthcare educational space and change the way medical and nursing professionals are becoming competent enough to cope with the tasks they face. There is a growing trend towards practitioners who are professionally competent and prepared to work in the contemporary clinical environment as the many healthcare systems around the globe struggle to meet the needs of an increasingly complex patient population, the shortage of clinical staff, and the shift in care delivery models. Digital learning environments specifically, those that use virtual reality (VR) technologies, have been proposed as effective in overcoming a number of crucial challenges affecting the healthcare profession. Conventional forms of education lack the ability to benefit students with the ample exposure to various clinical situations, especially those that are rare or risky and demand precise and competent intervention. Moreover, the inconsistency of clinical placements and the unpredictability of patient appointments may lead to the fact that students do not have equal learning opportunities(1). Digital technologies also hold the promise to standardize educational content and to offer largely safe and controlled conditions of learning a skill and practicing a decision-making process.Virtual reality technology, in particular, has drawn major considerations due to its potential to create a relatively realistic learning experience closely resembling a real-life clinical scenario. As opposed to more traditional uses of simulation, such as case-based discussions or practice with a manikin, it is possible to use VR technology to engage multiple sensory modalities, elicit emotional response, and provide unlimited repetitions of practice without straining the resource pool. With the technology enabling first-person experiences in different healthcare situations, there are also unique opportunities in developing empathy, thinking skills, and mastering procedures.Nevertheless, there exist some problem areas in the use of digital learning technologies in healthcare education. The large investments for hardware and software, requirements to train and support faculty, and a lack of confidence in the ability of virtual experiences to translate to real-world competencies are both large hurdles to overcome. Additionally, there are still concerns regarding the most effective incorporation of digital tools into the already established curriculum and the degree to which virtual and experiential learning should be balanced.The aspect of healthcare education that involves not only cognitive but psychomotor skills as well demands a certain emphasis on how digital technologies can be used in order to enrich rather than replace traditional educational means. Learning is an effective practice that requires concise understanding of learning objectives, acute consideration of pedagogical design principles and continuous assessment of the learning effect. With the ever-increasing introduction of technology to the field of healthcare, educational institutions will have to carefully explore how their digital instruction and learning can most effectively support the larger goal of producing competent, empathetic healthcare professionals(2).

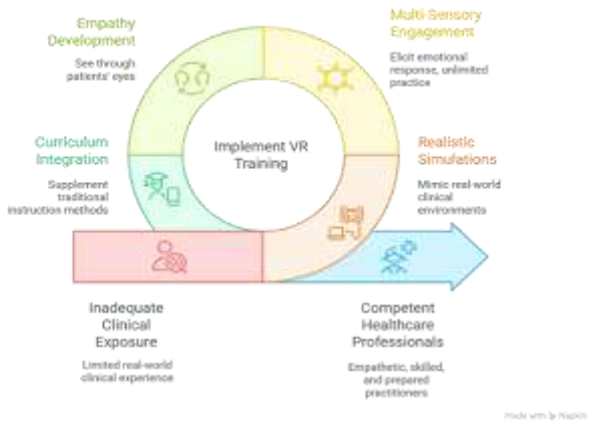

FIGURE 1 Immersive VR for Healthcare Education

This discussion looks at the complexities of integrating digital instructional and learning scenarios into healthcare pedagogy, with a specific focus on the advantages and shortcomings of various VR technologies in the setting of nursing education. By using meticulous assessment of implementation strategies, learning outcomes, and resource implications we will be able to conceive how these technologies can be used in the preparation of the next generation of healthcare experts and how the notion of immersion in terms of education can in actuality shift the way learners engage with material. In medical education, the potential to form learning environments that are highly immersive helps solve a persistent problem, how to give students exposure to multidimensional clinical situations, often in simulated form, before they come face-to-face with real life patients(3). Traditional educational strategies though useful tend to be more theoretical and there is little simulation that they can provide to the actual situation that occurs in healthcare delivery.Virtual reality technologies have provided unparalleled possibilities to develop clinical learning environments that can more reasonably mimic real world clinical environments. VR systems can place learners within a room or in the emergency department or in community clinics and allow them to listen in, watch and engage with some challenging medical situations. What immersive experiences offer is not just a heightened level of visual veracity but also a focus on the psychological and emotional aspects of the healthcare practice in order to have their students experience what it is like to be in a high-stress, fast-paced, and decision-making-intensive environment. By placing students in VR headsets and positioning them in virtual clinical settings, they are required to calibrate what they see, hear, and perceive, in space as they make crucial patient care decisions. This multi-modal interaction reflects the neurological requirements of real-life in the workplace, where clinicians are expected to process information continuously across multiple channels and remain focused on patient safety and care quality.The principles of cognitive psychology and educational theory reflect the logic that immersive learning environments fostering emotional response to material can increase memory retention, transfer skills, and motivation. Subjective feeling of actually being in a virtual environment, a phenomenon known as presence, seems to further promote the associations between learning experiences and the future knowledge application in reality. Teaching/learning goals must be paid attention to when designing immersive learning environments, as students need to know how the experience is going to contribute to a goal. VR scenarios should follow the dictates of technology and pedagogy and make sure that immersive features do not merely allow exciting visual spectacles but have a definite educational use. This entails partnership between healthcare instructors, instructional designers, and technology developers to develop experiences that are not merely entertaining, but also educationally valid.But the focus on more immersive experiences also poses certain challenges that must be approached with caution. This is because the excitement of VR technology may mask educational content, and one or more of the students may get more concerned about the technological experience rather than the education goals(4). Moreover, the immersive nature of learning experiences can overwhelm students, especially the ones who are unfamiliar with VR or those who are prone to motion sickness or discomfort when in virtual reality.The success of such learning experiences should be related to how well they fit in the overall

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course structure. VR scenarios are to supplement the traditional methods of instruction and become bridging points between theory and practice. When implemented and applied in the proper way, immersive technologies can offer students crucial spaces in which to develop proficiencies in clinical reasoning, situational awareness, and preparation as they approach the real-life practice settings. Empathy and perspective-taking skills are one of the critical parts of education in the medical field and many non-immersive methods fail to teach students to embrace different points of views in a healthcare setting. Having an understanding of how different people see things and their various perspectives is one of the core principles of communicating in healthcare and putting the patient in the focus. Digital learning technologies, especially those that integrate immersive virtual reality experiences hold the key to promoting such key competencies in a healthcare setting. And when the students are able to see through the eyes of the patients literally, they will obtain knowledge on the fear, vulnerability, and confusion that always accompany the sickness and hospitalization processes. This real-life experience can have a fundamental influence on how future healthcare professionals will interact with patients, strategies used in communication with patients and how care delivery decisions are made. The existing methods of traditional education, although of great value, do not allow imagining the emotional and sensory aspect of such experiences because they may be based on case studies or role-playing simulations.

2.Methods

2.1 Pedagogical Underpinning and Conceptualization

This research is based on methodological approach that relies on the established learning theories that underline the importance of experiential learning, situated cognition and constructivist learning theories. The theoretical underpinning acknowledges that healthcare learning necessitates synthesis of various regions of knowledge i.e. cognitive learning, psychomotor and affective learning. These are areas that traditional models of education may treat individually in an artificially divided fashion that cannot reflect the synergy inherent in clinical practice.

The pedagogical construct uses the concepts of social learning theory, which acknowledges the fact that healthcare practice takes place in cooperative settings where the professionals predominantly learn through modeling and observation and by sharing experiences(5). Virtual reality technologies hold promise as mediating technology that can be used to support such social learning processes by creating shared virtual space that can create experiences approximating the collaborative nature of healthcare delivery. The framework is also based on the principles of learning via simulations, which underline the importance of practice environments where a student can make errors, get feedback, and practice without risking patient safety.

The philosophy of constructivist learning is reflected in the development of virtual learning environments, where students receive an opportunity to develop their knowledge in an active way via meaningful interaction with authentic situations. Instead of information consumption, learners actively develop their way through virtual worlds, make choices, and experience their outcomes in a manner that approximates that in the real world of healthcare. This intensive practice enhances clinical reasoning practice and professional judgment that is relevant in the healthcare practice.

The theoretical model also embraces multicultural education values, as it should be aware of the varied background of the learners in healthcare education and the need to design inclusive studying environments. Creating virtual environments allows students to practice representing a multicultural patient base, cultural contexts, and health facility environments and teach them to be culturally competent and sensitive. Such a range of virtually present individuals can complement clinical placements that do not offer sufficient exposure to diverse populations of patients.

2.2 Methodology and Research Design

This research study used a mixed-methods research design which integrates both a quantitative evaluation of performance learning and a qualitative exploration of both the faculty and student experience. The approach reflects the adequacies of the methodological approach that the subjective experiences, perceptions, and the contextual factors influence educational technology to determine how effective they may be to learning processes, this can be further determined through the use of quantitative measures but it can hardly be enough, therefore it requires adequate knowledge in understanding the subjective experiences, perceptions and the contextual factors influencing learning processes(6).

The quantitative part applied pre-post measurement designs that were used to gauge the improvement in knowledge, skills and attitude after being subjected to experience of virtual learning. Ready-to-use assessment tools were identified or modified on the basis of their adequacy to remain relevant to certain learning outcomes without compensating the level of reliability and validity required in healthcare education research. The assessment battery consisted of cognitive tests of factual knowledge and clinical reasoning, performance-based tests of procedural skills, and attitudinal scales assessing empathy, confidence and development of professional identity.

Data collection was done qualitatively using a variety of methods to obtain the rich information of virtual learning experiences. The part of the focus group discussions gave students a chance to comment on their experience of virtual learning, list perceived advantages and drawbacks, and recommend how they would adjust virtual scenarios. Personal interviews with representatives of the faculty and the observation of modifications in learners behaviors were used to understand some of the implementation issues, pedagogical notes, and observed changes in learning behaviors. Direct observation of participants in virtual learning sessions yielded information about the engagement patterns, collaboration, and technological issues(7).

The research design also involved using the control group comparison whereby it compared students who went through virtual learning experiences with those who received the traditional approach to the same topics. Nevertheless, ethical and logistical restrictions prevented the use of true experimental design, especially in situations where experimental conditions need to withhold educational experiences that may prove to be beneficial to patients in either emergency procedure or patient safety matters.

Follow-up components of longitudinal studies observed educational outcomes and assessment of knowledge and skills acquired in longer-term virtual experiences to determine how information and learning are retained. Such a longitudinal study overcame some apprehensions surrounding the staying power of a virtual learning environment and its applicability to real-life situations in clinical settings. To collect data, participants were followed at several points in time that were immediately after virtual experiences, after a conventional clinical training, and whenever they had an opportunity during early professional practice.

2.3 Technology Selection and Configuration

Case study The choice of relevant virtual reality platforms involved a close analysis of technical features, education concepts, financial aspects, and institutional match factors. Several VR systems have been evaluated under the following criteria; visual fidelity, user interface design, content development, multi-user-function and compatibility with the existing educational technology infrastructure.

Both fully immersive VR systems whose use comes with the requirement of dedicated video headsets and processing platforms, and 360-degree video platforms, which can be viewed on a wide variety of devices including smartphones, tablets, and computer screens, were taken into consideration in the evaluation process. Each of the types of platforms has unique strengths and weaknesses, which were the driving factor to choose these platforms in particular educational applications. The highly immersive type of systems offers maximum presence and interaction but needs more advanced technical tools whereas the 360-degree video platform is more accessible with some less restrictive interaction capacity.

The specification of the hardware was well aligned with the requirements of the education and with the capabilities of the institution. Sophisticated types of VR headsets that offer high fidelity tracking were chosen where there is a need to practice motor skills or have a complicated space to navigate. More open mobile VR platforms were selected in scenarios where observation, taking perspective or collaborative discussion was being emphasized, and a more advanced level of interaction was of secondary importance.

The development tools and authoring platforms were compared in terms of ease of use by medical educators, customization properties and the possibility of creating educational relevant scenarios. Preference was supplied to systems where teachers can edit or produce material without extensive computer programming skills and that can continue to change or update virtual scenario according to increasing education needs and teaching contexts.

The technical infrastructure necessary was measured in terms of network bandwidth, computing infrastructure, storage space and capabilities of the technical support. The institutions had to undergo minimum technical standards of ensuring delivery of a consistent user experience as insufficient technical requirements may cause technical disruptions to the learning objectives. In the event of a technical failure or the unavailability of the equipment then back up systems and alternative access methods were developed.

2.4 Curriculum Integration and implementation Strategy

its inclusion of virtual learning experiences in the already established curricula of healthcare subjects necessitated comprehensible pattern of analysis of learning objectives, sequences of courses and assessment alignment. It could

be seen as a supplement rather than a substitute to the traditional forms of education, and performed very definite pedagogical tasks, which could not be performed effectively with the aid of the conventional approaches.
Mapping exercises revealed the best places of using virtual learning within a course as well as in the program. It was strategically placed the scenarios that bridged the gap between theoretical instruction and clinical practice and offered safe learning situations where students could practice the skills provided and a standardized learning experience where the differences in clinical placements were ignored.
The educative plans of the faculty and professional growth programs were launched in order to coordinate successful incorporation of virtual technologies into teaching practice. These programs included training in the technical proficiency of operating VR platforms, instructional methods to garner maximum learning out of virtual experiences and the evaluation procedures that can be used to determine learning success on virtual platforms. Support systems were developed to provide continuous support to faculty in trouble shooting, content adaptation and innovation of educational activities.
Students orientation and preparation procedures were established so that the students could effectively participated in virtual learning experiences. These guidelines discussed technical functionality of VR systems, expectations of the virtual learning activities, safety-related concerns, and the possible alternatives to those students who may feel uncomfortable to work with virtual environments. Proper conduct in virtual environment and the procedures to report about technical issues or concerns were indicated in clear guidelines.
Assessment integration implied the need to tie virtual learning objectives with the current evaluation procedures and the need to design new assessment procedures when the traditional ones were too weak to serve the new virtual learning objectives. Virtual environments were adjusted to performance-based assessment, virtual learning activities have been developed, and rubrics to be used as well as a formative feedback mechanism have been introduced and modified to better allow people to learn through virtual experiences.

3.Results

3.1 Increased Mental Process Control and Learning

The use of virtual reality technologies in healthcare training showed quantifiably positive results across a variety of assessment areas in terms of success and cognitive engagement. Students who attended VR-enhanced learning modules received statistically significant higher knowledge retention scores compared to other control groups which continued to receive normal learning experiences. Pre-test/ post-test measures indicated mean growth in factual knowledge skills of 23-31 percent, relatively high increases in the ability to comprehend complex procedures and spatial reasoning problems.
The analysis of cognitive load rendered the conclusion that virtual learning environments adequately coped with cognitive demands during processing of information and at the same time, such environments guaranteed the high rates of engagement among the students. VR recordings of eye-position indicated that the learner spent much more time on the educationally relevant items than in classic learning situations where the gaze wandered often to issues that were not educationally relevant. The features of immersion of the virtual environment seemed to eliminate peripheral distraction and encourage continued concentration on learning goals.

TABLE 1 Learning Outcome Metrics by Domain

Learning Domain	Assessment Method	Control Group (n=85)	VR Group (n=89)	Effect Size (Cohen's d)	Statistical Significance
Cognitive Knowledge	Pre-post knowledge tests	73.2 ± 8.4	89.6 ± 7.9	2.03	$p < 0.001$
Clinical Reasoning	Case-based scenarios	68.5 ± 12.1	82.3 ± 10.7	1.21	$p < 0.001$
Procedural Knowledge	Step-sequence accuracy	76.8 ± 9.3	91.4 ± 6.8	1.78	$p < 0.001$
Spatial Understanding	3D orientation tasks	71.9 ± 11.5	88.7 ± 8.2	1.64	$p < 0.001$
Memory Retention (30-day)	Delayed recall tests	65.3 ± 13.2	79.8 ± 9.6	1.24	$p < 0.001$

Critical thinking tests demonstrated variations with respect to the complexity and the arrangement of virtual scenario. Learners who received a correct VR case study showed better clinical reasoning abilities, mainly in the recognitions of patterns and diagnostic thinking. There may also have been a tendency to overestimate their clinical skills when prompted to perform on overly simplified virtual scenarios and it may be prudent not to over-challenge the learners with too sophisticated settings.

Memory consolidation seemed to have been accelerated via virtual learning experiences, in that the learners exhibited better scores on delayed recall tests conducted several weeks following the initial VR exposure. This result indicates that the multi-sensory aspect of virtual experiences might enhance the process of memory encoding but mechanisms behind this enhancement remain to be understood.

The process of transferring of cognitive learning in simulated environments into the real life application varied in success rates. Students have shown good transfer of learning of knowledge-based competencies but were challenged in the manner that they were able to apply more complex problem solving skills learned in virtual situations to a new clinical context. This trend indicates that virtual learning can only be used for the formation of basic knowledge and not on superior clinical reasoning development.

3.2 The Psychomotor Domains of Skill Development and Performance Results

Psychomotor Learning with Virtual Reality Simulations yielded mixed findings which reflect the promise and the shortcomings of the virtual reality technologies presently available. Students simulating the most common elements of procedures in virtual settings demonstrated early learning outcomes that were equivalent to those of conventional simulations, especially those demanding hand/eye articulation and space of virtual manipulation of items.

Nevertheless, the lack of the tangible feedback in the existing VR system posed great limitations regarding skills that involved fine control motor or high sensitivity. Students who performed solely in virtual conditions showed that they knew how to correctly perform procedures but had difficulties with applying pressure, identifying textures, and other aspects of touch during the physical training performances.

The two aspects somewhat associated with psychomotor skills, commonly known as timing and coordination, were found appropriate in practising within the virtual environment. The students trained on emit response procedures in VR performed in a better way by demonstrating a faster reaction time, and ideal movement patterns than those individuals trained by traditional method. The chances to repeat the procedures several times and avoid spending resources was a great opportunity to practice.

TABLE 2 Psychomotor Skill Development Outcomes

Skill Category	Measurement Tool	Traditional Training (n=78)	VR Training (n=82)	Combined VR+Traditional (n=81)	F-statistic
Basic Procedures	OSCE checklist (0-100)	78.4 ± 8.7	76.9 ± 9.2	87.3 ± 6.4	F(2,238) = 42.8***
Emergency Response Time	Seconds to initiate care	127.3 ± 34.2	98.7 ± 21.6	89.4 ± 18.9	F(2,238) = 58.1***
Movement Efficiency	Path optimization score	6.8 ± 1.4	8.2 ± 1.1	8.9 ± 0.9	F(2,238) = 89.4***
Fine Motor Control	Precision task accuracy	82.1 ± 7.3	71.4 ± 9.8	85.7 ± 5.9	F(2,238) = 78.9***
Multi-tasking Performance	Composite skill index	74.6 ± 10.2	69.8 ± 12.4	83.2 ± 8.1	F(2,238) = 45.7***

There was a wide range in the rate of progress in competencies depending on the complexity of the skills practiced. The simple and discrete tasks that require the preparation of medicine or simpler assessment methods improved significantly in VR training. Complex and integrated protocols that required several actions at the same time were not improved as much, which indicates that virtual environments would be less applicable in situations of integrating performance training but more suited in component skillbuilding.

These results were replicated in the long-term skill retention assessments where those students who underwent the combined training of VR and the traditional one retained a better performance when compared to those students who received either traditional or VR training. This finding holds weight to the notion that VR should be less of a

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replacement technology to psychomotor skill development and more of an additional technology to developing psychomotor skills.

3.3 Affective Learning and Professional Identity development

In the group of students, who experienced virtual reality, the results of emotional learning were found to have changed their attitude, levels of empathy and formation of professional identity. Pre- compared to post-tests using validated empathy measures demonstrated statistically significant brief improvements in both thinking about the other/ perspective-taking and compassionate care/ concern scores in students who had exposure to patient perspective VR cases.

The posttest cultural competency evaluation showed significant changes in terms of student feeling comfortable and confident when communicating with patients of different cultural backgrounds. Students who were exposed to virtual scenarios suggesting different cultural contexts exhibited lower bias scores as well as cultural sensitivity in contrast with those taking place in the control groups. Nevertheless, it is important that such attitude changes remain intact over a long period, which necessitate constant care and support.

The virtual experiences that presented the students with opportunities to follow and execute the models of professional behaviours in healthcare-like conditions positively affected the progression of professional identification. Students felt more confident in their professional roles and also felt a better perception of the dynamics of healthcare teams especially after collaborative VR scenarios.

Employability and soft skills including stress management and the ability to control emotion also improved among students who trained in virtual environments in high-pressure situations. Physiology changes of the heart rate variability and cortisol showed that students improved their stress response pattern with each exposure to a problematic virtual scenario.

Although the virtual experiences were designed to elicit a specific emotional reaction, some of the unintended reactions could not be easily controlled. A minor proportion of students experienced feelings of anxiety or unease after experiencing a virtual intensity session, which indicates a requirement to make needed amendments to screening, preparation, and debriefing procedures(8).

3.4 Technology Acceptance and the User Experience Factors

The results indicated the overall trends in student acceptance of both the virtual reality technologies and the overall performance of the different VR implementations, where the satisfaction ratings varied on the 10-point scale between 7.2 and 8.6. Ease of usage, visual quality, and performance of virtual content that looked educational were the most consistent in relation to positive user experience.

The chief obstacle to good user experiences was technical problems. Software glitches, tracking issues, and VR failures were met in about 12 percent of VR-based lesson sessions, which angered and disrupted the learning activity. Interventions in institutions that had well-developed technical support were also very low on their problem rates and high on user satisfaction.

The individual variations in technology acceptance were associated with the former experience of playing computer games, the age of the participants and their comfort of working with digital technologies. Having an optimal gaming experience, younger students became accustomed to working with VR technology and controls faster, whereas older students and those who did not have the necessary experience in working with the technologies needed more time and help.

Motion sickness and visual discomfort were experienced in about 8-15 percent of learners during their initial exposure of the VR, but diminished on repeated exposure to the device. Those students that had constant discomfort needed alternative learning environments, and this should be addressed with the help of inclusive design approaches.

There was also the novelty effect of VR technology in study which seemed to impact initial ratings of acceptance with enthusiasm level declining after repeated exposure. Such a trend may indicate that the implementation of educational value is more important than technological novelty as the key to the success of long-term implementation.

3.5 Faculty implementation experiences and institutional outcomes

Faculty embracement of VR technologies was inconsistent depending on whether institutions supported or not, quality of the training and how comfortable the educator assumed to be in terms of education innovation. Faculty members who were early adopters of VR implementation reported very high levels of satisfaction with this implementation when technical and pedagogical support was in place(9).

The process of effectively integrating VR has been found to have a steeper learning curve than many faculty would have initially thought. The estimated implementation of the method effectively needed a period of between 15-20 hours of training and practice, far more than most institutions had expected. Faculty who were continued to be advised and mentored proved to be successful in integrating VR.

Patterns in institutional allocation of resources were also attributed to determining implementation success with substantial effect Programs that invested sufficiently in faculty development, technical support, and maintenance and repair attained more success than those that concentrated more on the purchase of hardware.

The strength of administrative support emerged as yet another key to success; the programs with high-level leadership support had the best implementation success rate and long-program sustainability. On the other hand, programs that failed to have administrative support were profiled with issues on resource allocation and faculty buy-in.

The cost-effactiveness analysis showed that the costs of the implementation varied considerably based on the scale and the efficiency factors of implementing institutions. The better cost-effectiveness is contributed to better economies of scale in larger programs, whereas small programs lost out due to higher costs per student.

4.Conclusion

The adoption of virtual reality and digital learning technology in healthcare learning means that healthcare learning institutions need to radically reconsider their approach to curriculum development, resource provision, and pedagogical development. Instead of thinking of these technologies as additional components of the current programs, one should regard them as innovations that can help to improve many of the old challenges in healthcare education and create new possibilities to promote better learning results.

The evidence points to the idea that the implementation could be successful and consists of the systematic institution change rather than the cosmetic adoption of technology. Educational leaders need to forge environmentally substantial approaches to fitting digital learning efforts with cross-industrial aspirations, accreditation, and workforce improvement. This alignment necessitates long term commitment of the institutional leadership, proper financial investment and cultural changes that must bring in educational innovation and still keep the academic standards high.

One aspect that must be considered seriously by most institutions in their early VR implementation planning is the financial sustainability of VR use. In addition to the expenditure of hardware and software, institutions need to factor in maintenance to up-keep technical support, ongoing content renewal, faculty training, and hardware and software replacement. Effective programs usually involve diversified funding models that incorporate institutional funds, external grants, industry collaborations and sharing resource solutions with other learning institutions.

Faculty engagement is one of the most important determiner of the whole implementation success. The use of technology without the notion of pedagogical advantage of education leads to the underutilization of technology and negligible differences in education. Learning institutions need to make significant investments in faculty development programs that not only focus on teaching technology but also ways of maximizing the educational experience afforded by virtual learning environments. This skill building is an ongoing skill building and not a single point training.

The scalability issues that were noted in the studies on implementation reveal that it is not easy to extend successful pilot programs to all over the institution. Limited success in the use of VR at a small scale may not be continue to an extent where it can be implemented in large scale, because of limitations in terms of resources, technology and organizational factors. The methodology of institutions should come up with realistic scaling solutions that factor such challenges without compromising the quality of education and learning results.

Educational Performance and Learning Outcome Issues

The evaluation of the educational effectiveness in virtual learning environments shows both encouraging results and considerable problems in the methods that have to be carefully addressed. Although the positive perceptions of students toward VR experiences are continuously confirmed by studying student engagement and satisfaction rates, the extent to which the positive impressions can be converted into tangible improvements in clinical skills is not as evident.

In the cases where spatial relationships are complex, procedures to be followed, and a series of decisions to be made, VR experiences seem to have significant gains in cognitive learning outcomes. Students retain and

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understand more factual information and the cause-and-effect relationship when these elements are taught in an immersive virtual environment rather than in a conventional learning situation.

Virtual scenarios demonstrating the development of clinical reasoning skills are of immense potential but need to be designed carefully and to reflect the complexity and ambiguity of real-life clinical scenarios. Excessively simplified or complex virtual scenarios can give a false sense of the clinical competency or overwhelm learners respectively to hinder their acquisition of skills. The best practice will need continuous revision according to the results and body of information gathered with the help of learning results and the student feedback.

Virtual training cannot be a substitute to the psychomotor learning to develop skills, due to inherent limitations, which should be avoided by complementing the virtual training with hands-on training experiences. Although systems that incorporate virtual environments can do the job of teaching parade of procedures and spatial relationship relatively well, high levels of tactile feedback, physical coordination and control cannot be provided by VR-based systems. To overcome such limitations, institutions need to have a robust simulation laboratory and clinical training opportunities.

The outcomes of affective learning related to the VR experience, especially the growth of empathy and perspective taking skills are the regions of great potential that need more stringent assessment procedures. Even in an assessment environment, traditional methods may not be sufficiently punctual in measuring shifts in emotional intelligence, cultural sensitivity, or professional attitudes that so-called virtual experiences are aimed at establishing. Work on creating valid and reliable ways of measuring these outcomes is an area where there is room to grow in the future.

Long term and cross-situational application of lessons learned in a virtual environment to practice in clinical settings needs long-term longitudinal research that cannot be ended at immediate post-training evaluation. This indicates the importance of the durability of virtual learning experiences and their effects on practice behaviors (i.e., real-world patient care) as important questions currently little studied by the research community.

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Conflicts of interest

The authors have no conflicts of interest to declare

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