Immersive Technology in Nursing Education: A Framework-Guided Review Using Experiential Learning Theory

CHRISTIANA ADEYEMI[1], OPEOLUWA OLUWANIFEMI AJAYI[2], IRENE SAGAY[3], SANDRA OPARAH[4]
[1]*University of the Cordilleras. Baguio, Philippines*
[2]*Amazing Grace Adult Home, Akure, Ondo State, Nigeria*
[3, 4]*Independent Researcher, MD, USA*

Abstract- The increasing complexity of healthcare delivery and evolving patient care needs have accelerated the adoption of innovative educational strategies in nursing education. Immersive technologies, particularly Virtual Reality (VR) and Augmented Reality (AR), are emerging as transformative tools that offer experiential, interactive, and learner-centered approaches to clinical education. This framework-guided review examines the use of VR and AR in nursing education, applying Kolb's Experiential Learning Theory and Bloom's Digital Taxonomy to analyze their educational value, practical applications, and pedagogical outcomes. Kolb's Experiential Learning Theory emphasizes a cyclical process of learning through experience, consisting of four key stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. VR and AR simulations align well with this model by providing realistic clinical experiences where nursing students can practice critical skills, engage in reflective debriefings, apply theoretical concepts, and subsequently transfer their learning to real-world clinical settings. Additionally, Bloom's Digital Taxonomy offers a structured framework for evaluating cognitive engagement in digital learning environments, mapping VR/AR learning activities to higher-order cognitive domains such as applying, analyzing, evaluating, and creating. The review explores how immersive technologies are being utilized for a range of educational purposes, including clinical skills development, complex patient scenario management, empathy training, and interprofessional collaboration. Evidence suggests that VR and AR enhance knowledge retention, improve psychomotor skills, foster clinical reasoning, and boost learner engagement. Despite these advantages, challenges such as high costs, technological barriers, limited faculty training, and integration difficulties persist. The review concludes by emphasizing the need for comprehensive faculty development, evidence-based curriculum design, and further research on long-term learning outcomes. It highlights the importance of leveraging experiential learning frameworks to maximize the educational benefits of VR/AR technologies, ensuring their effective integration into nursing education for building competent, adaptable, and technology-savvy nursing professionals.

Indexed Terms- Immersive Technology, Nursing Education, Framework-Guided Review, Experiential Learning Theory

I. INTRODUCTION

The landscape of healthcare education is undergoing a profound transformation, driven by rapid advancements in digital technologies. As healthcare systems become increasingly complex and patient needs evolve, traditional pedagogical approaches in nursing education—often based on didactic instruction and passive learning—are proving insufficient to equip future nurses with the necessary clinical competencies, critical thinking skills, and adaptability (Menson *et al*., 2018; Eneogu *et al*., 2020). In this context, there is an urgent demand for innovative, engaging, and experiential learning methodologies that better align with contemporary healthcare challenges and technological environments (Scholten *et al*., 2018; Nsa *et al*., 2018).

Virtual Reality (VR) and Augmented Reality (AR) have emerged as transformative tools in healthcare education, particularly within the field of nursing (Mustapha *et al*., 2018; Ojeikere *et al*., 2020). VR refers to fully immersive, computer-generated environments that simulate realistic clinical scenarios, while AR superimposes digital information onto real-world settings to enhance situational awareness (Sutherland *et al*., 2019; Joda *et al*., 2019). Both technologies enable learners to interact with dynamic, life-like simulations in a controlled, safe environment, where mistakes become learning opportunities without risks to patient safety (Merotiwon *et al*., 2020). These immersive technologies offer unique advantages by facilitating hands-on, experiential learning that bridges the gap between theory and practice.

The integration of VR and AR in nursing education has accelerated in recent years due to several converging factors. First, the need for scalable, remote, and flexible educational solutions has become increasingly urgent, particularly in light of the COVID-19 pandemic, which disrupted traditional clinical placements and in-person simulations (Broisin *et al*., 2017; Angelopoulos *et al*., 2019). Second, VR/AR technologies have become more accessible and cost-effective, with improved usability and compatibility with common learning management systems. Finally, there is growing recognition among educators and healthcare institutions that VR/AR-based training enhances student engagement, improves retention of knowledge and skills, and prepares learners for high-stakes clinical environments.

This review aims to critically evaluate the application of VR and AR technologies in nursing education through the lens of two well-established educational frameworks: Kolb's Experiential Learning Cycle and Bloom's Digital Taxonomy. These frameworks provide structured methodologies for analyzing the learning processes, outcomes, and cognitive engagement associated with immersive technologies.

Kolb's Experiential Learning Cycle emphasizes the importance of learning through direct experience and iterative reflection. It outlines four key stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. VR and AR simulations naturally align with this cycle by allowing students to participate in clinical scenarios, reflect on their actions, integrate new knowledge, and apply their learning in future situations.

Bloom's Digital Taxonomy, an adaptation of the classic Bloom's Taxonomy for digital learning environments, provides a hierarchical framework for categorizing cognitive learning objectives in the digital age. It includes six cognitive levels: remembering, understanding, applying, analyzing, evaluating, and creating. This taxonomy offers a valuable lens for assessing how VR/AR technologies facilitate higher-order thinking skills, from basic knowledge acquisition to complex decision-making and problem-solving (Khoshnevisan and Le, 2018; Papanastasiou *et al*., 2019).

By applying these complementary frameworks, this review seeks to identify the strengths, limitations, and best practices for integrating immersive technologies into nursing education. It also highlights critical gaps in current research and provides recommendations for optimizing the use of VR/AR in nursing curricula.

The significance of VR and AR in nursing education lies in their potential to address persistent skills gaps and improve clinical preparedness. Traditional nursing education methods often rely on classroom instruction, limited laboratory simulations, and unpredictable clinical placements (Lubbers and Rossman, 2017; Zapko *et al*., 2108). These approaches may not consistently expose students to rare, high-risk, or emergent clinical situations, resulting in uneven preparedness for real-world practice.

Immersive technologies offer a powerful solution by providing standardized, repeatable, and customizable learning experiences. Through VR/AR simulations, nursing students can practice complex procedures, develop critical thinking and decision-making skills, and enhance their communication and teamwork abilities (Wu *et al*., 2019; Han, 2019). Such experiences improve not only psychomotor skills but also confidence and self-efficacy, essential for transitioning to clinical roles.

Furthermore, VR and AR technologies contribute to patient safety by enabling learners to master clinical competencies before engaging with actual patients. By simulating high-pressure scenarios—such as cardiac arrest, trauma resuscitation, or infectious disease outbreaks—students gain valuable experience in managing complex cases without jeopardizing patient outcomes.

The integration of immersive technologies into nursing education represents a significant advancement in preparing nurses for modern healthcare practice. By grounding this review in Kolb's Experiential Learning Cycle and Bloom's Digital Taxonomy, it offers a comprehensive analysis of how VR and AR can effectively enhance learning, bridge the theory-practice gap, and improve patient-centered care outcomes.

II. METHODOLOGY

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency and rigor. The review focused on the use of immersive technology in nursing education, guided by experiential learning theory as the conceptual framework. A systematic search was performed across major electronic databases, including PubMed, CINAHL, Scopus, ERIC, and Web of Science, along with grey literature sources such as conference proceedings, dissertations, and reports from nursing education organizations. The search strategy utilized a combination of controlled vocabulary and free-text terms, including "immersive technology," "virtual reality," "augmented reality," "simulation," "nursing education," "experiential learning," and "framework," combined with Boolean operators to refine the search.

Eligibility criteria were defined based on the Population, Intervention, Comparison, and Outcome (PICO) framework. Studies were included if they involved nursing students or nurse educators, incorporated immersive technologies such as virtual reality, augmented reality, or simulation-based learning, explicitly applied experiential learning theory or its key components to guide design or analysis, and reported educational outcomes such as knowledge acquisition, clinical skills development, learner engagement, or critical thinking. Both qualitative and quantitative studies were considered, including randomized controlled trials, quasi-experimental designs, mixed-methods research, qualitative studies, and systematic reviews. Studies were excluded if they did not focus on nursing education, lacked an experiential learning framework, or did not involve immersive technology. Only English-language studies were included, with no restrictions on publication date to capture the full scope of available evidence.

All references identified were imported into reference management software for de-duplication. Two reviewers independently screened titles and abstracts for relevance according to the inclusion and exclusion criteria. Full-text articles were retrieved for studies meeting the screening criteria or where eligibility was unclear. Disagreements were resolved through discussion or consultation with a third reviewer.

A standardized data extraction form was developed to capture key information from each included study, including author(s), year of publication, study design, sample characteristics, type of immersive technology used, application of experiential learning theory, educational interventions, outcome measures, and key findings. Data were verified by a second reviewer for accuracy and completeness.

The methodological quality of included studies was assessed using appropriate tools for each study design, such as the Joanna Briggs Institute Critical Appraisal Tools and the Mixed Methods Appraisal Tool. No studies were excluded based solely on quality; however, quality assessments informed the interpretation of findings during synthesis.

Data synthesis was conducted using a narrative, thematic approach due to the diversity in study designs, technologies, and outcomes. Studies were grouped according to the type of immersive technology used and the components of experiential learning theory applied, including concrete experience, reflective observation, abstract conceptualization, and active experimentation. Thematic analysis identified key patterns related to educational effectiveness, learner engagement, skill development, and practical applications in nursing education. Particular attention was given to studies that provided detailed descriptions of how experiential learning theory informed the design, implementation, and evaluation of immersive learning experiences.

Throughout the review process, the PRISMA guidelines were followed to ensure a systematic, transparent, and reproducible approach to study selection, data extraction, quality assessment, and synthesis. The resulting analysis provides a comprehensive, framework-guided synthesis of the current evidence on the application of immersive technology in nursing education through the lens of experiential learning theory, highlighting effective strategies, educational benefits, challenges, and directions for future research and practice.

2.1 Conceptual Frameworks

The effective integration of immersive technologies such as virtual reality (VR) and augmented reality (AR) in nursing education requires a strong conceptual foundation to maximize learning outcomes. Two widely recognized frameworks—Kolb's Experiential Learning Cycle and Bloom's Digital Taxonomy—offer essential guidance for structuring VR/AR-based educational interventions. Both frameworks provide distinct yet complementary perspectives on how immersive learning environments can foster knowledge acquisition, clinical skills development, and critical thinking.

Kolb's Experiential Learning Cycle presents a four-stage, cyclical model of learning grounded in the principle that knowledge emerges through the transformation of experience as shown in figure 1. This model is particularly suited to simulation-based education, where learners actively engage in realistic scenarios that replicate clinical environments. In the context of VR and AR, each of Kolb's stages can be explicitly operationalized to structure effective learning experiences for nursing students (Koivisto *et al*., 2017; Fewster-Thuente and Batteson, 2018).

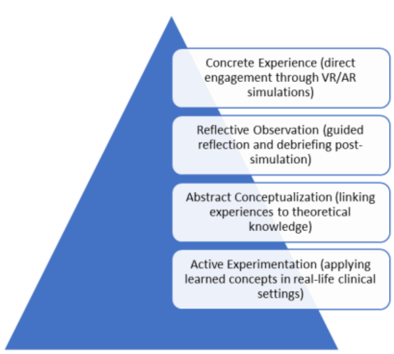

Figure 1: Kolb's Experiential Learning Cycle

The first stage, Concrete Experience, involves direct engagement with learning materials through immersive technologies. In this stage, nursing students participate in VR or AR simulations that emulate clinical situations, such as performing emergency interventions or managing patient care. These immersive experiences enable learners to engage their senses and emotions, offering authentic exposure to complex scenarios without the risks associated with real-life practice.

The second stage, Reflective Observation, emphasizes guided reflection and debriefing following the simulation. In this phase, learners critically review their actions, decisions, and emotions experienced during the VR or AR session. Structured debriefings led by facilitators allow learners to identify what went well, recognize errors, and discuss alternative approaches, enhancing metacognitive awareness and self-assessment skills (Tutticci *et al*., 2018; Allen *et al*., 2018).

The third stage, Abstract Conceptualization, involves connecting the simulated experience to theoretical frameworks and evidence-based knowledge. Learners synthesize what they encountered during the simulation with academic concepts, such as pathophysiology, clinical guidelines, and communication theories. This phase solidifies understanding by translating experiences into general principles that can guide future practice.

Finally, Active Experimentation focuses on applying the acquired knowledge and skills in actual or simulated clinical settings. Learners use insights gained from the VR/AR experience to modify their behavior and decision-making in subsequent practice opportunities, reinforcing the transfer of learning to real-world situations (Sihi *et al*., 2018; Steffen *et al*., 2019).

Kolb's model is highly relevant to simulation-based and virtual learning environments, as it aligns well with the experiential nature of VR/AR technology. By following this cyclical process, nursing students can continuously refine their clinical competencies and decision-making abilities in a safe and structured manner (McGaughey *et al*., 2017; Watts *et al*., 2017).

Bloom's Taxonomy, originally developed to classify educational objectives according to cognitive complexity, has been adapted into a digital framework known as Bloom's Digital Taxonomy. This revised model considers the impact of technology on learning and highlights the cognitive processes involved in digital education. It is particularly useful for guiding the design and assessment of VR/AR-based learning activities in nursing education.

The first cognitive domain, Remembering, involves the recall of foundational knowledge using digital tools. In VR/AR environments, this may include identifying anatomical structures, memorizing clinical protocols, or recalling disease processes while navigating a simulation (Moro *et al*., 2017; Babu *et al*., 2018).

The second domain, Understanding, requires learners to interpret and explain information derived from virtual experiences. Nursing students demonstrate understanding by discussing symptoms presented in a VR patient scenario or explaining the rationale behind a chosen intervention during debriefing sessions.

The third domain, Applying, refers to using learned concepts in practice. VR/AR simulations enable learners to apply theoretical knowledge by performing clinical procedures such as wound care, medication administration, or patient assessments within a virtual space, reinforcing skill acquisition through active participation.

The fourth domain, analyzing, challenges learners to examine and break down complex information in clinical simulations (Lamb *et al*., 2018; Frerejean *et al*., 2019). This may involve comparing different diagnostic approaches, identifying patient safety risks, or evaluating competing priorities in a virtual scenario.

The fifth domain, Evaluating, requires making informed judgments based on evidence and situational variables encountered in simulations. Nursing students engage in evaluation by critiquing their own actions or those of virtual team members, assessing ethical considerations, or deciding on the best course of action for patient care (Maddison and Strang, 2018; Pilnick *et al*., 2018).

The highest domain, Creating, involves generating new ideas, strategies, or solutions derived from the simulation experience. In nursing education, this could include designing care plans, developing patient education tools, or proposing innovative interventions based on insights gained through immersive learning.

VR and AR technologies can be effectively mapped onto Bloom's Digital Taxonomy by designing learning tasks that progressively engage students at each cognitive level. For example, a simulation may begin with simple recognition tasks (Remembering), progress through interpreting patient conditions (Understanding), applying procedures (Applying), and culminate in developing comprehensive care strategies (Creating). By aligning immersive learning activities with the taxonomy, educators can systematically cultivate higher-order thinking skills essential for competent and adaptive nursing practice (Stevenson and Hedberg, 2017; Southgate, 2019).

Kolb's Experiential Learning Cycle and Bloom's Digital Taxonomy offer robust frameworks for guiding the use of immersive technologies in nursing education. Together, they provide a complementary structure that supports experiential, reflective, and cognitive aspects of learning through VR and AR. These frameworks enable educators to design meaningful learning experiences that foster deep understanding, clinical competence, and critical thinking, ultimately enhancing nursing students' preparedness for complex healthcare environments (Berkhout *et al*., 2018; Younas and Maddigan, 2019).

2.2 Applications of VR/AR in Nursing Education

The integration of immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) into nursing education has opened new avenues for experiential learning, bridging the gap between theoretical knowledge and clinical practice. VR/AR simulations offer realistic, interactive, and scalable educational experiences that address various dimensions of nursing competency, ranging from technical skills to communication and teamwork as shown in figure 2 (Alexander *et al*., 2017; Hauze *et al*., 2019). This examines the primary applications of VR/AR in nursing education, focusing on four key areas: clinical skills development, complex clinical decision-making, empathy and communication training, and interprofessional education.

One of the most prominent applications of VR/AR in nursing education is in the development of essential clinical skills. Through highly realistic virtual environments, students gain hands-on experience in performing a range of technical procedures without the risks associated with live patient care (Kavanagh *et al*., 2017; Latka *et al*., 2018; Kononowicz *et al*., 2019). VR/AR technologies allow learners to practice skills such as wound care, catheter insertion, injections, intravenous therapy, and basic life support in fully simulated settings.

These virtual platforms provide immediate feedback, allowing students to identify and correct errors in real-time. This feature fosters iterative learning, in which students repeat procedures until they achieve proficiency, thereby improving skill retention and confidence. Unlike traditional simulation labs, which may be limited by physical resources or instructor availability, VR/AR tools can be accessed remotely and repeatedly, offering a consistent and scalable solution.

VR/AR also plays a critical role in the safe simulation of high-risk or invasive procedures that are rarely encountered during routine clinical placements but are vital for practice readiness. For example, VR-based simulations enable nursing students to practice endotracheal intubation, central line insertion, or trauma wound management without jeopardizing patient safety. These immersive technologies not only improve psychomotor coordination but also reduce anxiety associated with performing such tasks for the first time in real-life settings (Li *et al*., 2017; Engelbrecht *et al*., 2019).

Beyond technical skill development, VR/AR technologies are increasingly being used to train nursing students in complex clinical decision-making. These tools simulate dynamic, high-pressure clinical scenarios that require rapid thinking, diagnostic reasoning, and prioritized responses—skills critical for emergency care, critical care, and acute settings.

In VR/AR environments, learners can be immersed in simulated emergency situations such as cardiac arrests, sepsis management, or trauma resuscitation. These simulations require students to assess vital signs, interpret diagnostic data, administer medications, and implement life-saving interventions, mirroring the fast-paced and unpredictable nature of real clinical settings. Through repeated exposure to such high-stakes situations, nursing students develop cognitive flexibility and the ability to remain composed under pressure (Cantrell *et al*., 2017; Waxman *et al*., 2019).

Additionally, VR/AR technologies offer opportunities for scenario-based learning, where students must analyze complex patient cases, make clinical judgments, and experience the consequences of their decisions. This fosters critical reflection and clinical reasoning, preparing learners to apply evidence-based practices in actual healthcare environments. Through integrated debriefing features, students can review their performance and receive feedback on clinical choices, reinforcing learning through reflection and iterative practice.

VR/AR technologies also serve as powerful tools for fostering empathy and enhancing communication skills, both of which are essential components of holistic nursing care. Empathy-focused simulations immerse learners in the experiences of patients with chronic conditions, disabilities, or cognitive impairments, promoting deeper understanding and compassion (Trahan *et al*., 2019; Scholten and Granic, 2019).

For example, VR simulations that replicate the sensory and cognitive experiences of individuals with dementia enable students to appreciate the confusion, frustration, and isolation faced by these patients. Similarly, AR applications can simulate hearing loss, visual impairments, or mobility limitations, allowing nursing students to better understand the daily challenges of living with such conditions. By virtually "walking in the shoes" of patients, learners gain valuable insight into the importance of empathy and person-centered care.

Communication-focused VR/AR training provides opportunities for students to practice therapeutic communication strategies, engage in difficult conversations, and refine interpersonal skills. Simulations may involve interactions with virtual patients, family members, or healthcare colleagues, enabling learners to navigate scenarios such as breaking bad news, addressing patient concerns, or collaborating on care plans. These applications not only improve verbal and non-verbal communication but also help students develop cultural competence and emotional intelligence—essential traits in diverse healthcare settings.

Interprofessional collaboration is fundamental to effective healthcare delivery, and VR/AR technologies have emerged as valuable tools for promoting interprofessional education (IPE). Through collaborative virtual simulations, nursing students engage with learners from other disciplines such as medicine, pharmacy, respiratory therapy, and social work, simulating the teamwork required in actual clinical practice (Kuehn *et al*., 2017; Liaw *et al*., 2019).

These VR/AR scenarios present complex patient cases requiring coordinated care and shared decision-making among team members. Students can practice interprofessional communication, role clarification, conflict resolution, and collaborative problem-solving within a risk-free environment. This approach fosters mutual respect and enhances the understanding of each profession's scope of practice.

Moreover, VR/AR-based IPE allows learners from different locations to participate in joint training sessions, overcoming geographical barriers to collaborative learning. Such simulations are particularly valuable in preparing nursing students for roles in multidisciplinary teams, ensuring that they are ready to contribute effectively to integrated care models.

The application of VR and AR technologies in nursing education spans a wide range of learning domains, from technical skill acquisition to advanced clinical reasoning, empathy development, and interprofessional collaboration. These immersive tools enable students to engage in realistic, interactive learning experiences that enhance clinical competence, critical thinking, and compassionate care.

By providing safe, repeatable, and scalable learning environments, VR/AR platforms address key limitations of traditional nursing education methods. They prepare students to navigate the complexities of modern healthcare practice while reinforcing patient-centered, ethical, and collaborative approaches to care. As VR/AR technologies continue to evolve, their role in shaping the future of nursing education is poised to expand, offering exciting opportunities to transform how nurses are trained and how care is delivered (Baikulova and Suderevskaia, 2019; Wolz, 2019).

2.3 Evaluation of VR/AR through Experiential Learning Theory

The integration of Virtual Reality (VR) and Augmented Reality (AR) in nursing education presents a unique opportunity to enhance experiential learning. Kolb's Experiential Learning Theory (ELT) offers a comprehensive framework for evaluating how these immersive technologies foster active, meaningful learning. According to Kolb, learning is a cyclical process consisting of four stages: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation (Reshmad'sa and Vijayakumari, 2017; Ayad *et al*., 2019). This evaluates VR/AR-based nursing education through the lens of ELT, mapping immersive learning activities to each stage of Kolb's cycle, analyzing their educational impact, and presenting specific examples of effective VR/AR nursing simulations aligned with the model.

This stage involves direct participation in a learning activity that engages the learner's senses and emotions. VR/AR simulations naturally fulfill this requirement by immersing students in realistic clinical environments where they perform specific nursing tasks. In VR-based simulations, learners interact with virtual patients, administer medications, or perform life-saving interventions, while AR overlays digital data—such as vital signs or anatomical structures—onto real-world settings, enriching practical experiences. These activities offer the learner a "first-person" perspective of clinical practice, enabling hands-on learning without the risks associated with real patient care.

Following the immersive experience, learners are encouraged to reflect on their actions, decisions, and outcomes. VR/AR platforms often include built-in debriefing tools, enabling students to review performance metrics, receive instructor feedback, or re-watch simulation recordings. These reflection opportunities allow learners to analyze their behavior, identify areas of improvement, and process emotional responses to challenging clinical situations. Reflection is often facilitated by instructors through structured debriefing sessions, encouraging dialogue and peer discussion.

At this stage, learners integrate theoretical concepts and principles with their reflective observations to form a deeper understanding of clinical knowledge. VR/AR simulations often include educational modules that link practical activities with underlying theory, such as anatomy, pathophysiology, or pharmacology. Learners can revisit learning materials, adjust their clinical reasoning, and develop abstract frameworks for future decision-making. Through this process, students synthesize experience with academic knowledge, enhancing critical thinking and judgment.

The final stage involves applying newly acquired knowledge and insights to real-world practice or additional simulations. VR/AR technologies allow for repeated practice in varying scenarios, enabling students to test new approaches, refine techniques, and experiment with different clinical strategies (Birt and Cowling, 2017; Li *et al*., 2018). For example, students may reattempt a simulation with altered patient conditions to apply lessons learned in prior sessions. This cyclical experimentation fosters iterative learning and skill mastery, promoting readiness for clinical environments.

VR/AR technologies are inherently aligned with experiential learning principles, offering dynamic and interactive environments that allow learners to learn by doing. Unlike traditional lectures or textbook-based instruction, immersive simulations actively engage learners, triggering cognitive, emotional, and psychomotor domains simultaneously.

One key advantage of VR/AR is the ability to present complex, high-risk scenarios in a safe, controlled setting. Students can engage with rare or critical situations—such as cardiac arrest, severe trauma, or infectious disease outbreaks—without jeopardizing patient safety. These experiences provide "concrete experiences" that would otherwise be difficult to obtain during routine clinical rotations.

Additionally, VR/AR enhances reflection by offering objective performance feedback through tracking technologies. These platforms can record learner actions, measure response times, assess accuracy, and present detailed analytics, which deepen reflective learning. Moreover, the repeatable nature of VR/AR simulations encourages self-directed learning; students can revisit and refine their actions independently, reinforcing abstract conceptualization and active experimentation.

Furthermore, VR/AR facilitates the emotional engagement necessary for transformative learning. By placing learners in realistic, emotionally charged situations, such as delivering bad news or managing end-of-life care, VR/AR fosters empathy and emotional intelligence, critical components of patient-centered nursing care.

Several nursing education programs have successfully implemented VR/AR-based simulations that exemplify Kolb's learning cycle.

In this scenario, students are immersed in an intensive care unit setting, where they must rapidly identify signs of sepsis, administer appropriate interventions, and communicate with interdisciplinary teams (Bullard *et al*., 2017; Seam *et al*., 2019). *Concrete Experience,* students interact with a deteriorating virtual patient showing sepsis symptoms. *Reflective Observation,* after the simulation, students review vital signs, timelines, and decisions made. *Abstract Conceptualization,* educators link students' responses to evidence-based sepsis protocols and underlying pathophysiology. *Active Experimentation:* Learners repeat the simulation with adjusted parameters, applying refined strategies for early detection and intervention.

An AR application projects interactive wound models onto mannequins or clinical equipment, guiding students through wound assessment and dressing techniques.

Concrete Experience, students assess wounds in a blended physical-digital environment. *Reflective* Observation, learners evaluate their technique via AR-guided scoring and instructor feedback. *Abstract Conceptualization*, the simulation connects wound care decisions to concepts like infection control and tissue healing. *Active Experimentation*, students reattempt the procedure using different wound types or treatment protocols.

This simulation places students in the virtual perspective of an older adult with dementia, simulating sensory impairments and cognitive confusion. *Concrete Experience*, learners experience disorientation and communication barriers from a patient's point of view. *Reflective Observation, structured* debriefings allow learners to process their emotional responses and discuss challenges in dementia care. *Abstract Conceptualization*, educators guide learners in applying person-centered communication strategies and dementia care models. *Active Experimentation*, students apply these techniques in subsequent simulations or during clinical placements with dementia patients.

VR and AR technologies provide powerful platforms for operationalizing Kolb's Experiential Learning Theory in nursing education. By offering realistic, immersive experiences that mirror real clinical practice, these technologies effectively engage learners in the full learning cycle—from concrete experience to active experimentation. Through structured simulation designs and integrated feedback mechanisms, VR/AR enables nursing students to develop clinical competence, critical thinking, and emotional resilience in a safe, supportive environment. The alignment of VR/AR with experiential learning principles highlights their growing significance in advancing nursing education and preparing future nurses for complex, technology-driven healthcare settings (Strada *et al*., 2019; González *et al*., 2019).

2.4 Evaluation of VR/AR Using Bloom's Digital Taxonomy

The integration of immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) into nursing education has transformed the landscape of teaching and learning, providing new opportunities for experiential learning. Bloom's Digital Taxonomy, an adaptation of the original Bloom's Taxonomy, offers a structured framework for evaluating the effectiveness of VR/AR tools across varying levels of cognitive learning. By categorizing learning objectives from basic knowledge acquisition to advanced clinical problem-solving, this taxonomy enables educators to systematically assess the pedagogical value of immersive technologies in nursing education (Harris *et al*., 2019; Heitzmann *et al*., 2019).

At the foundational level of Remembering, VR/AR tools are designed to support the recall of factual knowledge, terminology, and basic concepts. In nursing education, this may include VR-based anatomical tours that allow learners to explore human body structures, memorize medical terminology, and identify anatomical landmarks. These applications often include labeling exercises, quizzes, and guided navigation tasks to reinforce memory retention. For instance, a VR simulation may guide students through the cardiovascular system, requiring them to recall and identify key components such as arteries, veins, and chambers of the heart.

The next cognitive level, Understanding, involves the ability to explain concepts and interpret information. VR/AR simulations can present dynamic clinical scenarios where students must explain patient symptoms or physiological responses. For example, an AR application projecting visualizations of disease progression, such as diabetic foot ulcers, can help students grasp underlying pathological processes. Learners can manipulate variables within the simulation, fostering comprehension of cause-and-effect relationships in disease management.

Applying represents the stage where learners use acquired knowledge to perform procedures or solve routine clinical problems. VR/AR technologies facilitate this by simulating hands-on experiences, such as inserting intravenous lines, administering medications, or conducting physical assessments. These tools offer interactive environments where learners apply protocols and practice psychomotor skills in a risk-free setting, enhancing both confidence and technical competence.

At the Analyzing level, VR/AR environments challenge students to deconstruct complex patient cases and recognize patterns within clinical data. Advanced simulations may involve multi-patient care scenarios where learners identify abnormal vital signs, prioritize care tasks, and differentiate between overlapping symptoms. For example, VR simulations may require students to analyze the trajectory of patient deterioration in an intensive care unit and select appropriate interventions based on clinical indicators.

The Evaluating level engages learners in making critical judgments and decisions under simulated conditions. VR/AR platforms often embed ethical dilemmas, medication reconciliation tasks, or diagnostic decision-making exercises. Nursing students are prompted to assess the risks and benefits of various interventions, justify their clinical decisions, and reflect on the outcomes within the simulation (Smallheer *et al*., 2018; Perry *et al*., 2019). This stage fosters advanced clinical reasoning and critical thinking, essential for effective patient care.

At the highest cognitive level, Creating, students use immersive technologies to generate novel solutions or develop care plans based on complex simulation experiences. In some VR/AR scenarios, learners are tasked with designing patient discharge plans, proposing preventive care strategies, or developing interdisciplinary collaboration approaches for patient care. By enabling students to synthesize knowledge from various domains, VR/AR fosters innovation and adaptive problem-solving in clinical practice.

Several nursing education programs have demonstrated the successful application of VR/AR technologies aligned with Bloom's Digital Taxonomy. For Remembering and Understanding, programs such as the "3D Organon VR Anatomy" platform offer immersive anatomical explorations that help nursing students identify body systems, memorize structures, and explain their physiological functions. These programs are widely used in foundational nursing courses focused on anatomy and physiology.

In the Applying stage, the Oxford Medical Simulation platform provides interactive scenarios where nursing students practice clinical procedures and emergency responses, such as managing anaphylaxis or cardiac arrest. Students engage in realistic patient encounters, apply clinical protocols, and receive automated feedback, enhancing their procedural skills and clinical decision-making abilities.

For Analyzing and Evaluating, programs like "SimX" deliver complex case-based simulations that challenge learners to assess multiple data points, prioritize interventions, and make clinical judgments under pressure. Scenarios include high-acuity situations such as trauma resuscitation or managing sepsis in critical care settings. These simulations promote higher-order thinking skills by requiring analysis of evolving patient conditions and defense of clinical decisions during debriefings.

At the Creating level, some nursing programs employ VR platforms that support team-based care planning and interdisciplinary collaboration (Flinter *et al*., 2017; Sweeney *et al*., 2018). In these simulations, students are tasked with developing comprehensive care plans for patients with chronic conditions or complex psychosocial needs. For instance, students may collaboratively design discharge planning strategies that incorporate medication reconciliation, community resource referrals, and follow-up care coordination, reflecting real-world complexities.

VR and AR technologies, when thoughtfully aligned with Bloom's Digital Taxonomy, offer powerful tools for fostering cognitive development in nursing education. From foundational knowledge recall to advanced problem-solving and clinical innovation, immersive simulations support learning across all cognitive levels. By leveraging VR/AR in structured, evidence-informed ways, nursing educators can enhance learner engagement, clinical competence, and critical thinking, ultimately preparing students for the multifaceted demands of contemporary healthcare environments. As these technologies continue to evolve, their integration with pedagogical frameworks like Bloom's Taxonomy will be key to maximizing their educational impact and ensuring effective, competency-based nursing education.

2.5 Benefits and Challenges

The incorporation of Virtual Reality (VR) and Augmented Reality (AR) in nursing education represents a major shift in pedagogical strategies, offering both significant advantages and noteworthy challenges. As immersive technologies become more prominent, nursing programs must evaluate their potential for improving learning outcomes, alongside addressing the barriers to widespread adoption as shown in figure 3(Dudding and Nottingham, 2018; Fealy *et al*., 2019). This critically analyzes the key benefits and challenges of using VR/AR in nursing education, particularly in relation to student engagement, skill retention, accessibility, costs, faculty readiness, and curricular integration.

One of the most significant advantages of VR/AR-based learning is the marked increase in student engagement and motivation. Traditional teaching methods—such as lectures and passive video demonstrations—often struggle to sustain student attention, particularly in complex or abstract topics. VR and AR technologies provide highly interactive, immersive environments that captivate learners by simulating real-world nursing scenarios.

VR/AR simulations allow students to take on active roles within clinical settings, making real-time decisions, solving problems, and interacting with virtual patients and environments. This active participation fosters a sense of presence and emotional connection, which enhances motivation and makes the learning experience more enjoyable and meaningful. Studies have shown that students using VR/AR report greater enthusiasm, curiosity, and readiness to engage with challenging material, resulting in deeper learning.

Additionally, gamification elements within VR/AR—such as scoring systems, challenges, and instant feedback—further enhance motivation by tapping into competitive and achievement-oriented learning styles. This motivational impact is particularly valuable for younger, tech-savvy generations of nursing students who are accustomed to digital environments.

VR and AR technologies significantly enhance the retention of knowledge and clinical skills. Unlike traditional learning methods, which may rely heavily on memorization, immersive technologies engage multiple sensory modalities—visual, auditory, and kinesthetic—thus reinforcing neural pathways associated with learning. VR/AR simulations are often structured to allow for repeated practice of clinical tasks, fostering long-term memory formation through repetition and immediate feedback.

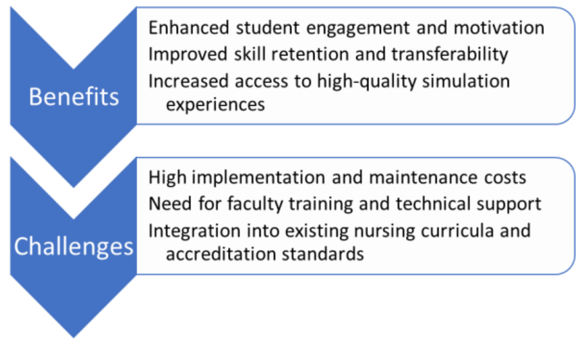

Figure 3: Benefits and Challenges

More importantly, VR/AR learning environments enable students to practice realistic clinical decision-making and psychomotor skills that can be directly transferred to real-life patient care settings. For example, repeated exposure to emergency scenarios, such as cardiac arrest simulations in VR, allows learners to internalize clinical protocols and improve their performance in high-pressure situations. Empirical research demonstrates that students trained with VR/AR exhibit greater accuracy, speed, and confidence when performing clinical procedures compared to those trained via traditional methods (Hsieh and Lee, 2018; Ho *et al*., 2019).

Accessibility is another notable benefit of VR/AR in nursing education. Traditional simulation-based education often requires specialized facilities, high-cost manikins, and significant staff resources, which may limit opportunities for frequent or individualized practice. VR/AR platforms, however, can deliver standardized, high-quality simulation experiences to learners regardless of location.

These technologies are especially valuable for remote or rural nursing programs, where access to sophisticated simulation labs may be limited. Cloud-based VR/AR solutions can be accessed via laptops, tablets, or VR headsets, enabling students to engage in clinical practice simulations from their homes or local learning centers. This flexibility not only democratizes access to advanced educational resources but also supports self-paced, independent learning.

Additionally, VR/AR simulations can offer exposure to rare, complex, or high-risk clinical cases that students may not encounter during traditional clinical placements. This ensures that all students have opportunities to develop competencies in a wide range of nursing scenarios.

Despite the clear benefits, the high costs associated with implementing and maintaining VR/AR technologies remain a major barrier. Initial investments include hardware such as VR headsets, AR-enabled devices, and compatible computers, as well as software licenses for educational applications. These costs can be prohibitive for many nursing programs, particularly in low-resource settings.

Furthermore, ongoing expenses—such as system updates, technical maintenance, and software subscriptions—add to the financial burden. Cost-benefit analyses are often required to justify these investments, especially in academic institutions with limited budgets (Posner and Sunstein, 2017; Asche *et al*., 2018). Without external funding or institutional commitment, the scalability of VR/AR in nursing education remains limited.

Effective integration of VR/AR into nursing curricula requires well-prepared faculty who are both pedagogically and technologically competent. Many nursing educators lack formal training in immersive technologies and may experience challenges in designing, delivering, and assessing VR/AR-based learning activities.

Faculty may face a steep learning curve in mastering VR/AR hardware, navigating software platforms, and troubleshooting technical issues. In addition, instructors must develop skills in facilitating debriefings and linking simulation experiences to theoretical frameworks such as Kolb's Experiential Learning Cycle and Bloom's Digital Taxonomy. Without adequate training and institutional support, faculty resistance to adopting these tools may emerge.

Furthermore, ongoing technical support is essential to ensure seamless operation of VR/AR systems during instructional activities. Institutions must invest in IT personnel and provide training opportunities to ensure the sustainability of VR/AR educational programs.

Another key challenge is the integration of VR/AR into established nursing curricula and compliance with accreditation requirements. Nursing education programs are often tightly structured, with limited flexibility to incorporate new technologies without disrupting course schedules or learning objectives.

Curriculum redesign is necessary to embed VR/AR simulations meaningfully into coursework, ensuring that these tools complement rather than replace essential clinical learning experiences. This requires careful alignment with competency-based education standards, clinical practice guidelines, and accreditation frameworks.

Moreover, evidence-based outcomes demonstrating the effectiveness of VR/AR in achieving required competencies must be documented to satisfy accrediting bodies and regulatory agencies. This calls for robust research and program evaluation efforts to validate the educational value of immersive technologies.

The integration of VR and AR technologies in nursing education offers transformative benefits, including enhanced student engagement, improved skill retention, and expanded access to high-quality simulations (Gambo *et al*., 2017; Pottle *et al*., 2019). However, these benefits must be balanced against significant challenges, such as high costs, faculty training needs, and curricular integration hurdles. Addressing these challenges requires institutional commitment, interdisciplinary collaboration, and evidence-based program development. With strategic planning and support, VR/AR technologies can become powerful tools in shaping the future of nursing education, fostering clinical competence, and improving patient care outcomes worldwide.

2.6 Recommendations and Best Practices

The rapid advancement of immersive technologies such as virtual reality (VR) and augmented reality (AR) has provided nursing educators with innovative tools to enhance learning and clinical preparedness. However, the effective integration of VR/AR requires deliberate planning grounded in educational theory and evidence-based practice. Several key recommendations and best practices emerge to guide the systematic adoption of immersive technologies in nursing education.

One of the foremost recommendations is to align VR/AR implementation with established learning theories, particularly experiential learning theory and cognitive frameworks such as Bloom's Digital Taxonomy. These theories provide essential guidance for selecting appropriate technologies and designing simulations that foster active engagement and knowledge retention. Kolb's Experiential Learning Cycle is particularly well-suited for structuring VR/AR learning activities, as it emphasizes learning through experience, reflection, conceptualization, and experimentation. Educators should ensure that VR/AR simulations explicitly address each of these stages. For example, immersive clinical simulations should begin with realistic patient care scenarios (concrete experience), followed by structured debriefing sessions (reflective observation), integration of theoretical content (abstract conceptualization), and opportunities for repeated practice or skills application (active experimentation). Similarly, Bloom's Digital Taxonomy offers a framework to scaffold VR/AR learning activities across cognitive domains, from basic recall and comprehension to complex problem-solving and creation of care plans. By explicitly mapping VR/AR interventions to these frameworks, educators can design experiences that build progressively from foundational knowledge to higher-order thinking skills.

Curriculum design strategies also play a pivotal role in ensuring the effective integration of VR/AR. Nursing programs should adopt a systematic, competency-based approach that aligns immersive technologies with learning objectives and clinical competencies. Curricula should identify specific clinical skills or cognitive competencies that are best suited for immersive technologies, such as assessment, communication, teamwork, or emergency response. VR/AR applications should be embedded within course modules where experiential learning is most critical, such as health assessment, pharmacology, and acute care nursing. A phased integration model can be employed, starting with low-complexity simulations for skill acquisition and gradually advancing to high-fidelity, multi-patient scenarios that foster critical thinking and clinical judgment. Additionally, assessment strategies should be adapted to include performance-based evaluations within VR/AR environments, such as objective structured clinical examinations (OSCEs) using simulation. Formative and summative assessments should measure both technical skills and cognitive outcomes, ensuring that learning is comprehensive and transferable to real clinical settings. Interprofessional learning opportunities can also be incorporated, allowing nursing students to collaborate with learners from other healthcare disciplines within shared VR/AR simulations to enhance communication and teamwork skills.

Faculty development is a critical enabler of successful VR/AR integration. Many nurse educators may lack prior experience with immersive technologies, creating barriers to effective implementation. Comprehensive faculty development programs should be established to build digital literacy, simulation pedagogy, and technological proficiency. Training should include hands-on workshops where faculty can explore different VR/AR platforms, practice designing and facilitating simulations, and learn troubleshooting techniques. Faculty should also be trained in debriefing methods that maximize reflective learning and support emotional safety within immersive environments. Instructional design support from educational technologists can further assist faculty in aligning VR/AR experiences with curricular goals and learning theories. Peer mentoring programs, in which experienced faculty guide their colleagues through the adoption process, can foster collaborative learning and reduce resistance to new technologies.

Institutions should also invest in sustained faculty development by integrating VR/AR competencies into professional development pathways, offering certifications or continuing education credits for faculty who complete immersive learning training. Furthermore, faculty should be involved in research and scholarship related to VR/AR integration, contributing to the evidence base and sharing best practices through publications and conferences. This scholarly engagement will not only enhance the quality of VR/AR use in nursing education but also ensure that faculty remain at the forefront of pedagogical innovation.

The effective integration of VR/AR in nursing education requires a comprehensive, theory-based approach that spans curriculum design, faculty development, and pedagogical alignment. By grounding immersive learning experiences in experiential and cognitive frameworks, designing structured curricula, and equipping faculty with the necessary skills, nursing programs can maximize the educational impact of VR/AR technologies and better prepare students for complex clinical practice environments.

CONCLUSION

This review highlights the significant potential of Virtual Reality (VR) and Augmented Reality (AR) technologies in advancing nursing education through experiential, immersive learning. Key findings indicate that VR/AR effectively enhance student engagement, increase motivation, and foster active participation by simulating realistic clinical environments. These technologies not only improve knowledge retention and psychomotor skills but also enable the transfer of learning to real-world clinical settings. VR/AR simulations offer safe, repeatable opportunities for practicing high-risk procedures, honing clinical decision-making, and developing empathy and communication skills. Furthermore, they expand access to high-quality simulation experiences, particularly for remote learners or those with limited clinical placement opportunities.

The analysis affirms the strong alignment between VR/AR applications and Kolb's Experiential Learning Theory, demonstrating how immersive technologies effectively support the full learning cycle—concrete experience, reflective observation, abstract conceptualization, and active experimentation. Additionally, VR/AR promote higher-order cognitive engagement consistent with Bloom's Digital Taxonomy, allowing students to progress from foundational knowledge to advanced clinical reasoning and problem-solving. These findings reaffirm the central role of experiential learning in digital environments, where active engagement, reflection, and practice are key to meaningful skill acquisition and competence development.

Despite these benefits, challenges such as high costs, the need for faculty training, and curricular integration must be addressed to maximize the educational value of VR/AR. Future research is needed to explore the long-term impacts of immersive technologies on nursing practice, including patient care outcomes, professional readiness, and career-long learning. Studies examining scalability, cost-effectiveness, and best practices for integrating VR/AR into accreditation standards will be essential for guiding sustainable implementation. Ultimately, VR and AR have the potential to transform nursing education by creating dynamic, learner-centered environments that prepare students for the evolving demands of healthcare practice.

REFERENCES

[1] Alexander, B., Becker, S.A., Cummins, M. and Giesinger, C.H., 2017. *Digital literacy in higher education, Part II: An NMC Horizon project strategic brief* (pp. 1-37). The New Media Consortium.

[2] Allen, J.A., Reiter-Palmon, R., Crowe, J. and Scott, C., 2018. Debriefs: Teams learning from doing in context. *American Psychologist*, *73*(4), p.504.

[3] Angelopoulos, A., Michailidis, E.T., Nomikos, N., Trakadas, P., Hatziefremidis, A., Voliotis, S. and Zahariadis, T., 2019. Tackling faults in the industry 4.0 era—a survey of machine-learning solutions and key aspects. *Sensors*, *20*(1), p.109.

[4] Asche, C.V., Kim, M., Brown, A., Golden, A., Laack, T.A., Rosario, J., Strother, C., Totten, V.Y. and Okuda, Y., 2018. Communicating value in simulation: cost–benefit analysis and return on investment. *Academic Emergency Medicine*, *25*(2), pp.230-237.

[5] Ayad, A., Wilkinson, E. and Matthews, R., 2019. Systemic experiential learning model for the evaluation of technological learning: The case of small satellite capability-building in Algeria. *International Journal of Technology Management & Sustainable Development*, *18*(1), pp.75-100.

[6] Babu, S.K., Krishna, S. and Bhavani, R.R., 2018, July. Virtual reality learning environments for vocational education: A comparison study with

conventional instructional media on knowledge retention. In *2018 IEEE 18th international conference on advanced learning technologies (ICALT)* (pp. 385-389). IEEE.

[7] Baikulova, M. and Suderevskaia, E., 2019. Futures Research: The Application of VR and AR Emerging Technologies in New Media: Future of Immersive Visuals Online.

[8] Berkhout, J.J., Helmich, E., Teunissen, P.W., van der Vleuten, C.P. and Jaarsma, A.D.C., 2018. Context matters when striving to promote active and lifelong learning in medical education. *Medical education*, *52*(1), pp.34-44.

[9] Birt, J. and Cowling, M., 2017. Toward future'mixed reality'learning spaces for STEAM education. *International Journal of Innovation in Science and Mathematics Education*, *25*(4).

[10] Broisin, J., Venant, R. and Vidal, P., 2017. Lab4CE: a remote laboratory for computer education. *International Journal of Artificial Intelligence in Education*, *27*, pp.154-180.

[11] Bullard, M.J., Leuck, J.A. and Howley, L.D., 2017. Unifying interdisciplinary education: designing and implementing an intern simulation educational curriculum to increase confidence in critical care from PGY1 to PGY2. *BMC Research Notes*, *10*, pp.1-6.

[12] Cantrell, M.L., Meyer, S.L. and Mosack, V., 2017. Effects of simulation on nursing student stress: An integrative review. *Journal of nursing education*, *56*(3), pp.139-144.

[13] Dudding, C.C. and Nottingham, E.E., 2018. A national survey of simulation use in university programs in communication sciences and disorders. *American Journal of Speech-Language Pathology*, *27*(1), pp.71-81.

[14] Eneogu, R.A., Mitchell, E.M., Ogbudebe, C., Aboki, D., Anyebe, V., Dimkpa, C.B., Egbule, D., Nsa, B., van der Grinten, E., Soyinka, F. and Abdur-Razzaq, H., 2020. Operationalizing Mobile Computer-assisted TB Screening and Diagnosis With Wellness on Wheels (WoW)) in Nigeria: Balancing Feasibility and Iterative Efficiency.

[15] Engelbrecht, H., Lindeman, R.W. and Hoermann, S., 2019. A SWOT analysis of the field of virtual reality for firefighter training. *Frontiers in Robotics and AI*, *6*, p.101.

[16] Fealy, S., Jones, D., Hutton, A., Graham, K., McNeill, L., Sweet, L. and Hazelton, M., 2019. The integration of immersive virtual reality in tertiary nursing and midwifery education: A scoping review. *Nurse education today*, *79*, pp.14-19.

[17] Fewster-Thuente, L. and Batteson, T.J., 2018. Kolb's experiential learning theory as a theoretical underpinning for interprofessional education. *Journal of allied health*, *47*(1), pp.3-8.

[18] Flinter, M., Hsu, C., Cromp, D., Ladden, M.D. and Wagner, E.H., 2017. Registered nurses in primary care: emerging new roles and contributions to team-based care in high-performing practices. *The Journal of ambulatory care management*, *40*(4), pp.287-296.

[19] Frerejean, J., Van Merriënboer, J.J., Kirschner, P.A., Roex, A., Aertgeerts, B. and Marcellis, M., 2019. Designing instruction for complex learning: 4C/ID in higher education. *European Journal of Education*, *54*(4), pp.513-524.

[20] Gambo, J.M., Bahreman, N.T., Watties-Daniels, D., Neal, M. and Swoboda, S.M., 2017. Can mobile technology enhance learning and change educational practice?. *CIN: Computers, Informatics, Nursing*, *35*(8), pp.375-380.

[21] González, A.V., Koh, S., Kapalo, K., Sottilare, R., Garrity, P., Billinghurst, M. and LaViola, J., 2019, October. A comparison of desktop and augmented reality scenario based training authoring tools. In *2019 IEEE International Symposium on Mixed and Augmented Reality (ISMAR)* (pp. 339-350). IEEE.

[22] Han, S., 2019. An integrative review on augmented reality/virtual reality simulation programs in the mental health area for health professionals. *International Journal of Contents*, *15*(4), pp.36-43.

[23] Harris, N. and Bacon, C.E.W., 2019. Developing cognitive skills through active learning: a systematic review of health care professions. *Athletic Training Education Journal*, *14*(2), pp.135-148.

[24] Hauze, S.W., Hoyt, H.H., Frazee, J.P., Greiner, P.A. and Marshall, J.M., 2019. Enhancing nursing education through affordable and realistic holographic mixed reality: the virtual standardized patient for clinical simulation. *Biomedical Visualisation: Volume 1*, pp.1-13.

[25] Heitzmann, N., Seidel, T., Opitz, A., Hetmanek, A., Wecker, C., Fischer, M.R., Ufer, S., Schmidmaier, R., Neuhaus, B., Siebeck, M. and Stürmer, K., 2019. Facilitating diagnostic competences in simulations in higher education: a framework and a research agenda. *Frontline Learning Research*, *7*(4), pp.1-24.

[26] Ho, L.H., Sun, H. and Tsai, T.H., 2019. Research on 3D painting in virtual reality to improve students' motivation of 3D animation learning. *Sustainability*, *11*(6), p.1605.

[27] Hsieh, M.C. and Lee, J.J., 2018. Preliminary study of VR and AR applications in medical and healthcare education. *J Nurs Health Stud*, *3*(1), p.1.

[28] Joda, T., Gallucci, G.O., Wismeijer, D. and Zitzmann, N.U., 2019. Augmented and virtual reality in dental medicine: A systematic review. *Computers in biology and medicine*, *108*, pp.93-100.

[29] Kavanagh, S., Luxton-Reilly, A., Wuensche, B. and Plimmer, B., 2017. A systematic review of virtual reality in education. *Themes in science and technology education*, *10*(2), pp.85-119.

[30] Khoshnevisan, B. and Le, N., 2018. Augmented reality in language education: A systematic literature review. *Adv. Glob. Educ. Res*, *2*, pp.57-71.

[31] Kingsley Ojeikere, Opeoluwa Oluwanifemi Akomolafe, Opeyemi Olamide Akintimehin. 2020 "A Community-Based Health and Nutrition Intervention Framework for Crisis-Affected Regions" Iconic Research and Engineering Journals 3(8):311-333

[32] Koivisto, J.M., Niemi, H., Multisilta, J. and Eriksson, E., 2017. Nursing students' experiential learning processes using an online 3D simulation game. *Education and Information Technologies*, *22*, pp.383-398.

[33] Kononowicz, A.A., Woodham, L.A., Edelbring, S., Stathakarou, N., Davies, D., Saxena, N., Car, L.T., Carlstedt-Duke, J., Car, J. and Zary, N., 2019. Virtual patient simulations in health professions education: systematic review and meta-analysis by the digital health education collaboration. *Journal of medical Internet research*, *21*(7), p.e14676.

[34] Kuehn, M.B., Huehn, S. and Smalling, S., 2017. Improving collaboration among social work and nursing students through interprofessional simulation. *Creative Nursing*, *23*(3), pp.179-183.

[35] Lamb, R.L., Annetta, L., Firestone, J. and Etopio, E., 2018. A meta-analysis with examination of moderators of student cognition, affect, and learning outcomes while using serious educational games, serious games, and simulations. *Computers in Human Behavior*, *80*, pp.158-167.

[36] Latka, D., Waligora, M., Latka, K., Miekisiak, G., Adamski, M., Kozlowska, K., Latka, M., Fojcik, K., Man, D. and Olchawa, R., 2018. Virtual reality based simulators for neurosurgeons-What we have and what we hope to have in the nearest future. In *Biomedical Engineering and Neuroscience: Proceedings of the 3rd International Scientific Conference on Brain-Computer Interfaces, BCI 2018, March 13-14, Opole, Poland* (pp. 1-10). Springer International Publishing.

[37] Li, L., Yu, F., Shi, D., Shi, J., Tian, Z., Yang, J., Wang, X. and Jiang, Q., 2017. Application of virtual reality technology in clinical medicine. *American journal of translational research*, *9*(9), p.3867.

[38] Li, X., Yi, W., Chi, H.L., Wang, X. and Chan, A.P., 2018. A critical review of virtual and augmented reality (VR/AR) applications in construction safety. *Automation in construction*, *86*, pp.150-162.

[39] Liaw, S.Y., Soh, S.L.H., Tan, K.K., Wu, L.T., Yap, J., Chow, Y.L., Lau, T.C., Lim, W.S., Tan, S.C., Choo, H. and Wong, L.L., 2019. Design and evaluation of a 3D virtual environment for collaborative learning in interprofessional team

care delivery. *Nurse education today*, *81*, pp.64-71.

[40] Lubbers, J. and Rossman, C., 2017. Satisfaction and self-confidence with nursing clinical simulation: Novice learners, medium-fidelity, and community settings. *Nurse Education Today*, *48*, pp.140-144.

[41] Maddison, C. and Strang, G., 2018. Do action learning sets facilitate collaborative, deliberative learning?: A focus group evaluation of Graduate Entry Pre-registration Nursing (GEN) students' experience. *Nurse education in practice*, *28*, pp.285-291.

[42] McGaughey, J., O'Halloran, P., Porter, S., Trinder, J. and Blackwood, B., 2017. Early warning systems and rapid response to the deteriorating patient in hospital: a realist evaluation. *Journal of advanced nursing*, *73*(12), pp.3119-3132.

[43] Menson, W.N.A., Olawepo, J.O., Bruno, T., Gbadamosi, S.O., Nalda, N.F., Anyebe, V., Ogidi, A., Onoka, C., Oko, J.O. and Ezeanolue, E.E., 2018. Reliability of self-reported Mobile phone ownership in rural north-Central Nigeria: cross-sectional study. *JMIR mHealth and uHealth*, *6*(3), p.e8760.

[44] Merotiwon Damilola Oluyemi, Opeyemi Olamide Akintimehin, Opeoluwa Oluwanifemi Akomolafe. 2020 "Modeling Health Information Governance Practices for Improved Clinical Decision-Making in Urban Hospitals" Iconic Research and Engineering Journals 3(9):350-362

[45] Merotiwon Damilola Oluyemi, Opeyemi Olamide Akintimehin, Opeoluwa Oluwanifemi Akomolafe. 2020 "Developing a Framework for Data Quality Assurance in Electronic Health Record (EHR) Systems in Healthcare Institutions" Iconic Research and Engineering Journals 3(12):335-349

[46] Merotiwon Damilola Oluyemi, Opeyemi Olamide Akintimehin, Opeoluwa Oluwanifemi Akomolafe. 2020 "Framework for Leveraging Health Information Systems in Addressing Substance Abuse Among Underserved Populations" Iconic Research and Engineering Journals 4(2):212-226

[47] Merotiwon Damilola Oluyemi, Opeyemi Olamide Akintimehin, Opeoluwa Oluwanifemi Akomolafe. 2020 "Designing a Cross-Functional Framework for Compliance with Health Data Protection Laws in Multijurisdictional Healthcare Settings" Iconic Research and Engineering Journals 4(4):279-296

[48] Moro, C., Štromberga, Z., Raikos, A. and Stirling, A., 2017. The effectiveness of virtual and augmented reality in health sciences and medical anatomy. *Anatomical sciences education*, *10*(6), pp.549-559.

[49] Mustapha, A.Y., Chianumba, E.C., Forkuo, A.Y., Osamika, D. and Komi, L.S., 2018. Systematic review of mobile health (mHealth) applications for infectious disease surveillance in developing countries. *Methodology*, *66*.

[50] Nsa B V Anyebe, C Dimkpa, D Aboki, D Egbule, S Useni, R Eneogu. (2018). Impact of active case finding of tuberculosis among prisoners using the WOW truck in North central Nigeria. *The international Union Against Tuberculosis and Lung Disease*. 11(22), ppS444

[51] Papanastasiou, G., Drigas, A., Skianis, C., Lytras, M. and Papanastasiou, E., 2019. Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills. *Virtual Reality*, *23*(4), pp.425-436.

[52] Perry, A.G., Potter, P.A. and Ostendorf, W.R., 2019. *Nursing Interventions & Clinical Skills E-Book: Nursing Interventions & Clinical Skills E-Book*. Elsevier Health Sciences.

[53] Pilnick, A., Trusson, D., Beeke, S., O'Brien, R., Goldberg, S. and Harwood, R.H., 2018. Using conversation analysis to inform role play and simulated interaction in communications skills training for healthcare professionals: identifying avenues for further development through a scoping review. *BMC medical education*, *18*, pp.1-10.

[54] Posner, E.A. and Sunstein, C.R., 2017. Moral commitments in cost-benefit analysis. *Va. L. Rev.*, *103*, p.1809.

[55] Pottle, J., 2019. Virtual reality and the transformation of medical education. *Future healthcare journal*, *6*(3), pp.181-185.

[56] Reshmad'sa, L. and Vijayakumari, S.N., 2017. Effect of Kolb's Experiential Learning Strategy on Enhancing Pedagogical Skills of Pre-Service Teachers of Secondary School Level. *Journal on School Educational Technology*, *13*(2), pp.1-6.

[57] Scholten J, R Eneogu, C Ogbudebe, B Nsa, I Anozie, V Anyebe, A Lawanson, E Mitchell. (2018). Ending the TB epidemic: role of active TB case finding using mobile units for early diagnosis of tuberculosis in Nigeria. *The international Union Against Tuberculosis and Lung Disease*. 11(22), ppS392

[58] Scholten, H. and Granic, I., 2019. Use of the principles of design thinking to address limitations of digital mental health interventions for youth. *Journal of Medical Internet Research*, *21*(1), p.e11528.

[59] Seam, N., Lee, A.J., Vennero, M. and Emlet, L., 2019. Simulation training in the ICU. *Chest*, *156*(6), pp.1223-1233.

[60] Sihi, D., 2018. Home sweet virtual home: The use of virtual and augmented reality technologies in high involvement purchase decisions. *Journal of Research in Interactive Marketing*, *12*(4), pp.398-417.

[61] Smallheer, B., Hunt, J. and Smith, J., 2018. Using critical care simulations to prepare nursing students for capstone clinical experiences. *Dimensions of Critical Care Nursing*, *37*(2), pp.69-77.

[62] Southgate, E., 2019, March. Virtual reality for Deeper Learning: An exemplar from high school science. In *2019 IEEE conference on virtual reality and 3D user interfaces (VR)* (pp. 1633-1639). IEEE.

[63] Steffen, J.H., Gaskin, J.E., Meservy, T.O., Jenkins, J.L. and Wolman, I., 2019. Framework of affordances for virtual reality and augmented reality. *Journal of management information systems*, *36*(3), pp.683-729.

[64] Stevenson, M.E. and Hedberg, J.G., 2017. Mobilizing learning: a thematic review of apps in K-12 and higher education. *Interactive Technology and Smart Education*, *14*(2), pp.126-137.

[65] Strada, F., Bottino, A., Lamberti, F., Mormando, G. and Ingrassia, P.L., 2019. Holo-BLSD–A holographic tool for self-training and self-evaluation of emergency response skills. *IEEE Transactions on Emerging Topics in Computing*, *9*(3), pp.1581-1595.

[66] Sutherland, J., Belec, J., Sheikh, A., Chepelev, L., Althobaity, W., Chow, B.J., Mitsouras, D., Christensen, A., Rybicki, F.J. and La Russa, D.J., 2019. Applying modern virtual and augmented reality technologies to medical images and models. *Journal of digital imaging*, *32*, pp.38-53.

[67] Sweeney Haney, T., Kott, K., Rutledge, C.M., Britton, B., Fowler, C.N. and Poston, R.D., 2018. How to prepare interprofessional teams in two weeks: an innovative education program nested in telehealth. *International journal of nursing education scholarship*, *15*(1), p.20170040.

[68] Trahan, M.H., Smith, K.S., Traylor, A.C., Washburn, M., Moore, N. and Mancillas, A., 2019. Three-dimensional virtual reality: Applications to the 12 grand challenges of social work. *Journal of technology in human services*, *37*(1), pp.13-31.

[69] Tutticci, N., Ryan, M., Coyer, F. and Lewis, P.A., 2018. Collaborative facilitation of debrief after high-fidelity simulation and its implications for reflective thinking: student experiences. *Studies in Higher Education*, *43*(9), pp.1654-1667.

[70] Watts, P.I., Ivankova, N. and Moss, J.A., 2017. Faculty evaluation of undergraduate nursing simulation: A grounded theory model. *Clinical Simulation in Nursing*, *13*(12), pp.616-623.

[71] Waxman, K.T., Bowler, F., Forneris, S.G., Kardong-Edgren, S. and Rizzolo, M.A., 2019. Simulation as a nursing education disrupter. *Nursing Administration Quarterly*, *43*(4), pp.300-305.

[72] Wolz, K.M., 2019. Building Faculty Competence and Self-Efficacy for Using Z Space Virtual Reality (VR) Software in the Classroom.

[73] Wu, W., Hartless, J., Tesei, A., Gunji, V., Ayer, S. and London, J., 2019. Design assessment in virtual and mixed reality environments: Comparison of novices and experts. *Journal of Construction Engineering and Management*, *145*(9), p.04019049.

[74] Younas, A. and Maddigan, J., 2019. Proposing a policy framework for nursing education for fostering compassion in nursing students: A critical review. *Journal of advanced nursing*, *75*(8), pp.1621-1636.

[75] Zapko, K.A., Ferranto, M.L.G., Blasiman, R. and Shelestak, D., 2018. Evaluating best educational practices, student satisfaction, and self-confidence in simulation: A descriptive study. *Nurse education today*, *60*, pp.28-34.