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Concept Paper

Enhancing Nursing Simulation Education: A Case for Extended Reality Innovation

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Abstract: This concept paper explores the use of extended reality (XR) technology in nursing education, with a focus on three case studies developed at one regional university in Australia. Tertiary education institutions that deliver nursing curricula are facing challenges around the provision of simulated learning experiences that prepare students for the demands of real-world professional practice. To overcome these barriers, XR technology, which includes augmented, mixed, and virtual reality (AR, MR, VR), offers a diverse media platform for the creation of immersive, hands-on learning experiences, situated within virtual environments that can reflect some of the dynamic aspects of real-world healthcare environments. This document analysis explores the use of XR technology in nursing education, through the narrative and discussion of three applied-use cases. The collaboration and co-design between nursing educators and XR technology experts allows for the creation of synchronous and asynchronous learning experiences beyond traditional nursing simulation media, better preparing students for the demands of real-world professional practice.

Keywords: extended reality; nursing; educational technology; simulation education

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1. Introduction

The provision of authentic learning experiences for undergraduate (pre-registration) nursing students is an ongoing challenge for tertiary education institutes globally [1]. Traditionally, real-world learning experiences were the sole approach to offer authentic learning experiences within nursing curricula, ensuring adequate and contextualised preparation for practice as a registered health professional [2,3]. Although workplace learning remains effective in preparing nursing students for the realities of professional practice [3,4], the shift from apprenticeship-style nursing education to university-based education and an increasingly competitive marketplace for industry-supported work experience, have led to a decrease in students being exposed to the contextual demands of real-world professional practice [2,5]. Moreover, workplace learning hours within nursing curricula vary substantially between countries. For example, the United Kingdom requires nursing students to achieve a minimum of 2300 h of workplace learning, and New Zealand requires a minimum of 1100 h, whereas Australian students are only required to achieve a minimum of 800 h of workplace learning prior to graduation. The variable hours and the competitive nature of gaining quality industry work placements for countries such as Australia, has contributed to an increasing reliance on educational institutions to provide authentic simulated learning experiences that adequately prepare nursing students for professional practice [2,5–7]. Paradoxically, the healthcare industry is increasingly demanding that new graduate nurses be “work ready”, with the ability to autonomously apply skills learnt within their degree programs, within complex and continually changing healthcare environments [3,7–9].

1.1. Nursing Simulation Education

Simulated learning within nursing curricula generally encompasses learning experiences to assist students in attaining and practising skills within safe, physical environments that are designed to look like a hospital or other healthcare environment [10]. Often referred to as simulated learning environments (SLE), equipment such as low-to-high-fidelity (realism) task trainers and mannikins are typically used in combination with roleplay and simulated patient scenarios to facilitate incremental learning (i.e., novice to expert), without the risk of harming actual patients [3,7]. Extending beyond developing and rehearsing psychomotor skills, contemporary programs seek to create contextual asynchronous and synchronous experiences that also promote cognitive (facts, critical thinking, clinical reasoning), and affective skill (beliefs, emotional intelligence, empathy) development, while adhering to the principles of nursing education theory [5,8]. The experiential learning theory (ELT) conceptualised by Kolb [11] is most often used to underpin nursing simulation education, supporting the idea that the acquisition of knowledge is derived from learner experience (concrete or abstract) and relies upon reflection to form generalisations and a new understanding [11].

The value of simulated learning for practicing skills within a supportive environment prior to workplace learning, increasing self-efficacy, and increasing confidence and competence for workplace learning are well documented [3,10]. However, the effectiveness of simulated learning for preparing work-ready graduates is sparse [7,12,13]. Additionally, students have commented on a lack of perceived authenticity and realism in simulated learning, particularly when using mannikins within an SLE [7]. A systematic review and meta-synthesis of 27 studies by Handeland et al. [14] evaluating nursing students' experiences of using mannikins described the phenomena as "seeing the manikin as a doll or a patient". The manikin as a doll was drawn from students' perceptions that mannikins were akin to a plastic doll, devoid of human expression such as communication and emotion, which hindered the real learning of nursing practice through the application of affective skills such as empathy [14]. However, the unreal nature of the manikin allowed students to practice skills unhindered, without fear of hurting anyone (failsafe) [14]. Interestingly, a study investigating the realism and presence of utilising real-life human patients for nursing education within an SLE by MacLean et al. [15] found that nursing students commented on the need to increase the realism, to enhance learning. The students in this study noted a lack of authenticity, including a lack of background noise and distractions such as those from patient call buzzers, monitor alarms, and other nursing staff during the experience. A more recent study of nursing students' perceptions of simulated learning by Tan et al. [12] concluded that the authenticity of simulated learning experiences were important to nursing students, with real-world work perceived as more complex than what was portrayed within simulated learning [14]. Students specifically commented on the inability to simulate the management of multiple patients, time management skills, and resource management skills, as well as realistic interprofessional communication and opportunities for teamwork [12].

1.2. Making the Case for XR Innovation

Technology-enabled approaches, such as the use of extended reality (XR) media, including immersive virtual reality (IVR), augmented reality (AR), and mixed reality (MR) may be one way to afford nursing students more authentic simulated learning experiences that cannot be achieved with traditional simulation media [8,16–18]. The embedded media diversity of XR technology presents enormous potential for the development of simulated learning experiences that require active student engagement and participation, which are seen as crucial to improving learning outcomes [12,19]. One key advantage of XR technologies such as IVR is the ability to situate learners within virtual environments using head-mounted displays (HMDs), conveying the contextual (physical and mental) sensations of being present and immersed in the world around them, a virtual world [20,21]. Presence and embodiment are the main psychological concepts of building reality perception in IVR users, replacing the real world, and allowing for the feeling of being within an environment and interacting with the virtual environment [21]. Augmented reality (AR) is a technology that overlays digital information onto the real world, often using a mobile device or wearable technology, such as smart glasses [22,23]. AR can enhance a user's perception of reality, by adding digital objects or information to the live view of their environment, making it possible to interact with both the real and digital worlds simultaneously [22,23]. Mixed reality (MR) is a technology that blends elements of both AR and IVR to create a continuum of connection between digital objects and the real world [24]. MR creates a hybrid environment where users can interact with both digital and real-world objects (such as high-fidelity mannikins) in a seamless way.

Therefore, this concept paper explores the potential of XR technology in enhancing traditional nursing simulation within higher education institutions, through an exploration of three case studies developed within one large regional Australian university. Through this exploration, we aim to provide insights and practical guidance for nursing educators and instructional designers interested in using XR media to enhance simulated learning within higher education contexts.

2. Materials and Methods

The concept paper is guided by a document analysis methodology [25]. Document analysis can be particularly useful in evaluating the design features of XR software from a learning strategy perspective, enabling researchers to gain a better understanding of the software and its features, as well as the intended user experience and learning outcomes [26]. Therefore, this study employs a document analysis methodology to explore the design features of three XR applications developed to augment the simulated learning experience for undergraduate nursing students.

In 2018, a new educational design framework was initiated at one large regional Australian university, with a focus on promoting teaching innovation and expanding practical support and resources [27]. Within this context, a small group of nursing and midwifery educators proposed the development of three case studies using XR technology, to increase the realism and accessibility of simulated learning experiences for students within their nursing and midwifery programs. The case studies were developed as stand-alone research prototypes for initial testing among undergraduate nursing, midwifery, and medical student cohorts, rather than full curriculum and university system integration. Each case study was co-designed by nursing and midwifery educators and XR technology experts, with the prototype development funded by the institution's new educational design program.

The prototype development was guided by the scrum design framework [28]. Scrum is based on three principles: transparency, inspection, and adaptation, and is underpinned by the empirical process control theory, which emphasises that knowledge is gained from experience, and decision-making from what is known [28]. The transparency principle enables the team to collectively conceptualise and define the final product outcome and development endpoint [28]. The inspection and adaptation principles involve four key processes: the sprint planning, daily scrum, sprint review, and sprint retrospective. Sprints are considered the main aspect of the production phase, where the entire team plans a development sprint, whereby the deliverables or outcomes of each sprint are discussed, and the sprint duration is defined. Following a sprint, the team meets to reflect upon the progress and feasibility of the end outcome [28]. The prototypes presented were: (1) the Compromised Neonate (CN); (2) the Road to Birth (RtB); and (3) Conflict Resolution (Angry Stan). Each was conceptualised through regular team meetings over a three-month period, with each case study developed over twelve weeks, with sprints scheduled every two weeks, until each program was completed and ready for testing. The programs were designed using various hardware and instructional design components, for accessibility, and to target specific learning outcomes.

3. Results

3.1. The Compromised Neonate

The simultaneous application of psychomotor, cognitive, and affective skills required for neonatal resuscitation is an area in which the incorporation of XR technology, specifically IVR, has the potential to complement traditional simulated-learning media [16]. The compromised neonate program was designed in response to anecdotal student feedback of wanting more time to practise and/or refresh their neonatal resuscitation skills prior to workplace learning. Traditional simulation methods for practicing these skills outside of the curriculum-prescribed simulation learning were often inaccessible, or complicated by resource availability in terms of trained staff, equipment, and learning environment [29]. Nursing and midwifery educators therefore wanted to be able to make the practice of these lifesaving skills more accessible for their students from remote locations away from the educational institution, such as the students' residence.

The comprehensive design and initial testing of the program has been previously published [16]. The collective team aim was to be able to remotely immerse a student in a contemporary hospital-based birthing environment, where the student would be able to undertake self-directed learning of the procedural psychomotor skills of neonatal resuscitation, according to the Australian Resuscitation Council guidelines [16,30]. Approximately 10% of all neonates born in Australia will require some sort of resuscitation measure, with only 1% requiring advanced neonatal resuscitation skills [16,30]. As a result, all health-professional students working in maternity or neonatal care need to be well prepared for these events, ready to employ a range of resuscitation skills at any time, due to their unexpected and rare nature [8,16]. Given the focus of the brief, the program was produced for use by both immersive (IVR) and non-immersive (desktop VR) virtual reality media, with the final prototype accessible via desktop or laptop personal computer, tethered IVR (HTC VIVE and Samsung Oculus Rift) and untethered mobile IVR (Samsung Galaxy mobile phones and compatible Samsung – Oculus Gear VR headsets, sourced in Newcastle, Australia), accommodating for within-institution and remote student use [16].

Using IVR, and upon application of an immersive headset (with audio), students are presented with a 360-degree view of a virtual birthing room, where they are immersed within a scenario featuring a compromised neonate requiring resuscitation (Figure 1c). Students are then required to employ their theorical and practical knowledge of neonatal resuscitation by employing the procedural skills in their correct sequence, to resuscitate the neonate. The birthing environment, including equipment, was designed based on what was used within the Australian acute birthing care context, ensuring authenticity. To promote knowledge retention, and offer a scaffolded approach, two learning modes, a guided and unguided mode, were developed. The guided mode is based in behaviourist learning theory. Nursing has a long association with a behaviourist approach, wherein clinical skills have been honed using repetitious drills [31]. Within the guided mode, students are provided with a series of prompts required for successful resuscitation (Figure 1a), using handheld controllers for interaction with the environment (Figure 1b). Incorrect responses result in the student not being able to progress within the simulation, until the correct procedures have been identified [16].

(**a**) (**b**) (**c**)

Figure 1. The Compromised Neonate virtual reality educational application. (**a**) Demonstration of conducting a neonatal resuscitation assessment. (**b**) Demonstration of interacting with the experience using a handheld controller. (**c**) Demonstration of the compromised neonate requiring medication.

A cognitivist approach is adopted throughout the program, which requires critical-thinking and problem-solving skills to be employed [32]. For example, students are challenged to distinguish the need for the escalation of care of the neonate, such as identifying the need for medical assistance, and interpreting the neonate's physical assessment score, as well as identifying the correct medications and dosages (Figure 1c) [16]. In addition, the application of affective skills is essential to successfully navigate the program. Students are required to interact with the baby's father, choosing appropriate family-centred communication, explaining what has happened to the baby, and identifying the need for post-resuscitation communication and education. More experienced students can perform these procedures using the unguided mode, which reflects how the student is required to autonomously practise during real-world workplace learning [16].

Following development, initial testing of the Compromised Neonate was undertaken within a small group (n = 7) of third year undergraduate midwifery students at the originating higher education institution [16]. During a usual neonatal resuscitation simulated learning experience that employed the use of high-fidelity simulation mannikins, students were additionally asked to test the Compromised Neonate program using mobile IVR (untethered Samsung-Oculus Gear VR headsets) and provide initial feedback on the Compromised Neonate program [16]. The feedback from anonymous post experience survey questions indicated that the simulation met the students' learning needs, allowed for interactive feedback and guidance, resembled a real-life situation, and was seen as an enjoyable experience that could likely improve their confidence in their neonatal resuscitation skills [16]. Due to the prototype nature of the program, empirical testing, such as a randomised controlled trial amongst a large cohort of students to evaluate its effectiveness compared to traditional simulation methods, was not possible, with testing mostly limited to ad hoc student use within the originating institution.

3.2. The Road to Birth

The use of XR technology is becoming increasingly popular, offering new ways to visualise and understand complex spatial concepts, such as human anatomical and physiological processes [20]. The initial concept for the RtB program evolved out of discussions among nursing and midwifery educators when brainstorming methods to enhance the teaching of complex spatial concepts, such as foetal positioning in utero in relation to maternal anatomy and physiology. Traditional learning approaches were typically static in nature (cadaveric specimens and plastic models), with access to these learning opportunities outside of education institutions often inaccessible for students, as described above [20]. Therefore, the primary design objective was to integrate XR technology, to provide nursing and midwifery students with an interactive and remote learning resource that could assist students in visualising the internal anatomical changes of pregnancy, and foetal positioning.

The collective team aim was to provide nursing and midwifery students with an internal view of pregnancy, allowing students to visualise the dynamic reproductive anatomical and physiological changes that occur over the 40+ weeks of human gestation [20,33]. The position and presentations of the foetus need to be clearly understood by all healthcare professionals working in maternity care. A number of these positions are favourable for a vaginal birth, whilst others may make a vaginal birth more difficult, and lead to complications in the birthing process, such as an operative birth by forceps, ventouse, or caesarean section [20]. The detailed development and testing of the RtB program have been previously published [20,33].

Allowing for within-institution and remote use, a multimodal approach was devised for interaction with the RtB environment [20,33]. The RtB was developed for use with IVR (SteamVR-compatible) mobile smartphone/tablet devices (both iOS and android), as well as being compatible for use on a personal computer (Figure 2a). In addition, the program was designed to run on the mixed reality Microsoft HoloLens headset (sourced in Newcastle, Australia), with gesture-controlled interactivity, as featured in (Figure 2b).

(**a**) (**b**) (**c**)

Figure 2. The Road to Birth multimodal XR learning program. (**a**) Demonstration of the RtB being used on a smart tablet. (**b**) Demonstration of a student using the RtB on the Microsoft HoloLens. (**c**) Demonstration of the RtB timeline interface.

Taking a constructivist educational perspective [34], the RtB program allows students to actively engage in their own learning, by exploring and manipulating the digital anatomy content, and thus building on their prior learning and experiences. The RtB program includes four main digital anatomy interfaces: (1) the base anatomy, (2) the pregnancy timeline (Figure 2c), (3) birth considerations, and (4) an adaptable quiz-mode function. As illustrated in Figure 2c, students can interact with the anatomy interfaces by manipulating the pregnancy animation, to view both the foetal and maternal anatomical changes that occur during each week of pregnancy. Students are also able to visualise and manipulate uncommon placental and foetal positions that may not be congruent with normal birth practices, requiring specialist consultation [20,33].

The active engagement with the program affords students the ability to construct their own understanding of the material, by relating it to their own experiences. From a behaviorist perspective, the program includes a quiz function that allows self-assessment and the reinforcement of knowledge, promoting the idea that behaviour is shaped by the reinforcement of correct knowledge acquisition [20,33]. Aligning with Kolb's ELT, the program also provides opportunities for learners to reflect on, and apply, their knowledge in real-world settings [11]. Due to its portability on phone/tablet devices, students can use the program during workplace learning, as a personal and consumer education tool, potentially enhancing health literacy amongst consumers, and promoting collaboration [20,33].

The initial testing of the RtB (in its smartphone/tablet and IVR forms) was undertaken amongst two cohorts of undergraduate midwifery students, one within the originating Australian university (n = 19) and one with a partner university in Belgium (n = 139) [20]. Amongst the Australian cohort, the results indicated that the program was a useful learning resource that assisted with visualising the internal anatomical changes of pregnancy, and understanding foetal positioning in utero [20]. The students in Belgium indicated that the program had an above-average usability, according to the System Usability Scale (SUS), and improved student understanding of female reproductive anatomy and foetal positioning. The students also found the program to be fun to use, and there were no perceived negative impacts on learning. The experience of both samples of students of using the program in the education context was positive. Further testing of the RtB program remains in progress. The RtB has been deployed for testing amongst a small cohort of medical students undertaking problem-based learning in one large Midwestern university in the United States of America (USA), a large cohort of Midwifery students for various education outcomes within the United Kingdom (UK) as part of a PhD project, and as a health practitioner and consumer engagement tool in one large Midwestern Hospital in the USA, with all study outcomes pending.

3.3. Conflict Resolution—Angry Stan

The Conflict Resolution program was designed as a proof of concept to provide a simulated learning experience wherein nursing students could be immersed in an intense conflict situation. It's an unfortunate reality that nursing, medical, and midwifery staff often find themselves in intense conversations with healthcare consumers, and these conversations require skills in conflict resolution [35]. In nursing, constructively managed conflict has been linked with improved patient safety and quality of nursing care. Alternatively, poorly managed conflict can adversely affect nurses' mental health, affecting the healthcare organisation overall, and lead to poor patient outcomes [35]. The teaching of these skills at the time of development was resource-intensive, requiring specialist trained staff and actors within a simulated learning environment, and was only featured during the students' second year of study. This meant that students could have been exposed to conflict situations while engaging in a work placement without having been exposed to, or equipped with, conflict resolution skills. Therefore, the collective brief was to be able to safely immerse undergraduate nursing students in an intense interaction with an emergency department patron, providing exposure to an intense interaction, while providing students with the opportunity to practice conflict resolution skills from the perspective of a registered healthcare professional.

The program was again designed for accessibility (i.e., within-institution and remote student use), including tethered and untethered IVR (Oculus Rift S and Lenovo Daydream headsets), and desktop VR. To increase the authenticity of the experience, the Conflict Resolution program was paired with an off-the-shelf heart rate wrist monitor, essentially using an elevated heart rate (above baseline) as a proxy measure for the stress response elicited by the simulated experience (Figure 3c). Upon application of the IVR headset (with audio), students are transported to an environment that replicates a contemporary Australian hospital emergency department (Figure 3a), where they meet Stan (Angry Stan, appearing in Figure 3b). Stan is trying to find out about the condition of his friend, who was involved in a car accident, and progressively becomes frustrated and angry during the interaction. In general, staying calm is a trait required by nurses in resolving conflict [36]. Based on this premise, the IVR headset was paired with the heart rate wrist monitor, measuring a student's heart rate (Figure 3c) as a proxy measure of biometric stress [37,38].

(**a**) (**b**) (**c**)

Figure 3. The Conflict Resolution (Angry Stan) program. (**a**) Demonstration of the emergency room environment. (**b**) Demonstration of Angry Stan & mini game. (**c**) Demonstration of heart rate writs monitor.

Students are required to interact with Stan by using the hand controllers to select appropriate responses that either assist in calming, or escalate Stan's emotions. The student's heart rate is detected by the IVR headset, and is used in combination with text-based prompts. Essentially, the higher a student's heart rate, the harder it is for a student to calm Stan. In addition, features were added to increase the cognitive load placed on the student, to reflect the challenging dynamics of real-world healthcare environments, beyond what is possible with traditional simulated-learning media [36–40]. These features included a mini game (Figure 3b) in which a flashing red light accompanied by an audio buzzer appears randomly throughout the experience, and needs to be switched off periodically, otherwise it will become increasingly louder and more distracting. Moreover, an intense background noise, including a crying baby, is also used, increasing the level of concentration and emotional intelligence required to successfully resolve Stan's grievances. Initial testing of the Conflict Resolution program is in progress, and is the focus of a PhD study at the originating institution. The program has been deployed in IVR amongst a large cohort (n = 400) of nursing students undertaking a nursing and mental health subject at the originating Australian university. The program is additionally being utilised amongst a cohort of business students within one large Midwestern university in the USA, for the initial testing of empathy traits, with all results pending.

4. Discussion

This article presents three novel XR simulated learning experiences that were co-created by university educators in the fields of nursing and midwifery, in collaboration with XR technology experts from a prominent regional university in Australia. The first case study describes the Compromised Neonate program, which was designed to enhance the development of the psychomotor, cognitive, and affective skills required when performing neonatal resuscitation in real-world contexts. The second case study, the RtB, was designed to provide students with an internal view of pregnancy over the course of human gestation, and to assist with the teaching of complex foetal–maternal anatomical spatial relationships. The third case study, Conflict Resolution, provides students the opportunity to be safely immerse in an intense interaction with an emergency department patron, with gamification features used to increase the realism and cognitive load, to reflect the dynamics of real-word professional practice environments. All case studies use multimodal XR media for within-institution and remote student use. Each experience showcases a unique design objective and development approach that reflects the nature of the XR content, to enhance simulated learning beyond traditional simulation media.

To date, the uptake of XR technology within nursing simulation education has been largely driven by small groups of technology and nursing content experts who are enthusiastic about using XR to optimise student learning. This is particularly true within the Australian higher education context [8,27]. Barriers to the broad upscaling of XR media within nursing curricula include a deficit in empirical efficacy studies, the sparse application of nursing learning theories underpinning design and development, difficulties in attracting funding, and difficulties in sustaining XR experiences beyond their development for curriculum and university system integration [8,27,41,42]. However, there is a growing recognition of the application of XR technology in nursing simulation education.

An umbrella review evaluating the use of metaverse technology in nursing education identified the application of virtual reality (VR) technology (desktop and IVR) as the primary technology medium being used to enhance simulated nursing education [43]. A systematic review by Shorey and Ng [44] evaluated the use of VR simulation among nursing students and registered nurses. Of the included studies, five utilised IVR technology, with most included studies using desktop VR, and high-fidelity simulation mannikins. Of the five studies that utilised IVR, all were used for psychomotor skill development, aiding in intravenous device insertion or venepuncture-type procedures [44]. Kim et al. [45] conducted a systematic review of XR-based paediatric nursing simulation programs, identifying fourteen studies for inclusion. Due to the varying definitions of VR and MR used within the article, only four included studies were identified that used IVR and AR for psychomotor skill development [45]. In this review, IVR and AR were used for teaching paediatric intensive care skills, such as basic infant care, feeding practices, the prevention of neonatal infection, paediatric airway management, injection practice, and wound care skills [45]. Lastly, a scoping review by Fealy et al. [8] evaluated the integration of IVR in nursing and midwifery education, identifying two studies. IVR was used in psychomotor skill development for cardiopulmonary resuscitation and urinary catheterisation [3]. These reviews suggest that the integration of XR technologies in nursing simulation education is emerging, with considerable scope for increasing the application of XR technology beyond IVR use for psychomotor skill development.

Incorporating learning theory into the design process is a crucial aspect of using these technologies in effective teaching and learning [42]. Learning theories serve as the foundation for understanding how students can acquire new knowledge, skills, and behaviours [7,46,47]. As a result, incorporating these theories into the design process ensures that educators are actively involved in creating XR experiences that are effective in promoting student learning [48–50]. Moreover, educators need to identify and select suitable technological equipment to support the learning outcomes [51]. Despite the proven advantages of IVR systems, simulated learning for skill acquisition using HMDs may not be the best method for every kind of student or teaching concept. As a result, educators, learning designers, and subject experts should follow scientific methods and/or frameworks during the instructional design process [51]. The utilisation of phases of design or design-based research methodologies, such as the scrum framework, can provide a practical approach to support XR content creators and educators. Figure 4 details a useful roadmap for conceptualising and organising the design of an XR learning environment. In particular, this roadmap can serve as a valuable guide to ensure the effective integration of learning theories and educational goals into the design process [51].

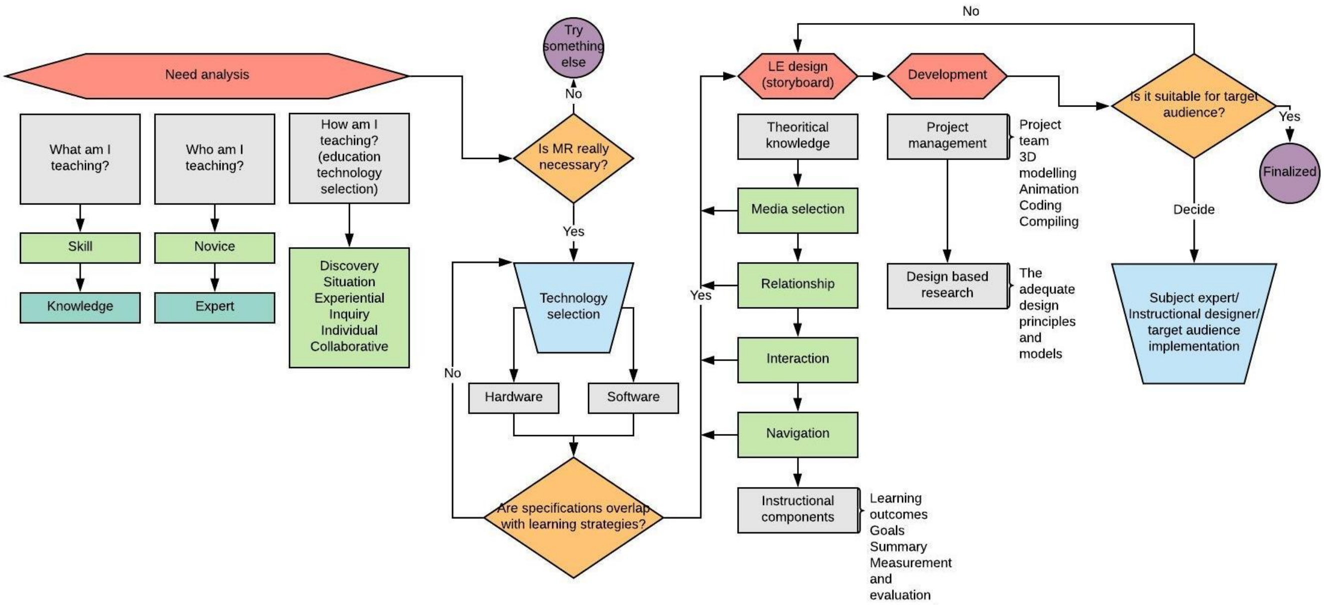

Figure 4. A pathway to assist with the educational interactive design process [51].

The Technological Pedagogical Content Knowledge (TPCK) framework, and the Substitution, Augmentation, Modification, Redefinition (SAMR) models are two widely used frameworks that can be additionally employed to assist nursing educators during the design process [52,53]. TPCK refers to the interplay between technological knowledge, pedagogical knowledge, and content knowledge, and asserts that for the effective integration of technology, all three types of knowledge are required, necessitating collaboration between experts [52,53]. The SAMR model categorises the different ways in which technology can be integrated into teaching and learning activities, ranging from simple substitution, to the creation of new and unique learning experiences, enabled by the application of various XR technology media [52,54]. The integration of learning theories into the design process, as highlighted in frameworks such as TPCK and SAMR, can serve as a guiding principle for the development of effective XR educational experiences.

An innovative policy-based co-creation model for the design of immersive health-related content has additionally been presented by Antoniou et al. [55]. The authors suggest an 8-step problem-solving framework when considering the application of XR technologies, as follows: (1) Defining the problem—XR technologies can be used to simulate many areas of healthcare. Involving the right people in the design process, and clearly identifying and defining the problem at hand can assist in providing a sense of direction and purpose to the project. (2) Assembling evidence—this involves gathering evidence to support the project, reviewing relevant information, such as what has been already done, and the current landscape, from various sources, providing valuable insights into the technology and content being created. (3) Constructing alternatives—based on the evidence gathered, this step involves developing a range of alternative courses of action or strategies to address the problem. This includes weighing up traditional development pipelines with alternative methods. (4) Selecting criteria—identifying criteria that can be used to measure and evaluate the effectiveness of the project, such as cost, technique, or pedagogical outcomes. (5) Projecting outcomes—making realistic projections of the outcomes or impacts of the project, considering how realistic or viable each outcome is, such as, *do we have the relevant personnel with technical skills?* (6) Confronting trade-offs—this involves weighing up the outcomes in relation to the selected evaluation criteria. (7) Decision-making—based on the previous steps, a final decision is made on the best strategy to address the problem. (8) Sharing the results of the process—this is the final stage, where the well-considered project process is shared in order to communicate the rationale behind the chosen problem, design, technology, outcomes, and evaluation methods [55].

The three case studies described in this paper broadly highlight how nursing educators can engage with the co-design of XR-enhanced simulated learning experiences for nursing student learning. By considering these examples, as well as applying theorical principles and frameworks, educators and XR content creators can ensure that their designs result in impactful and accessible learning experiences. It is important to acknowledge that learning is a multifaceted process. The effective integration of technology-enabled teaching approaches must be informed by an understanding of individual learner characteristics, and environmental factors that may impact learning outcomes [47,48,56]. The main limitation of all the presented case studies was that they were not developed or funded for broad curriculum or sustainable university system integration. Furthermore, empirical efficacy testing, in the form of randomised controlled trials of the three presented cases, has not been conducted, and this has been recognised as a barrier to XR adoption, based on the wider systematic review literature [42]. There is an urgent need to empirically examine the effectiveness of XR teaching methods for simulation nursing education, compared to traditional simulated media, in preparing work-ready graduates.

5. Conclusions

XR technologies may offer educational benefits beyond traditional simulated learning media, in the preparation of work-ready graduates. By providing learners with the opportunity to visualise abstract concepts in a 3D format, express their understanding of phenomena, observe the dynamic relationships between variables in a system, and experience events that may be inaccessible due to constraints such as distance, cost, time, safety, or scarcity, the integration of XR technology into nursing education offers a unique and innovative solution. The collaboration between nursing educators and XR technology specialists at one regional university in Australia has resulted in the development of three diverse and impactful case studies that demonstrate the potential of XR to enhance the simulated-learning experience for students. The embedded media diversity of XR technology provides students with the opportunity to actively engage in immersive and hands-on learning experiences, within virtual environments that can be designed to reflect the complexities of real-world healthcare situations, most importantly in psychomotor, affective, and cognitive skill acquisition.

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