

# Nursing XR: A VR Application to Teach Decision Making to Student Nurses

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**Abstract:** This paper validates an approach to the design and development of VR applications that are integrated into the curricula and address fundamental student needs. To accomplish this, a case study describing the process undertaken to create Nursing XR, a wound dressing scenario where the patient is discharged home and requires follow up care and treatment by a nurse. The aim of the VR application is to support nursing students in developing their communication, risk assessment, holistic assessment, and person-centred clinical decision-making skills. To design Nursing XR, needs and initial requirements were collected via a workshop with student nurses. The workshop, which involved 10 student nurses and two lecturers in nursing from two Universities (Co-Is) and was led by the PI, supported by the learning technologist and the head developer of the company used for development of the software. Results from the workshop identified two major needs for the students: the need to undertake practical applications of the procedures learned in the lectures and the need to build confidence in the skills required of a nursing student. These needs were the foundations for the design process, which followed an artefact-based approach. The artefacts generated during the design were also used to elicit additional interaction and software requirements from the nursing lecturers. An iterative lean development process was followed by the company for the software implementation. Throughout the development, students and lecturers were involved as user testes ensuring that the user experience of the application was satisfactory, and the application fit for purpose. In this paper, we describe the high-level design and development process followed by the multidisciplinary team to develop Nursing XR and report initial qualitative findings from the workshop focus group.

**Keywords:** Extended Realities, Virtual Reality, Design Process, Nursing, Education

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## 1. Introduction

Recent developments in extended realities (XR) technologies have brought new ways to envision teaching and learning within the classroom, opening the door to experiential learning (Kolb, 2015) by digitally recreating situations that are close to reality and allow students to make informed choices and practice what they have learnt.

Nursing is a subject that requires students to be able to develop emotional connections and holistic assessment skills (NMC, 2018). These characteristics lend themselves to exploit the ability of XR technologies to create experiential learning opportunities for students within a safe simulated environment (Saab et al., 2021).

The use of XR technologies as a tool to teach procedural, emergency, soft, and psychomotor skills in nursing subjects is not novel (Plotzky et al., 2021). For instance, Oliveira et. al. (2021) developed a serious game tool aimed at developing emotional competencies for nursing students, Elliman et al. (2016) recreated a hospital ward with dementia patients, whilst Choi (2019) developed a simulation to teach wound care procedures.

However, processes and practices for the development of XR applications for education that are integral to the curriculum rather than isolated interventions are still lacking (Hamilton et al., 2021, Gilardi et al. 2021).

This paper contributes to the subject of serious games by presenting Nursing XR, a VR application focused on a wound dressing scenario for injured patients recently discharged into their home from hospital. The application focuses on facilitating simulated practice and developing students risk assessment and decision-making skills. The paper also contributes to the subject of XR applications design for education by providing a case study of the application of Gilardi et al.'s (2021) design process.

## **2. Related Work**

The application of XR technologies to nursing education is a subject that is emerging in the academic literature. Recent literature reviews (Plotzky et al., 2021, Saab et al., 2021, Chen et al, 2020, and Fealy et al., 2019) highlight that the subject still needs further development and the need of rigorous studies and a unified language to describe XR technologies in the field. They also indicate that VR has the potential to facilitate engaging forms of learning, which is supported by Saab et al.'s (2021a) and Baxter and Hailey's (2020) studies on student views on the use of VR for education; and offer a cognitive walkthrough for procedures (Choi, 2019). There is a lack of studies that discuss the effectiveness of the use of VR in nursing education. Chen et al.'s (2020) meta-analysis highlights that VR is effective in improving knowledge, but it is not more effective than traditional methods in skills, satisfaction, confidence, and performance time. This partially aligns with Smith and Hamilton's (2015) study which found no significant difference between control groups and VR groups, but also discovered that VR shows positive trends for increasing perceived levels of preparedness (Smith and Hamilton, 2015).

The possible equivalence between VR and traditional methods shows that VR is powerful as a self-learning tool to complement teaching in nursing (Chang and Lai, 2021). However, the successful use of VR as a teaching tool in nursing is influenced by how the application and the interactions are designed and the user experience it can provide. Empirical evidence of this is shown for instance in Chang and Lai (2021), Komizunai et al. (2020), Botha et al. (2020), and Choi (2019) which illustrate how design limitations in the applications affect how users experience the simulation. For instance, Chang and Lai (2021) identify the lack of realism in the simulation as a key theme whilst Choi (2019) found that interaction through controllers limits the authenticity of the simulation.

## **3. Methodology**

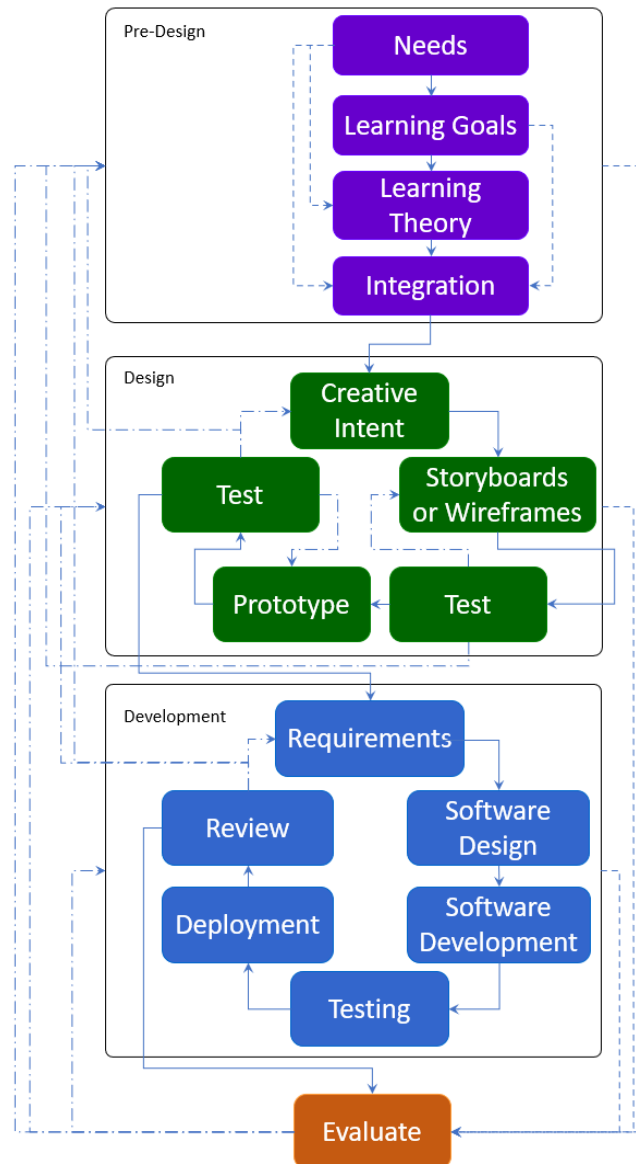
The Nursing XR application was developed following Gilardi et al.'s (2021) process (see figure 1), which requires a close collaboration between faculty experts, students, and developers.

The pre-design and design stages of Gilardi et al. (2021) are grounded in participatory design (Sears et al., 2007). Vasilchenko et al. (2020) advocate participatory design as an approach that extends to multiple levels of people interaction promoting creativity, reflection, and collaboration. Based on these principles the project involved partnership and collaboration with students, industry, and academics.

An initial blue sky thinking process between the Co-Is (nursing experts) and the Project Lead (XR expert) was used to identify the needs for the nursing programme, identifying the broad areas of decision making, and wound dressing as suitable for XR development and as an area that would benefit the current delivery of nursing programmes.

Following ethical approval, student nurses enrolled in part 2 and 3 on the BSc and MSc Adult and Mental Health nursing at the University of the West of Scotland were invited to participate in an online interactive workshop aimed at gathering students and faculty needs. Ten student nurses responded to the workshop advert and attended the session. In addition to the student nurses, two lecturers in nursing from two different Universities (Co-Is), the PI and developers from the company used for the software development participated in the workshop.

The online workshop combined: knowledge scoping activities, aimed at understanding students familiarity with the subject; barriers and facilitators scoping, aimed at identifying the students' needs and current best practice; blue sky brainstorming activities, aimed at understanding the student vision for the application integration within the teaching programme. The workshop was concluded by a nominal group consensus activity in which findings were discussed and classified based on impact on learning and desirability of adoption. The workshop allowed the faculty to understand student needs and to initially identify where the application could be integrated within the programme. It also helped consolidate the notion that experiential learning (Kolb, 2015) should be the main pedagogical theory that underpins the project.



**Figure 1:** Design process from Gilardi et al. (2021)

Workshop outcomes were used as input for a co-design approach to the scenario development between the faculty experts and the company development team. The resulting scenario and branching narrative were used to guide the development of the application. An initial evaluation with the pre-alpha version of the software was undertaken, the session consisted of three students and two faculty (Co-Is) undergoing a playthrough of the VR scenario observed by the PI, which took notes of the emerging behaviours during the playthrough and moderated a focus group with the participants.

#### 4. Designing Nursing XR

In this section the design and development process followed will be mapped on the Gilardi et al.'s (2021) process shown in figure 1.

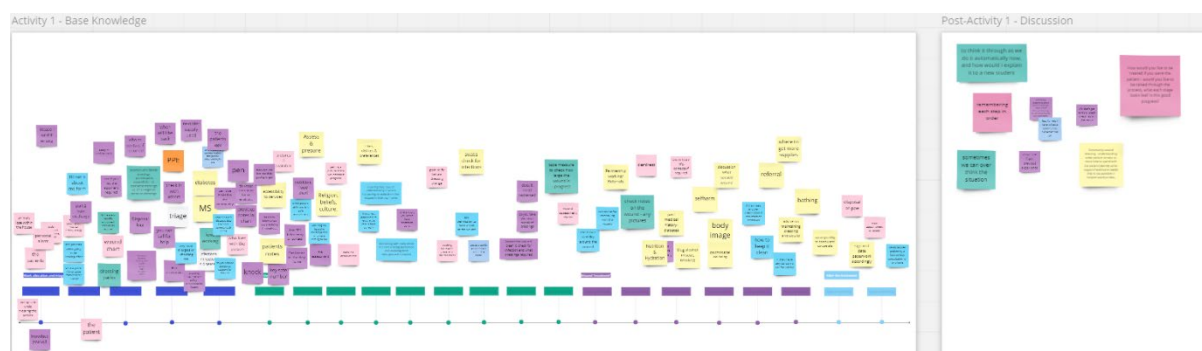
##### 4.1.1 Pre-Design

In preparation for the design workshop with students the two nurse lecturers documented the process of wound management guided by best practice guidelines. The Nursing and Midwifery Council (NMC) Future Nurse Standards (NMC, 2018) outline the minimum requirements of a registered nurse and form the basis of all nursing programmes within the UK. The standards set out key skills and competencies which centre around communication, decision making and safe effective care. In addition to the NMC standards there is a wealth of best practice guidelines, pathways and frameworks which support students and registered nurses to make

clinical decisions, thus enabling them to develop and advance their knowledge and skills in the field (NMC, 2018; Lister et al., 2021; Clinicalskills.net, 2022).

This initial process of documentation identified the problem definition and examined the learning and teaching objectives within the current curriculum. This established a working outline of the process for the team and decision points and stages to help prompt the students during the workshop.

The workshop began with an introduction to XR and the overarching aim of the project to develop experiential learning for nursing students to teach how to perform assessment and decision making about patients through a wound dressing scenario. During the workshop, the participants developed a storyboard displaying their knowledge of the patient journey and how to undertake a wound dressing, see figure 2.



**Figure 2:** Patient journey timeline developed by the students during the workshop.

This captured the elements of workflow that were less understood and key decision points to be integrated into the Nursing XR scenario. Students reflected on finding it difficult to remember all the steps of the patient journey and this was related to their preference to a kinetic approach to learning and limited exposure to wound management in clinical practice. Notably all students spoke about visualising how to undertake the process and the communication and decision-making skills they would use at different points. The students identified low confidence as a key theme in this workshop, in terms of exposure to wound assessment and management in real life and in terms of using XR technology. Involvement in the XR scenario design was viewed by the students as helping them to develop the knowledge, skills, and confidence to feel prepared going into real life situations and to be confident communicating with practice supervisors and patients. In principle the students voiced that the aim of the project was innovative and would be useful in their learning particularly applying theory to practice.

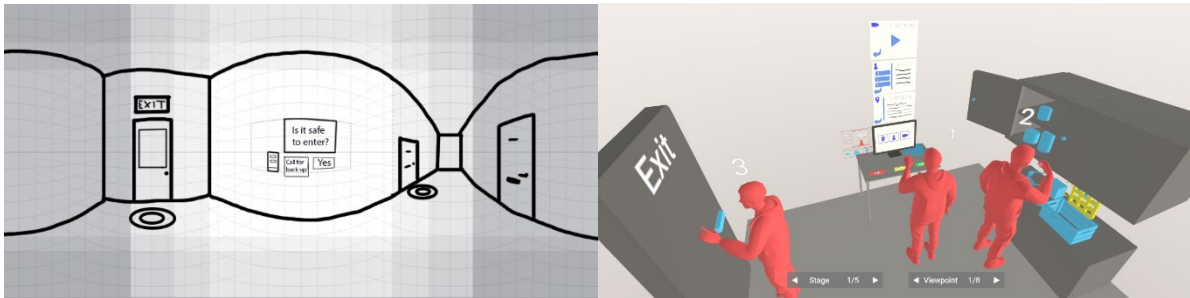
#### 4.1.2 Design

The preparation work undertaken for the workshop discussed in 4.1.1 was used to outline the process and decision-making points to the design and development team. It also formed the basis for the scenario development and the process of designing three-dimensional spaces and interactions within the VR application through paper wireframes and low fidelity prototypes.

An authentic scenario was developed based on clinical practice in a community setting and was underpinned by the best available research. In the development of the scenario, a branching narrative was applied to illustrate the range of unfolding actions and decisions of the student, which consequently results in an array of endpoints or outcomes for the patient (Riedl & Young, 2006). In concordance with the method of branching narrative, variation was scripted at this design stage in anticipation of the potential requirements and decisions of the user (Verkuyl et al, 2019). The participatory design approach mentioned in section 3 continued between the lecturers and learning technologists to shape and review the narrative, ensuring the content mirrored the patient's journey, decision points, safe practice, and current research and clinical guidelines. In addition, when integrating the branching narrative into the product design, cognisance was taken to ensure accessibility and learning needs of the user were incorporated. This included but was not exclusive to, verbal and written narrative, pictures, videos, access to decision support throughout the scenario and an introductory tutorial to aid digital literacy. To have a joint understanding and sharing of common language the lecturers created a wound in the simulation lab and distributed key documents and photos to illustrate the clinical activity the students would be engaged in. This enabled the designers to grasp the complexity of the procedure and scale of individual objects required

within the XR environment resulting in a scenario composed by three main stages: triage room, where students prioritise participants and gather the material they need for the patient visit, patient house, where the students holistically assess the patient behaviour, their environment and make decisions on the treatment of the wound, and finally the triage room again where they are debriefed on their performance.

The information gathered to prepare for the workshop and the results from the workshop were integrated to develop a series of paper prototypes in the form of 360 wireframes, see figure 3 left.



**Figure 3** Left: Low fidelity paper wireframe of the corridor scene, where students have to make the decision whether the environment is safe to enter, [360 interactive version here](#); Right: mid-fidelity prototype of the triage room developed in ShapesXR.

The paper wireframes were used to elicit requirements from the lecturers enabling them to discuss specific interactions and functionalities that should appear in the final application. The wireframes further showed how the environment would look and feel, but also, how different actions could take place by rapidly sketching and modifying the designs and displaying them in 360; thus, providing a sense of space and ability to pre-visualise the scene in VR. This was achieved by using an equirectangular grid template upon which sketches were drawn at each application stage. The sketches were then embedded into a webpage using the A-Frame Web XR framework. UI 'hotspot' elements were placed on the different sections of the wireframes to highlight interactions, affordances, and waypoints. The wireframes provided an effective approach to test and validate the conceptual design of the experience and effectively elicit requirements and feedback from the faculty experts.

Once the initial design ideas were validated, mid-fidelity prototypes of each scene were developed using ShapesXR (figure 3 right). ShapesXR is a VR application designed to develop three-dimensional prototypes in VR. Using a VR application to design VR experiences allowed the designers to iterate through their design process and test with the faculty experts. The participatory design experience at this stage took place by being immersed within the mid-fidelity prototype, resulting in very quick alterations and iterations of the initial design choices and provided more options for discussing both usability and aesthetic features. When each prototype was validated with the faculty experts, the mid-fidelity designs were exported into Unity, providing the starting point for development.

## 4.2 Development

The development followed a scrum agile process (Schwaber, 2004). The application was developed in the Unity Engine targeting Meta Quest 2 devices using the XR Interaction Toolkit (XRIT) and designed to be played in a seated position. The XRIT provides VR camera rig, action-based input, object interaction and haptic/visual feedback components which enable development of fully immersive experiences. With the various types of user actions required to simulate the experience, we extended the functionality of the components provided in the XRIT adding a body anchored inventory system, gesture based, and non-diegetic and diegetic interfaces, figure 4. To produce the simulated patient, a 3D character model was generated. The experience composed of three embedded interfaces; a smartphone, touchscreen computer, and inventory bag all of which are interacted with using a mix of diegetic interactions and graphical user interfaces. Touch input for these interfaces was simulated through raycasting from the player's index finger when their physical index finger is extended and checking for collisions between the raycast and an interactable interface element.



**Figure 4:** Three screenshots from the VR App showing non diegetic (tutorial and conversation choices) and diegetic interfaces (bag and medical equipment) used throughout the app.

## 5. Initial Evaluation

An initial qualitative evaluation of the pre-alpha application was performed with students and faculty experts. The ten students that took part in the pre-design workshop were invited to evaluation session, only three students responded to the call, the two faculty experts also took part in the evaluation as they did not experience the VR application before the session. The session consisted of a playthrough of the scenario and observation of participants during the playthrough, including note taking; resulting in a post-playthrough focus group. During the playthrough session the impact of interaction design on the experience evidenced in Chang and Lai (2021), Komizunai et al. (2020), Botha et al. (2020), and Choi (2019) was observed. Students and faculty had difficulties in understanding the mapping of the controllers and several bugs interfered with immersion and presence. As the pre-alpha did not have a tutorial for the controllers, it was observed that, participants tended to move around the space by moving with the wheeled office chairs instead of teleporting in the VR application. This caused participants to collide with each other and elements of the environment, forcing the principal investigator to intervene and reposition participants back to their original location. This was an interesting behaviour from the usability point of view and highlighted the importance of clear navigation interactions within the application. Other unexpected issues were observed with the body anchored system, some participants with a large body shape were unable to reach the body sockets of the virtual nurse to anchor tablet, bag, or ID card to it, causing the participants to push the controllers into their body in an attempt to reach the sockets.

The application was designed as single player and to be delivered to students in a shared physical space. Interesting communication behaviours emerged between students while they were in the application. During the triage stage, students started discussing the patients with each other and agreed on a course of action, which mirrors the decision making and teamwork that takes place within clinical practice. During the visit to the patient house, students discussed the environment and how they could undertake a risk assessment and interpret the environment to identify if the patient was coping and potentially required further care intervention and support. As such communication skills development was achieved in two ways: in-application, through the selection of different conversation snippets that allowed students to interact with the non-player character and reflect on what is the best approach to talk to patients; and in-real-life, through interaction with peers within the same physical room, discussing the scenario as they progressed through it.

The playthrough session was followed by a focus group, which was audio recorded and transcribed. Participants appreciated the realism of the environment and tasks:

*"It's quite realistic as well. [...] I personally felt I was back on a placement at a patient's door thinking I should do this before I go in, I should ask this before I go in"* – Participant 2

*"I thought, was quite real I felt quite immersed in the experience, there was a couple of things that felt natural for me, you know, when I was moving around the room and I got to the home..."* – Participant 4

However, they noted how the current bugs and their inexperience with using VR controllers distracted them from the scenario. This was expected as the software was still in pre-alpha. To overcome their inexperience with VR, participants suggested a preparatory VR session to allow them to familiarise themselves with the controls before using it in the class.

Participants also felt that when in the experience they should play the role in full:

*"I thought of myself as a nurse, and what steps I should be taking before I make any other steps. And just ensure that I've kind of covered everything before moving on to the next step."* – Participant 2

Participants also felt that it could supplement their placement with experiences they would not otherwise be exposed to:

*"Yeah, I've only had mental health placements so far, but you don't really see wounds much. I've not seen them much at all actually. And placement terms, I don't know. It depends where you get your placement. And it depends to patients that are obviously admitted and stuff. So, I don't know how many unless you are on general placement you see that. So, it'd be good for the mental health side of things, if you don't see it on placement."* – Participant 3

Students were asked whether they see this as beneficial for their learning. They felt that the application was valuable, and the immersion and presence induced by the application was beneficial to their learning. Participants felt they had a safe space to experiment and learn without feeling judged, while at the same time had the ability to discuss decision making and interactions with their peers. This prompted reflection on the experience of simulated practice, as this extract of conversation between two student participants highlights:

*"Participant 01 - I actually think it's really good. [...] Because it takes you away. You can hear other people, but they're not part of what you're doing. If you're not like...*

*Participant 2 (interrupting Participant 01) - I totally agree with that, I can be quite anxious at times and quite aware of my surroundings and shy and things. Some people might not gonna come out their shell. But again, with that on, you're in a different environment altogether I felt and didn't feel as if I was going to holding them back from shouting or seeing anything around asking a question. It was...*

*Participant 01 (interrupting Participant 02) - and nobody can see what you are doing, they cannot see you are making a mess. [...] it's good in that sense that you can learn at your own pace without feeling pressure without people watching you"*

Finally, student participants were asked where they would see the application integrated within the programme. Participant 01 expressed firmly:

*"It's got to be under skills lab. Because this is something you're doing, you're getting shown how to do CPR on someone that's just as important going to somebody's house that needs a dressing changed a few times a week [...]"* - Participant 01

This led onto students brainstorming how Nursing XR could integrate theory and skills lab sessions, for example:

*"I could see it, put your stuff on and then go into the simulation (Nursing XR). And do it that way. I can see it tying in with that"* - Participant 04

Students highlighted that this would complement their practical skills development through the integration of theory and simulated practice, identifying that Nursing XR could be used throughout the progression of the programme to develop and consolidate their learning.

## 6. Conclusions

This paper adds to the growing body of evidence in the application of XR for teaching. The implementation and evaluation of Gilardi et al.'s (2021) design and development process has shown to be an effective model in the creation of Nursing XR, a VR application for wound management and assessment for student nurses.

Gilardi et al.'s (2021) is rooted in participatory design. The value of working across disciplines and with the end user created the conditions for shared understanding of needs and outcomes, clarity of professional languages, and collaborative learning. Ultimately this resulted in a product which met the intended aims of facilitating simulated nursing practice and developing student nurses' skills, as well as identifying where and how the resulting VR application can be integrated within the Nursing programme.

Incidental learning also emerged throughout the project, particularly from testing and evaluation, which provided insight into user ability and the physical learning environment. Nursing XR not only provided students with an opportunity to undertake decision making, risk assessment and wound management, but also elicited collaboration and discussion on prioritization of patients, treatments, and holistic assessment of the patient environment through peer discussion between students in the same physical room while immersed in the VR application.

Gilardi et al.'s (2021) process was shown to be viable and effective for XR application development and adaptable and transferrable to nursing education and simulation. Future work needs to take account of the monetary and staff resources required for the participatory development, which are high and resource intensive. However, these can be reduced through agreement of IP ownership between developers and clients.

The gamification aspects of the project are yet to be implemented and will consist of a scoring system for actions undertaken during the scenario and reflection points through questions embedded within the environment.

Considering the incidental learning from the project, future work will consider potential research into the physical learning environment in which VR applications are used. A thorough evaluation of the benefits of the application will be undertaken as next step for this project.

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