



# Virtual Reality Training Simulators as a Learning Method for Medical Equipment: The IV Infusion Pump

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**Abstract.** The integration of virtual reality (VR) simulators in medical education shows promise, particularly for training with equipment like the IV infusion pump. This study explores VR as an innovative tool to enhance learning, engagement, and information retention. Research supports VR's effectiveness in visualizing complex concepts and reinforcing higher-order learning. To evaluate its impact, we tested a VR training simulator with five nursing student volunteers. Participants found the experience engaging after adjusting to the controls, though some reported discomfort with the Meta Quest 3 headset and blurry visuals due to lens distance. While the study was limited to a student capstone timeframe and in scale, findings suggest VR simulations have strong potential as medical training tools.

**Keywords:** VR Simulation, Virtual Reality, Learning Methods, Healthcare, Nurse Training.

## 1 Introduction

VR or Virtual Reality is a technology that is slowly being welcomed into learning environments. The results of VR Learning based on literature review have been overwhelmingly positive. The effect of increased comprehension ability and learning motivation are great motivators to use VR technology in learning environments [1]. A few years ago, technologies such as AR (Augmented Reality) and VR (Virtual Reality) were not well known until 2016 [2]. In fact, VR technology has been present since the late 1950's [2]. Given its potential to reduce costs and improve training efficacy, VR technology shows promise as an educational tool for medical equipment, particularly for medical equipment such as the IV infusion pump.

## 2 Related Works

The integration of virtual reality (VR) in educational settings has gained significant attention due to its potential to enhance learning outcomes across various disciplines. Several studies have explored the effects of VR simulators as learning tools, demonstrating positive impacts on student engagement and content retention.

In dental education, a VR-based simulator was developed to train fifth-year dental students in performing root canal access opening procedures [10]. The study assessed the effects of stereoscopic 3D rendering and hand-tool alignment on learning effectiveness. Participants were divided into four groups based on these parameters. Results indicated overall improvement from pre-test to post-test scores, except for the group using stereoscopic rendering with misaligned hand tools, suggesting the importance of proper alignment in VR simulations.

Geological education has also benefited from VR applications. A mobile learning app utilizing VR was tested among 102 university students to evaluate its impact on learning outcomes and motivation [1]. The study found that VR learning activities, delivered via Google Cardboard and smartphones, enhanced comprehension and information retention, highlighting VR's effectiveness in engaging students in complex subjects.

In the field of hospitality and tourism, the Hong Kong Polytechnic University developed a VR learning space for wine education [5]. Feedback from 40 undergraduate students indicated high levels of satisfaction and engagement, with 90% describing the experience as fun and refreshing. However, concerns were noted regarding

user interface design, headset comfort, and safety, emphasizing the need for careful consideration of user experience in VR applications.

Anatomy education has similarly seen positive results with VR integration. A study involving 48 student volunteers compared VR learning methods with traditional textbook approaches [6]. The VR group demonstrated a significantly improved learning performance and engagement, suggesting that VR can enhance memorization and understanding in content-heavy subjects.

Chemistry education research evaluated the effectiveness of immersive VR environments for teaching orbital hybridization [9]. Participants were divided into groups using text-based learning and two VR interaction methods (hand gestures and controllers with ray casting). While no significant differences were found in learning outcomes between the groups, the study highlighted VR's potential to offer equivalent educational value with increased engagement.

In architectural education, an immersive VR interactive learning system was created for training in Chinese tenon structures [3]. Among 24 participants divided into picture-based, physical, and VR interaction groups, the VR group reported the highest satisfaction and interactivity levels, proving VR's ability to enhance practical skills training.

A study on search efficiency and learning examined the effects of cueing in desktop-VR learning environments [7]. Participants engaged in tasks requiring object location within a virtual workshop. Results showed that movement cues significantly reduced search times compared to light cues, indicating that specific VR design elements can improve learning efficiency.

Collectively, these studies demonstrate that VR offers unique affordances—interactivity, accessibility, and 3D visualization—that enhance learning experiences and foster greater engagement among students. Immersive VR simulations have been shown to improve spatial and cognitive understanding, essential for mastering complex scientific processes in lab-based activities [14]. By incorporating accessibility features such as vertical control adjustments, VR environments can cater to users with mobility constraints, levelling the learning field for all students. The use of 3D visualizations parallels findings where students exhibit improved understanding of abstract and complex structures when viewed in immersive environments. These affordances are particularly crucial in nursing education, where equipment operation and spatial orientation are key components of competency development.

## **2.1 Advantages & Disadvantage of VR in Medical Education**

The advancement of AI and VR technology has improved access to training equipment, reduced medical equipment costs, and enhanced student engagement [1, 9, 10]. The average cost of medical education at the University of Alberta is nearly a quarter million Canadian dollars for four years [12]. Reducing the need for physical machines could lower tuition and equipment costs, benefiting both students and faculty. A MacEwan University nursing faculty member noted that limited machine availability makes hands-on learning less engaging, highlighting the need for VR-based training methods for medical equipment like the IV Pump.

However, VR development remains challenging due to its steep learning curve and lack of comprehensive documentation. While tools like Unity offer script libraries to simplify development, VR development still requires advanced understanding, making it difficult for beginners to adopt [2, 9]. Additionally, cognitive overload can cause motion sickness and reduced engagement, particularly for first-time users. Research suggests that while VR enhances learning when combined with traditional teaching, its novelty can overwhelm students, affecting retention and experience [4].

## **3 Hypothesis and Research Question**

Before the study was conducted, we researched into studies that focused on evaluating the effectiveness of VR simulators in education systems. Some papers were related to the medical field and some used as edutainment [3, 5, 6].

Based on these readings, we have these hypotheses on the effectiveness of learning the IV Pump machine with VR simulators:

1. Developing VR simulation techniques for medical equipment is feasible and using it will increase engagement and increase information retention; provide a positive experience for students to learn how to use medical equipment

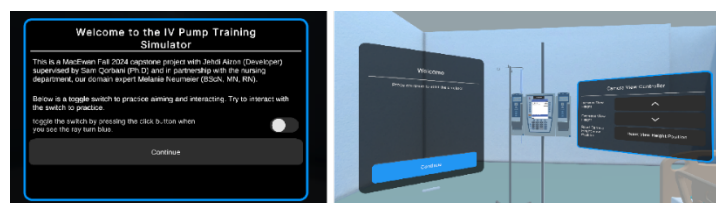
2. Students will learn the process of using IV pump in rather shorter period with a few rounds of practice that can be repeated with ease and the knowledge can be transferred the actual equipment.
3. Using VR to train and learn will decrease the time needed to use the physical IV Pump and improve learning outcome thereby increasing efficiently and decreasing the cost for educational institutions. (We plan to test this part in the next phase of this study in larger scale).

## 4 Methodology and Testing

The simulator was developed using Unity, a well-documented and widely used game engine known for its robust compatibility with VR platforms. Unity's 2022 version was chosen due to its extensive libraries and support for XR development, including direct compatibility with the Meta Quest 3 and other Oculus headsets. This compatibility simplified the setup process and provided access to essential tools for immersive VR interactions, making Unity an ideal choice for creating a user-friendly VR training experience for nursing students. The setup was implemented on a PC with Unity 2022.3 installed, connected to Meta Quest 3 headsets, allowing for a smoother development process and high-quality visual performance [13].

### 4.1 Development

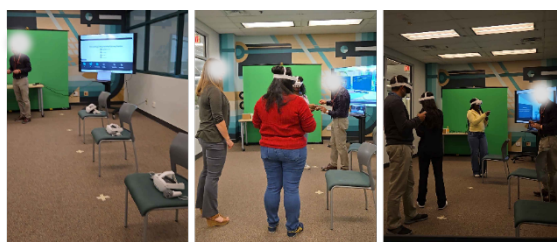
We recreated a 3D model of the Infusion Pump and created a minimal hospital room. To avoid cognitive overload, we only added a hospital bed and a stationary IV drop. After users press “Continue” on the splash screen shown in “Fig. 1.”, users are teleported into the hospital room. The simulator allows for the players to move around either physically or by the joystick controller. To interact with any interactable elements, users must point the ray using the left or right controller and if interactable, the ray will turn blue and press the trigger button held by the index finger, *Interact Button*.



**Fig. 1.** Splash screen with credits and toggle to practice point and click (left image). Simulator room (right image) with dialogue box with narrated instructions (left side), simulator (middle), and a dialogue box to adjust and reset camera height for accessibility (right side).

### 4.2 Testing

A small user study was conducted with five nursing students (Fig.2.), split into two groups: second-year students (Group A, n=2) and third-year students (Group B, n=3). These participants tested the VR IV Pump Simulator to assess its potential as a training tool. Data was gathered through a series of self-efficacy questions, with responses rated on a scale from 1 (strongly disagree) to 5 (strongly agree). This allowed us to evaluate usability, engagement, and perceived effectiveness.



**Fig. 2.** Photos of participants user testing the VR training simulator.

The testing was organized into three main phases: introduction, testing and observation, and a final survey and feedback session. Participants were given instructions on the VR headset’s basic controls and functionality,

including physical adjustments to the Meta Quest 3 headset, controller usage, and safety precautions to prevent motion sickness or discomfort. Students were encouraged to freely explore the VR simulator with minimal guidance, allowing them to engage naturally with the virtual IV pump. Observations were made to capture real-time reactions, comments, and any frustrations encountered with the hardware or simulator, providing insight into potential improvements. After the testing phase, participants completed a questionnaire to rate their experience across several categories, including usability and overall satisfaction. They also provided subjective feedback on specific pain points, such as challenges with hardware or interaction design within the simulator.

The usability questions focused on ease of understanding the VR controllers, the usefulness of feedback (visual or auditory), and the simplicity of completing steps within the simulation. Subjective questions explored participants' perceptions of learning through VR, interest in using the IV pump, and how helpful they found the VR-based training.

The results provided valuable data on the simulator's effectiveness as a learning tool, highlighting areas for future improvement and fine-tuning to enhance usability and engagement. The insights gathered will inform further development to ensure the simulator is both accessible and educationally valuable for nursing students.

## 5 Data Analysis

We asked participants eight usability and subjective questions as seen in Table 1. The survey results indicate overwhelmingly positive feedback across all usability and opinion questions, with most responses at the highest rating of "5" (strongly agree). All participants unanimously rated the VR simulator's usability as either "agree" or "strongly agree," suggesting a highly intuitive and easily navigable interface. The feedback mechanisms, including visual and auditory cues, received perfect scores, indicating their effectiveness in guiding users through tasks. Participants universally agreed on the ease of learning to use the Virtual IV Pump and the helpfulness of VR as a learning method. The simulator significantly boosted engagement, with all users reporting increased interest in IV pump training through VR. While the tips and dialogue were unanimously considered helpful, there was a slight variation in ratings (60% "5" and 40% "4"), suggesting potential for minor improvements in instructional content delivery.

**Table 1.** Table of usability and subjective questions based on an efficacy scale with "1," strongly disagreeing and, "5," strongly agreeing.

| Category                     | Questions                                                                                       |
|------------------------------|-------------------------------------------------------------------------------------------------|
| <b>Usability Questions</b>   |                                                                                                 |
|                              | (1) I can understand the VR controllers easily.                                                 |
|                              | (2) I think the feedback (visual or sound) is useful.                                           |
|                              | (3) I can complete the given steps within the simulation easily.                                |
| <b>Subjective (Opinions)</b> |                                                                                                 |
|                              | (4) I can learn to use the Virtual IV Pump easily.                                              |
|                              | (5) I have become more interested in learning about the IV Pump through VR Training.            |
|                              | (6) I found the tips and dialogue helpful to learning the IV Pump.                              |
|                              | (7) I found the learning method through VR simulation to be helpful.                            |
|                              | (8) What was a pain point or challenge using the simulation (hardware or simulation experience) |

## 6 Discussion and Conclusion

The high usability and engagement ratings highlight the VR IV Pump simulator's effectiveness in enhancing learning and motivation. Its ease of use and feedback mechanisms support smooth task completion, reinforcing VR's potential for teaching complex nursing equipment. While most responses were positive, some users reported visual or physical discomfort, especially those with prescription glasses. Future studies could address this by offering prescription lens inserts or better headset adjustment guidance to improve user experience and learning outcomes.

Within this student project and pilot study, we demonstrated that (1) VR simulation development is feasible and practical, and (2) it provides an engaging, low-stress learning experience compared to handling expensive

physical equipment. Future research will expand the sample size and employ a pre-post study to measure VR's effectiveness in skill acquisition.

By employing VR's interactivity, accessibility, and immersion in nursing education we could potentially bridge between theoretical knowledge and hands-on practice. Our experiment shows that VR training offers cost-saving benefits by reducing reliance on physical IV pump machines, lowering maintenance expenses, and expanding access to specialized training. Furthermore, VR enables safe, repeated practice without equipment wear and tear and increased accessibility, enhancing the learning experience.

However, fully replacing traditional on-machine learning with VR may present challenges, such as cyber sickness in first-time users and lack of user touch feedback. Thus, VR should be integrated thoughtfully, serving as a complementary tool rather than a complete substitute for hands-on training.

## 6.1 Limitations and Future Research

With more time and resources, we could add advanced features like enhanced interactivity and assessment tools. While the prototype met its goals, future iterations could further refine usability and immersion. Due to the ethics approval requirements, our study focused on usability and general opinions, with volunteer participants providing feedback without compensation. However, we are planning to extend this study and conduct a larger scale user testing after needed approvals. Future work could expand the simulator to include more medical devices, customizable controls, a realistic environment, and interactive quizzes to enhance learning. A larger, long-term study could further assess VR's impact on immersion, information retention, and effectiveness as a nursing training tool.

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