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The Effectiveness of Learning Media with Virtual Reality Non Immersive Ventilator Laboratory on Student Knowledge, Learning Motivation, and Self-Efficacy

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Abstract

Mechanical ventilators are complex medical devices essential to critical nursing education; however, learning in health colleges has predominantly been conducted through conventional methods such as lectures and handbooks, with limited practical exposure. Limited equipment, high costs, and lack of hands-on experience have contributed to low levels of knowledge, learning motivation, and self-efficacy among students. This study was conducted to develop and evaluate a Virtual Reality-based Ventilator Laboratory using 360-degree video as an innovative learning medium that provides immersive and interactive experiences. The research applied a Research and Development approach using the Analysis, Design, Development, Implementation, and Evaluation model. The effectiveness evaluation employed a quasi-experimental design with a pretest–posttest control group. A total of 50 nursing students were randomly assigned to an intervention group and a control group. Data were collected using validated questionnaires and analyzed using paired and independent-samples t-tests and effect-size analysis. The results showed significant improvements in knowledge, learning motivation, and self-efficacy in the intervention group compared to the control group. The intervention demonstrated a moderate effect on knowledge and large effects on learning motivation and self-efficacy. It was concluded that Virtual Reality-based learning media were effective in enhancing students' understanding of mechanical ventilators.

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Introduction

In the era of rapid technological development, the use of technology in education is one of the important innovations to improve the quality of learning. One technology that is attracting increasing attention is Virtual Reality. Virtual reality is a technology that uses a headset to simulate a virtual environment in which the user is immersed, creating the impression that they are physically present in that space (Kouijzer et al., 2023).

Meanwhile, according to Radianti et al. (2020), Virtual reality is a computer-based interactive simulation that allows users to experience an immersive environment resembling the real world. In learning, Virtual reality has been proven to increase students' cognitive and emotional engagement, thereby strengthening the process of knowledge formation (constructivist learning theory). In addition, the Cognitive Load theory reveals that learning supported by spatial visualization and multisensory experiences, such as in Virtual reality media, can reduce cognitive load and accelerate understanding of abstract concepts, such as mechanical ventilator work systems.

Virtual reality technology offers a more immersive, interactive learning experience, helping students better understand complex material. In the health sector, especially in medical and nursing education, the use of Virtual reality is a potential learning method for improving students' understanding and skills in clinical concepts.

Psychologically, Virtual reality media is also believed to increase learning motivation. Based on the Attention, Relevance, Confidence, and Satisfaction (ARCS) Motivation Model (Keller, 1987), learning that is attractive, relevant, and provides a sense of achievement will trigger students' intrinsic motivation. The use of Virtual reality can fulfill the elements of Attention and Relevance through attractive visual displays. In addition, mission achievement in Virtual reality learning creates a sense of accomplishment that drives Confidence and Satisfaction, two other elements of the Attention, Relevance, Confidence, and Satisfaction (ARCS)model.

In addition, VR media can increase self-efficacy, an individual's confidence in his or her ability to complete certain tasks. Bandura (1997) stated that direct experience (enactive mastery) and vicarious experience (vicarious experience) are the two main sources of strengthening self-efficacy. Through Virtual reality Video, students can observe the procedures performed by virtual avatars or instructors, thereby increasing their confidence in understanding and applying the material.

According to research conducted by Menhard (2024) and Wulandari et al. (2025), the use of Virtual Reality in learning has been shown to improve student engagement and learning outcomes compared to conventional methods. Fira et al. (2023) investigated the use of virtual reality in Keselamatan dan Kesehatan Kerja (Occupational Health and Safety, K3) courses. The results showed that 76% of students liked Virtual Reality-based learning media, and media validation reached 81%, which was categorized as "Very Feasible".

Mechanical ventilators are complex medical devices with various modes and parameter settings, and they pose a risk of complications if misused. However, in many health colleges, students receive only theoretical explanations through pocketbooks or lectures, without hands-on practical experience, due to limited tools. As a result, students' understanding of mechanical ventilators tends to be low. The high price of mechanical ventilators makes it difficult for most private universities (private universities) to provide this tool as a means of practice. Students often only learn about ventilators through pictures or illustrations, without the opportunity to run real simulations. This condition creates a gap between the theory learned and the skills needed in the field.

Limited access and conventional methods result in students' knowledge of working principles, modes, and monitoring of mechanical ventilators that are not optimal. Students are less motivated to study ventilators because the material is considered difficult and abstract, and there is no engaging, direct practice media. The lack of real experience leads students to doubt their abilities when they encounter patients on ventilators, resulting in low self-efficacy. In accordance with the *Asosiasi*

Institusi Pendidikan Ners Indonesia/Association of Indonesian Nursing Education Institutions (AIPNI) curriculum in 2024, the learning outcomes for mechanical ventilator teaching materials are that students can explain the order of mechanical ventilator settings.

Various studies have shown that the use of Virtual reality in nursing education can significantly increase knowledge, learning motivation, and self-efficacy (Kim et al., 2022; Foronda et al., 2020; Lee, 2022). However, there are still limitations of similar research in Indonesia, especially those that integrate these three aspects simultaneously. Therefore, the development of contextual Virtual reality-based learning media and the evaluation of their effectiveness on student motivation, knowledge, and self-efficacy are important for addressing the challenges of modern nursing education.

Higher education in the field of health, such as at *Sekolah Tinggi Ilmu Kesehatan*/College of Health Sciences (STIKes), requires students not only to understand theory but also to have strong practical skills. The application of Virtual reality in health learning can provide a more interactive learning experience, especially for understanding the body's anatomical structure, medical procedures, and complex clinical scenarios (Mergen et al., 2024). Lectures and pocket books provide only theoretical understanding, while mechanical ventilators are clinical skills that require visualization and practical experience. Virtual reality can simulate a clinical environment that resembles real conditions without risk to the patient. With Virtual reality Video technology, students can experience learning as if they were in an Intensive Care Unit (ICU) room, view the device display from various angles, and follow procedures more realistically. This increases cognitive, affective, and psychomotor involvement compared to traditional methods. Virtual reality allows students to practice repeatedly, explore ventilator modes, and understand the working principles in a fun, risk-free way.

According to the Kerangka Kualifikasi Nasional Indonesia / Indonesian National Qualifications Framework (KKNI) level 6 (Bachelor of Nursing), students are required not only to master theory but also to analyze problems, apply knowledge in real contexts, and demonstrate practical skills and clinical decision-making. Mastery of mechanical ventilators is part of the *Capaian Pembelajaran Lulusan*/Graduate Learning Outcomes (CPL) in the field of critical nursing, encompassing knowledge, general skills, special skills, and professional attitudes. The use of Virtual reality aligns with the demands of *Kerangka Kualifikasi Nasional Indonesia* (KKNI) because it helps students understand the concept of ventilators through visualization and simulation, provides virtual practice experiences that are close to clinical skill competencies, and builds confidence and readiness to face real patients. In the Critical Nursing Constitutional Court, there is no practicum for mechanical ventilator teaching materials.

Sekolah Tinggi Ilmu Kesehatan/ College of Health Sciences (STIKes) Mitra Husada Karanganyar, as a health education institution, also needs to adapt to advances in learning technology to improve the quality of education. However, the effectiveness of Virtual reality-based learning media on student learning, knowledge, and motivation remains a topic that warrants further research. Based on research by Radianti et al. (2020), although Virtual reality shows great potential in education, there are still challenges in its implementation, such as the cost of procuring devices and the readiness of lecturers and students to use them. Thus, Virtual reality supports outcome-based learning in accordance with the *Kerangka Kualifikasi Nasional Indonesia*/Indonesian National Qualifications Framework (KKNI), aiming to produce graduates who are competent, adaptable to technological developments, and ready to face clinical challenges in the world of work.

The video about Virtual reality -based mechanical ventilators allows students to see more reality (immersion) with a virtual environment that resembles real conditions in the Intensive Care Unit (ICU) without risk to patients and mechanical ventilators. One important topic in health education is the use of ventilators, which are vital devices in the treatment of patients with respiratory

distress. Health students need a deep understanding of ventilator operation, given its crucial role in caring for critically ill patients.

In addition, in the private sector, it is still very difficult to purchase mechanical ventilators due to their high cost. The researcher hopes that, with this virtual reality learning method, students will find it easier to understand ventilators than by simply reading pocket books and listening to lectures. However, the effectiveness of Virtual Reality-based learning methods in increasing students' knowledge, motivation, and self-efficacy remains under-researched. Therefore, this study aims to analyze the effectiveness of learning methods with Virtual Reality technology about ventilator simulations on student knowledge, so that it can provide empirical evidence about the benefits of this technology in supporting the learning process in the health sector. Teaching materials for mechanical ventilators are in the Critical Nursing course.

A preliminary study conducted at Sekolah Tinggi Ilmu Kesehatan Mitra Husada Karanganyar in March 2025 on 10 7th semester students about ventilators in critical nursing courses with conventional methods, namely explanations with pocket books alone, found that 7 out of 10 students lacked knowledge, which was still below NBL, while 6 out of 10 students were less motivated in learning ventilators and as many as 5 out of 10 students still lacked confidence. For ventilator teaching materials, there is no practice because the *Capaian Pembelajaran Lulusan* (CPL) of this teaching material only covers what is known. The results of the preliminary study indicate that most students still lack adequate knowledge of mechanical ventilators. This indicates a gap between the expected competencies and students' understanding of them. In fact, basic knowledge of ventilators is an important cognitive skill in critical nursing. Conventional methods, such as lectures and pocketbooks, have not been able to provide optimal conceptual and practical understanding. Low motivation to learn is also an important obstacle. As many as 6 out of 10 students in the preliminary study reported that they were less motivated to study ventilators because learning was limited to pocket books and lecturer explanations, without real practical experience. Low motivation to learn can lead to minimal student engagement, potentially reducing learning outcomes and interest in understanding the ventilator concept more deeply. In addition, students' self-efficacy in understanding ventilator material is also low. 5 out of 10 students reported lacking confidence in their ability to understand and apply the material. In fact, self-efficacy strongly influences students' success in facing academic and clinical challenges, as stated by Bandura (1997). Low self-efficacy indicates that students need a more immersive, realistic learning experience to improve their self-confidence.

Based on the background above, the author aims to investigate the effect of learning about ventilators using Virtual Reality on the knowledge scores, motivation, and self-efficacy of STIKes Mitra Husada Karanganyar students. This study aims to determine the effect of Ventilator Laboratory Virtual Reality on the knowledge, learning motivation, and self-efficacy of Sekolah Tinggi Ilmu Kesehatan Mitra Husada Karanganyar students.

Materials and Methods

Research Design

This research uses a Research and Development (R&D) approach to develop a Ventilator Laboratory Virtual Reality-based learning media and test its effectiveness. The development model used is ADDIE, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation. This approach was chosen because it can produce learning media innovations that meet students' needs and systematically and measurably improve learning quality.

Media Development Stage

The development stage began with a needs analysis, conducted through observation of 7th-semester students at Sekolah Tinggi Ilmu Kesehatan Mitra Husada Karanganyar, which revealed

limitations in understanding the use of ventilators due to a lack of practical media. Furthermore, curriculum and material analyses were conducted to ensure the media aligned with the learning outcomes of the Critical Nursing course. At the design stage, Virtual Reality media simulate ventilator use in an Intensive Care Unit (ICU) environment, with several modes (Volume Control Ventilation (VCV), Pressure Control Ventilation (PCV), and Synchronized Intermittent Mandatory Ventilation (SIMV)). The development stage includes creating Virtual Reality content, validation by media and material experts, and validity testing using the Content Validity Index (CVI). The implementation stage was carried out in small groups (10 respondents) to assess usability using the Usefulness, Satisfaction, and Ease of Use (USE) Questionnaire. Finally, the evaluation stage is conducted to address the media's shortcomings before it is used more widely.

Product Effectiveness Test Stage

After the media were developed, an effectiveness test was conducted using a quasi-experimental pretest-posttest control-group design. The intervention group received learning using Ventilator Laboratory Virtual Reality media, accompanied by a pocket book, while the control group used only the lecture method and a pocket book. Measurements were taken before (pretest) and after the intervention (posttest) to determine changes in students' knowledge, learning motivation, and self-efficacy.

Population and Sample

The research population comprises all 7th-semester students at Sekolah Tinggi Ilmu Kesehatan Mitra Husada Karanganyar, totaling 50 individuals; therefore, the sampling technique used is total sampling. The sample was randomly divided into two groups (intervention and control). Inclusion and exclusion criteria were established to ensure respondents' suitability, including readiness to participate in Virtual Reality-based learning.

Variables and Instruments

The independent variables in this study were Ventilator Laboratory Virtual Reality learning media, while the dependent variables included knowledge, learning motivation, and self-efficacy. The research instruments included a demographic questionnaire, a knowledge questionnaire (25 questions), a learning motivation questionnaire (20 items), and a self-efficacy questionnaire (35 items). All instruments have been tested for validity and reliability, with Cronbach's Alpha values> 0.8, indicating they are feasible.

Data Analysis

Data analysis was carried out using univariate analysis to describe respondent characteristics and bivariate analysis to test group differences, using independent t-tests or nonparametric alternatives. In addition, the paired t-test or the Wilcoxon test is used to look for changes before and after the intervention.

Ethical Statement

This study received ethical approval from the Health Research Ethics Committee of Sekolah Tinggi Ilmu Kesehatan Mitra Husada Karanganyar (KEP-K STIKes Mitra Husada Karanganyar) with approval number 010/KEPK-STIKes MHK/EC_DD/XI/2025. Prior to data collection, all participants were provided with complete information about the study and gave written informed consent to participate. Participants were assured that their participation was voluntary and that they could withdraw at any time without consequences. The confidentiality of all data was strictly maintained, and participants' identities were protected by using codes instead of personal identifiers throughout the research process.

Results and Discussions

Results

Phase 1 (Virtual Reality Media Development using the ADDIE method)

Analysis

The analysis stage shows that ventilator learning in the Critical Nursing course still faces a main obstacle: limited practical tools, leading the learning process to be theoretical and lacking direct experience for students. The results of interviews with lecturers and students revealed that this condition affects understanding, learning motivation, and student confidence in facing clinical practice. Therefore, innovative learning media are needed that provide a more interactive learning experience and are closer to real-world conditions. Ventilator Laboratory Virtual Reality-based media is considered relevant because it can simulate ventilator use visually and immersively. In addition, curriculum and materials analysis show that the use of Virtual Reality aligns with the demands of cognitive and psychomotor competencies in the 2025 Curriculum.

Design

The design stage involves creating Virtual Reality learning media that meet students' needs and the curriculum. This process includes selecting a Virtual Reality headset that is ergonomic, comfortable, and compatible with smartphones, as well as designing 360°-based Ventilator Laboratory video content that simulates ventilator use in the Intensive Care Unit (ICU) room. The content covers important aspects such as device introduction, ventilator settings, monitoring, and alarm handling. Furthermore, the content is integrated with the Virtual Reality device, enabling interactive use. This stage aims to produce media that is easy to use, realistic, and able to improve the student learning experience.

Development

In the development stage, Ventilator Laboratory Virtual Reality media is realized through content creation, video editing, and system integration. This process involves validation by media experts and subject matter experts to ensure feasibility from both technical and substantive aspects. The results of the validity test showed an average Content Validity Ratio (CVR) of 0.93 and a Content Validity Index (CVI) of 0.96, which placed it in the feasible category. Feedback from experts is generally minor improvements, such as visual enhancement and audio-visual synchronization. Overall, the media is deemed valid, relevant, and ready for user testing.

Implementation

The implementation stage was carried out through a small-group trial involving 10 students. The results showed a significant increase in knowledge, learning motivation, and self-efficacy after the use of Virtual Reality media, with a $p<$ value of 0.001 for all variables. In addition, the results of the Usefulness, Satisfaction, and Ease of Use (USE) questionnaire indicate that the media are highly feasible, especially in usefulness (83.75%) and ease of use (83.12%), which are in the very feasible category. This shows that Ventilator Laboratory's Virtual Reality media is effective and easy to use for learning, as well as for increasing student engagement and the learning experience.

Phase 2 (Product Effectiveness Test)

A comparative analysis of test results between the intervention and control groups was conducted to determine the effectiveness of virtual reality-based learning media in increasing students' knowledge, learning motivation, and self-efficacy. Independent-samples t-tests were used

to assess differences between pretest and posttest results across the two groups. The analysis results provide an overview of the extent to which the intervention can significantly affect the variables studied.

Table 1. Results of the Independent Test & Effect Size of the Intervention Group and Control Group (n = 50, Intervention = 25, Control = 25)

Test	Mean ±SD		Value p	*Effect Size*
	Intervention	Controls		
Knowledge *pretest* score	64.32 ±11.542	51.04 ±10.663	<0.001	
Learning *motivation* pretest score	57.20 ±2.872	53.36 ±4.405	<0.001	
Self-efficacy pretest *score*	51.64 ±3.522	51.12 ±3.723	0.614	
Knowledge *posttest* score	84.48 ±8.666	62.08 ±12.968	<0.001	0.2031
Learning *motivation posttest* score	63.92 ±3.673	56.40 ±4.387	<0.001	1.8587
Posttest *self-efficacy score*	61.12 ±4.419	56.24 ±3.419	<0.001	1.2352

Table 1 presents the results of the independent t-test between the intervention and control groups at the pretest and posttest, for the variables of knowledge, learning motivation, and self-efficacy. At the pretest stage of knowledge, the average intervention group (64.32; Standard Deviation (SD) ±11.542) was significantly higher than that of the control group (51.04; SD ±10.663), as indicated by a p value of < 0.001. Likewise, for the learning motivation variable, the intervention group had an average of 57.20 (SD ±2.872), which was higher than the control group's 53.36 (SD ±4.405), with a p-value of < 0.001. This shows that, before the intervention, the intervention group already had a higher level of knowledge and learning motivation than the control group. Therefore, subsequent analyses should account for these initial differences, for example, by examining changes in scores from pretest to posttest within each group to assess the intervention's effectiveness more accurately. Meanwhile, in the self-efficacy pretest variable, there was no significant difference between the two groups, as indicated by the p-value of 0.614. These results showed that the initial self-efficacy levels in the intervention and control groups were equal before the intervention.

The results of the independent t-test on the posttest scores showed a significant difference between the intervention and control groups on all variables studied. In the knowledge variable, the average score of the intervention group was 84.48 (SD ±8.666) higher than that of the control group of 62.08 (SD ±12.968), with a p< value of 0.001. Cohen's d effect size of 0.2031 falls in the medium effect category, indicating that the use of the Virtual Reality Ventilator Laboratory significantly improves student knowledge compared to conventional learning.

Regarding learning motivation variables, the intervention group obtained an average of 63.92 (SD ±3.673), while the control group obtained 56.40 (SD ±4.387), with a significant difference (p < 0.001). The effect size of 1.8587 falls in the large effect category, indicating that the Ventilator Laboratory Virtual Reality-based learning intervention has a very strong effect on increasing student learning motivation.

For the self-efficacy variable, the intervention group had an average score of 61.12 (SD ±4.419), which was higher than the control group's 56.24 (SD ±3.419; p < 0.001). The effect size of 1.2352 is classified as large, indicating that the use of Ventilator Laboratory Virtual Reality has a strong impact on increasing students' self-confidence in understanding and applying ventilator materials. Overall, the t-test and effect size posttest results confirmed that the Ventilator Laboratory Virtual Reality intervention was more effective than conventional learning methods.

As a follow-up to the independent t-test results, the average (mean) and standard deviation (SD) of posttest scores were presented for the intervention and control groups to clarify the magnitude of the difference in learning outcomes between groups after treatment. Presenting the mean values and standard deviations provides an overview of the score distribution. It supports the interpretation that Ventilator Laboratory Virtual Reality-based learning interventions yield better results than conventional learning.

Table 2. Mean & SD Intervention Groups and Control Groups (n = 50, Interventions = 25, Controls = 25)

Variable	Intervention Groups		Control Group		*p value*
	Mean Difference	SD	Mean Difference	SD	
Knowledge	20.16	2.88	11.04	2.31	<0.001
Motivation	6.72	0.80	3.04	0.02	<0.001
Self Efficacy	9.48	0.90	5.12	0.30	<0.001

Based on Table 2, all variables indicate that the intervention group's average posttest score is higher than that of the control group, with a statistically significant difference ($p < 0.001$). For the knowledge variable, the average in the intervention group was 20.16 (SD 2.88), while the control group was 11.04 (SD 2.31). In the learning motivation variable, the average intervention group was 6.72 (SD 0.80) higher than the control group, which was 3.04 (SD 0.02). Similarly, in the self-efficacy variable, the intervention group obtained an average of 9.48 (SD 0.90), while the control group obtained 5.12 (SD 0.30). These findings confirm that the use of Ventilator Laboratory Virtual Reality learning media yields better results in student knowledge, learning motivation, and self-efficacy than the learning method without a Virtual Reality intervention.

Discussion

Stage 1

This study found that the development and implementation of a Virtual Reality–based Ventilator Laboratory using the ADDIE model was effective in improving students' knowledge, learning motivation, and self-efficacy in critical nursing education.

These findings indicate that Virtual Reality provides a meaningful solution to the limitations of conventional learning, particularly the lack of practical tools and clinical exposure. At the analysis and design stages, integrating realistic Intensive Care Unit simulations and ergonomic devices helped align learning objectives with student needs. This is consistent with Kim & Yoo (2025) and Babaita et al. (2024), who emphasized that immersive and interactive Virtual Reality environments enhance understanding, engagement, and clinical skill acquisition. The development stage further ensured content accuracy and instructional relevance through expert validation, reinforcing the importance of systematic design in producing effective educational media (Aydin et al., 2025; Darojat et al., 2022; Arkadiantika et al., 2020).

From an implementation perspective, Virtual Reality-based learning facilitated active, safe, and repetitive practice, which is essential in developing clinical competence without risking patient safety. This aligns with Haley & Wacker (2022), who reported that Virtual Reality enhances confidence, intrinsic motivation, and engagement in nursing students. Additionally, positive user responses regarding usefulness, ease of use, and satisfaction suggest that this technology is well accepted and practical for integration into educational settings. Similar findings were reported by Stenseth et al. (2025) and Birrenbach et al. (2021), highlighting the role of Virtual Reality in improving learning experiences and retention through immersive simulation.

Overall, this study contributes to advancing educational innovation in nursing by demonstrating that Virtual Reality can bridge the gap between theory and practice. The findings have important implications for educational institutions and policymakers, suggesting that adopting technology-enhanced learning as a strategy to improve the quality of clinical training is warranted. Continuous evaluation and refinement, as suggested by Tarmizi et al. (2020), remain essential to ensure that Virtual Reality media remains effective, user-friendly, and aligned with evolving educational needs.

Stage 2

This study found that Virtual Reality–based Ventilator Laboratory learning was more effective than conventional methods in improving students' knowledge, learning motivation, and self-efficacy. These findings highlight the important role of immersive technology in transforming nursing education by providing contextual and experiential learning that cannot be achieved through lectures alone. Virtual Reality enables students to visualize complex clinical procedures and engage actively in simulated environments, leading to deeper conceptual understanding and improved clinical readiness. This is consistent with Liu et al. (2023) and van Dinther et al. (2023), who emphasized that Virtual Reality enhances conceptual comprehension and creates authentic learning experiences, particularly for complex clinical topics. The ability to repeatedly observe and practice procedures in a safe environment also strengthens knowledge retention, as supported by Sung et al. (2024), Arif et al. (2025), and Kiegaldie & Shaw (2023).

In terms of learning motivation, the interactive and engaging nature of Virtual Reality fosters curiosity, attention, and emotional involvement in the learning process. Students are more likely to participate actively and explore learning materials when they are presented in immersive formats. These findings align with Lutfi et al. (2025), Patdilah et al. (2025), and Li et al. (2022), which demonstrated that Virtual Reality enhances learning experiences and increases motivation through interactive and realistic environments. Additional support from Chang et al. (2025) and Gutiérrez-Jara et al. (2025) further confirms that Virtual Reality improves procedural understanding and sustains learner engagement.

Furthermore, Virtual Reality plays a significant role in strengthening students' self-efficacy by allowing them to practice without fear of making harmful errors and by providing immediate feedback within simulations. This safe and controlled environment builds confidence and supports independent learning. Similar findings were reported by Dito et al. (2025), Perez (2025), Lin et al. (2024), and Jans et al. (2023), who found that Virtual Reality enhances self-confidence and perceived competence in both academic and practical skills. Overall, this study contributes to educational practice by demonstrating that Virtual Reality can serve as an effective strategy to bridge the gap between theory and clinical application, and it offers strong implications for integrating technology-based learning into nursing curricula and policy development, as also highlighted by Shorey & Ng (2021).

A limitation of this study is the relatively small and homogeneous sample, which may limit the generalizability of the findings. Future research is recommended to involve larger and more diverse populations and to explore the long-term impact of Virtual Reality on clinical performance in real healthcare settings.

Conclusion

The study demonstrated that the development and implementation of Virtual Reality–based Ventilator Laboratory learning media were feasible and effective for nursing education, providing an interactive, immersive learning experience that improved students' understanding, motivation, and self-efficacy compared to conventional methods. The intervention group showed better overall learning outcomes, supported by meaningful effect sizes, indicating the educational value of Virtual

Reality in complex clinical topics such as mechanical ventilation. Therefore, this technology has strong potential for integration into nursing curricula to enhance the quality of clinical learning. It is recommended that educational institutions adopt and support Virtual Reality-based learning through adequate infrastructure and training. At the same time, future studies should expand the scope of content and evaluate long-term impacts on clinical competency.

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