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Improving Psychomotor Competence in Midwifery Nursing Students through Virtual Reality-Based Education

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Abstract

Virtual reality (VR) has become an innovative tool in nursing and midwifery education worldwide, offering immersive learning experiences that can improve skill acquisition and promote safe clinical practice. This study investigated the effectiveness of VR-assisted learning in enhancing the psychomotor abilities of midwifery nursing students. A quasi-experimental study was conducted at Suez Canal University's Faculty of Nursing, including the simulation laboratory and the antenatal outpatient clinic of the university hospital. Sixty undergraduate midwifery students were selected through stratified random sampling and assigned equally to either a VR-assisted study group or a traditional learning control group. Data were collected from September 2024 to January 2025 using five instruments: a self-administered questionnaire, the System Usability Scale, Leopold's maneuver checklist, an antenatal maternal physical assessment tool, and a student satisfaction survey. While VR training produced slightly higher knowledge scores than conventional teaching, the difference did not reach statistical significance ($p = 0.35$). Baseline assessments showed no significant differences in psychomotor performance between groups for Leopold's maneuver and maternal assessment ($p = 0.11$ and $p = 0.07$). After the intervention, the VR group exhibited significantly better psychomotor competence in Leopold's maneuver (43.13 ± 1.46; 42.6 ± 3.82) and maternal physical assessment (36.33 ± 1.81; 37.6 ± 0.67) than the control group (36.53 ± 2.29; 32.77 ± 4.28) and (30.13 ± 3.98; 27.3 ± 3.96) during both immediate and follow-up post-tests ($p = 0.000$). Additionally, 97 percent of students in the VR group achieved the highest grade in system usability evaluation, and 63.3 percent reported being extremely satisfied with the VR learning experience. Incorporating VR into midwifery training significantly enhanced students' psychomotor skills, practical performance, and satisfaction compared with traditional simulation-based learning, although knowledge improvements were not statistically significant. VR-assisted education should be integrated into midwifery and maternal health curricula to improve practical skill development, with ongoing student feedback to continually refine the VR learning process.

Keywords: Virtual reality, Midwifery, Psychomotor competence, Nursing students

Introduction

Psychomotor competence, encompassing technical skills, motor coordination, and clinical decision-making, is essential for effective training in nursing and midwifery. Although traditional laboratory sessions and clinical rotations are considered the standard approach, they often fail to bridge the gap between theoretical knowledge and practical clinical readiness [1, 2]. Challenges such as limited access to clinical environments, ethical restrictions, and concerns about patient safety further exacerbate this disconnect. Consequently, there is an increasing demand for alternative teaching strategies that provide students with high-fidelity, safe, and repeatable experiential learning opportunities [3].

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Virtual reality-assisted learning (VRAL) has emerged as a promising solution to address these limitations. By engaging students in immersive clinical simulations, VRAL enables repeated practice of complex procedures and exposure to high-risk scenarios in a controlled environment. This approach not only enhances procedural accuracy, confidence, and decision-making but also develops essential non-technical skills, including critical thinking, communication, and situational awareness [4]. Nevertheless, implementing VRAL in healthcare education presents challenges, such as high equipment costs, the need for specialized faculty training, increased cognitive load, and difficulties in aligning VRAL with traditional curricula [5].

The growing adoption of VR worldwide underscores its feasibility and potential for educational use. By 2023, the global number of VR users had exceeded 65 million, rising from 22.5 million in 2017 [5]. While the entertainment and gaming sectors have primarily driven this growth, it also suggests that VR platforms are becoming increasingly accessible for educational applications. Evidence from systematic reviews and meta-analyses in nursing and midwifery indicates that VR outperforms conventional teaching methods in improving clinical preparedness and procedural knowledge. VR has been shown to effectively support skill acquisition for a variety of procedures, including intravenous insertion, chemotherapy administration, and labor management [6].

Empirical research further supports these findings. For instance, a quasi-experimental study in Ghana demonstrated that VRAL simulations covering birthing scenarios—from labor management to placental inspection—significantly enhanced midwifery students' clinical readiness, psychomotor abilities, confidence, technical skills, and decision-making [7]. Similarly, a pilot usability study with 43 UK undergraduate midwifery students reported high satisfaction with VR (mean SUS = 75.9), highlighting its effectiveness as a safe and practical method for practicing complex clinical tasks before real-world placements [8].

Building on this evidence, the present study integrates VRAL with Kolb's Experiential Learning Theory to optimize learning outcomes. Kolb's model comprises four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. This framework encourages deeper cognitive engagement and is particularly suited to practice-based disciplines like midwifery, ensuring that students not only complete virtual tasks but also reflect on, understand, and apply skills in real clinical contexts. Applying Kolb's model enhances clinical reasoning, knowledge retention, and the relevance of learning to authentic practice [9].

Despite VRAL's expanding use in nursing education, its adoption in midwifery remains limited, particularly for essential obstetric procedures such as Leopold's maneuvers and antenatal maternal assessments. While numerous studies report improvements in knowledge and student satisfaction, few have examined whether these gains translate into sustained performance in clinical practice. Longitudinal research evaluating the transfer of VR-acquired competencies to real-world settings is notably lacking [10, 11].

To address this gap, the current study evaluates a VRAL module designed to teach Leopold's maneuvers and antenatal maternal assessment based on Kolb's experiential learning framework. The study investigates both immediate learning outcomes and the retention and application of skills in actual clinical settings. By combining a robust educational theory with VR integration, this research contributes to the theoretical understanding of VRAL in midwifery education and provides empirical evidence of its impact on clinical competence.

Theoretical Background

Kolb's Experiential Learning Theory [12] presents learning as a continuous four-stage cycle consisting of concrete experience, reflective observation, abstract conceptualization, and active experimentation. This framework provides a practical lens for understanding how midwifery students can develop psychomotor abilities, such as performing Leopold's Maneuvers and antenatal assessments, when engaged with Virtual Reality-Assisted Learning (VRAL) [12].

During the concrete experience phase, students in the VRAL group interacted with pre-designed 3D VR modules that simulated Leopold's Maneuvers and antenatal examinations, followed by hands-on practice with high-fidelity manikins. This immersive setup allowed students to physically perform assessments while visualizing internal fetal positions, strengthening both spatial awareness and tactile skills. Training sessions were structured with 10-minute intervals, supervised closely to ensure focused practice, and students' psychomotor performance was evaluated immediately using validated assessment tools.

The reflective observation stage encouraged students to analyze their performance critically. They identified challenges, questioned uncertainties, and discussed their learning experiences. Facilitators guided these reflections through verbal feedback, offering constructive advice on technique, timing, and clinical accuracy. The VR Usability Survey (Tool II) further prompted students to assess the practical and educational value of the VR experience, enhancing critical thinking about the training process [13].

In the abstract conceptualization phase, learners integrated practical experiences and reflections with theoretical knowledge. Prior to VR engagement, students completed structured instruction, including a 30-minute instructor-led session, printed guides, and skill checklists that explained the clinical rationale behind Leopold's Maneuvers and prenatal evaluations. The VR modules reinforced these concepts visually, helping students connect their

actions to clinical reasoning. This approach moved students from rote performance toward a deeper understanding of fetal positioning, presentation, and maternal assessment, emphasizing their significance in safe obstetric care.
The final stage, active experimentation, occurred during follow-up clinical practice. One week after the VR sessions, students applied the skills in real-world settings at the antenatal outpatient clinic of Suez Canal University Hospital. Each participant conducted an antenatal assessment on a pregnant woman (28–32 weeks of gestation), following the same sequence used in the VRAL module. Performance was measured using a validated clinical skills checklist during timed 10-minute sessions, and students completed a VR Satisfaction Survey to evaluate how well the VR training prepared them for practical clinical application [14].

Research Gap and Study Significance

VRAL is increasingly recognized as a solution for improving midwifery students' psychomotor skills, particularly in response to limited clinical access, ethical constraints, and patient safety concerns [3]. By enabling repeated practice, reflection, and safe error-making, VRAL allows learners to acquire skills more thoroughly and confidently [15].
Despite growing interest, few studies have systematically applied pedagogical frameworks, such as Kolb's Experiential Learning Theory, to guide VRAL design in midwifery education [10]. Most research has concentrated on short-term knowledge improvement or student satisfaction, with little focus on whether VR-acquired skills translate effectively to clinical performance. Evidence examining the application of essential obstetric techniques, like Leopold's Maneuvers and antenatal assessments, in actual clinical placements is especially limited [16].
This study addresses these gaps by using Kolb's framework to design and evaluate a VRAL module targeting Leopold's Maneuvers and antenatal assessments, with an emphasis on skill transfer to real-world clinical practice. The approach offers cost-effective and scalable training while contributing both theoretically and empirically to midwifery education. It also supports evidence-based curriculum development, enhancing students' competence, confidence, and readiness for clinical practice through immersive, safe, and structured learning experiences [7].

Aim of the study
The primary aim of this research was to examine the effect of virtual reality-assisted learning (VRAL) on improving psychomotor competence among midwifery nursing students.

Objectives
- To evaluate and compare pre- and post-training knowledge related to psychomotor competence between students exposed to VR training and those receiving conventional training.
- To determine the baseline psychomotor competence of midwifery nursing students prior to VR intervention.
- To compare post-intervention psychomotor skill levels between students trained via VR and those trained using traditional methods.
- To assess midwifery students' satisfaction with VR-assisted learning as a clinical training strategy.

Operational definitions
Psychomotor competence: The capacity to perform clinical procedures safely, accurately, and consistently by integrating knowledge with practical skills to achieve proficiency while adhering to ethical standards. Competence was measured during antenatal clinical rounds using validated assessment checklists.
Virtual reality-assisted learning (VRAL): A teaching method where students wear VR headsets linked to mobile devices to view preloaded 3D procedural videos while simultaneously practicing these steps on simulation mannequins in the clinical skills laboratory.

Research hypotheses
H1: Midwifery students who participate in VR training will demonstrate significantly higher psychomotor competence compared to students undergoing traditional clinical training.
H2: Midwifery students who receive VR training will report significantly greater satisfaction with their learning experience compared to those trained using conventional methods.

Research design
This study utilized a quasi-experimental design, which is suitable for assessing the effects of an intervention. The design involved two groups: one receiving the innovative VRAL intervention and the other receiving standard instruction. Both groups were evaluated before (pre-test) and after (post-test) the intervention to determine whether VRAL led to superior improvement in knowledge and skills [17].

Study setting

The study was conducted at the obstetrics and gynecology skills laboratory of the Faculty of Nursing, Suez Canal University, and the antenatal outpatient clinic of the affiliated university hospital. The laboratory, located on the third floor of the educational building, contains six beds with obstetrics and gynecology mannequins, each accommodating six students per session. The antenatal clinic consists of two rooms: one for history-taking with desks and chairs, and a second with two areas—an examination bed and an ultrasound-equipped bed—accommodating up to three students at a time for practical training on real pregnant women.

Study sample

Participants were third-level midwifery students, male or female, who had not previously used VR technology for performing Leopold's Maneuvers or maternal physical assessment. Pregnant women with gestational age (GA) of 28–37 weeks were included. Exclusion criteria included students with prior clinical skills knowledge or experience outside the midwifery curriculum, pregnant women with GA below 28 weeks, multiple pregnancies, uncorrectable visual impairments, active vestibular disorders, and students missing scheduled training sessions.
Sample size was calculated using G*Power version 3.1.9.7 for a one-tailed t-test comparing two independent means. Assuming an effect size (d) of 0.79 based on previous findings by Oh and Kim [18], with $\alpha = 0.05$ and power $(1–\beta) = 0.90$, and equal allocation between groups (N2/N1 = 1), the required sample size was sixty participants, with 30 students in each group.

Sampling technique

To ensure fair representation of students from all areas of midwifery clinical training, a stratified random sampling approach was adopted. The total cohort of 120 students was divided into four specialty groups: antenatal care, high-risk pregnancies, labor and delivery, and postpartum care. From the antenatal training group, 60 students were selected proportionally, with fifteen students randomly chosen from each list of trainees.
Once selected, participants were randomly allocated into two equal groups: a study group (n = 30) and a control group (n = 30). Randomization was carried out using computer-generated numbers to reduce selection bias and ensure both groups had comparable baseline characteristics.
The study group first received theoretical instruction on antenatal maternal physical assessment and Leopold's Maneuvers, followed by hands-on practice using VR-assisted modules. The control group received the same theoretical content but practiced the skills through conventional methods, including instructor demonstrations and supervised re-practice. This design ensured that the theoretical material was consistent across groups while allowing the study to isolate the impact of the instructional method on clinical skill development.

Data Collection Tools

Five primary instruments were employed to gather data for this study:

Tool I: Self-administered questionnaire

This tool consisted of two sections:
• Section 1: Demographic Profile – Collected information on students' age, gender, residence, contact details, and prior experience with virtual reality.
• Section 2: Knowledge Assessment on Psychomotor Competence – Developed by the researcher following a comprehensive literature review, this section evaluated students' understanding of Leopold's Maneuvers and related maternal-fetal assessment concepts, including:

- The purpose of each maneuver is the grip.
- Key definitions (e.g., fetal lie, attitude, position, presentation).
- Maternal physical assessment indicators (e.g., Linea nigra, striae gravidarum).

The assessment included 12 multiple-choice questions (MCQs) with four options each. Scoring is assigned 1 point for each correct response (total score range 0–12), with ≤6 indicating unsatisfactory knowledge and >6 representing satisfactory knowledge [19]. This tool was used in both pre- and post-test evaluations and demonstrated good internal consistency (Cronbach's $\alpha = 0.78$).

Tool II: System usability scale (SUS)

Adapted from [8], the SUS is a standardized instrument for evaluating technology usability, including VR applications. It consists of 10 items: odd-numbered items are positively worded, while even-numbered items are negatively worded. Responses are rated on a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). Negatively worded items are reverse-scored, producing item scores ranging from 0 to 4. The sum of all items is multiplied by 2.5 to yield a total score between 0 and 100. Higher scores reflect better usability, with percentiles and letter grades ranging from F (failing) to A+ (superior performance). Reliability for this scale was high (Cronbach's $\alpha = 0.77$) [8].

Tool III: Leopold's maneuver checklist
Developed by obstetrics and gynecology experts, this 22-item checklist (CVI = 95%) evaluates students' clinical performance in Leopold's Maneuvers. Items are grouped into three stages: preparation (1–6), execution (7–18), and post-procedure activities (19–22). Each item is scored as 0 (incorrect/not performed), 1 (partially correct), or 2 (correct and complete in proper sequence). Total scores range from 0 to 44, categorized as unsatisfactory (0–14), competent (15–29), or proficient (30–44). The tool showed strong internal consistency (Cronbach's α = 0.83).

Tool IV: Antenatal maternal physical assessment checklist
This 19-item checklist, validated by an expert committee (CVI = 95%), assesses students' performance in maternal physical assessment. Items are organized into preparation (1–2), procedure execution (3–15), and post-procedure care (16–19). Each item is rated 0 (incorrect/not done), 1 (incomplete), or 2 (correct and complete), with a total score range of 0–38. Performance levels are classified as unsatisfactory (0–19), competent (20–28), or proficient (29–38). The tool demonstrated good reliability (Cronbach's α = 0.77).

Tool V: Student satisfaction questionnaire
Adapted from Saab *et al.* [8], this questionnaire assessed students' satisfaction with VR-based training. It included two items evaluating satisfaction with learning clinical midwifery scenarios via VR and overall experience, rated on a 5-point Likert scale (1 = extremely dissatisfied, 5 = extremely satisfied). Total scores ranged from 2 to 10, with higher scores reflecting greater satisfaction. Reliability was high (Cronbach's α = 0.88). An open-ended item allowed students to describe the procedure they most enjoyed practicing through VR-assisted learning.

Table

Tool	Purpose	Items	Validity	Reliability (α)	Scoring
Knowledge Assessment	Theoretical mastery	12 MCQ	CVI = 0.95*	0.78	0–12 (Cutoff: > 6)
Leopolds maneuver Checklist	Procedural skills	22 steps	CVI = 0.95*	0.83	0–44 (Competent: ≥15)
Maternal physical assessment Checklist	Procedural skills	19		0.77	0–38 Proficient ≥29
VR Satisfaction Scale	User acceptability	2 Likert	–	0.88	2–10 (Higher = better)

*Content Validity Index from expert panel in the field of maternity nursing

Ethical considerations
The study obtained ethical approval from the Research Ethics Committee of the Faculty of Nursing, Suez Canal University, in July 2024 (Approval No. 277/7/2024) and was conducted in accordance with the Declaration of Helsinki. The purpose, significance, and procedures of the study were clearly explained to all participants. Written informed consent was obtained from students who voluntarily agreed to participate, with assurances that their involvement posed no risk and that they could withdraw at any time without any academic or personal consequences. All collected data were anonymized using identification codes and securely stored to maintain confidentiality.

Data collection procedure
Following ethics approval, official permission was obtained from the Dean and Vice Dean for Education and Student Affairs at the Faculty of Nursing. Data collection took place between September 2024 and January 2025, following a structured four-phase protocol:
1. Preparation Phase – Study instruments were developed based on a thorough literature review and validated by three maternity nursing experts to ensure content accuracy and clinical relevance. The research team also completed standardized training in VR-assisted learning, including didactic sessions, hands-on simulation practice, and proficiency assessments for equipment operation. All instruments were pretested to confirm reliability before full implementation.
2. Baseline Assessment Phase – Eligible midwifery students were introduced to the study, including its objectives, significance, and voluntary nature. Students were given 24 hours to consider participation and could ask questions during Q&A sessions. Data were then collected through face-to-face interviews using Tools I–IV in a private clinical skills laboratory, with sessions lasting 45–60 minutes under consistent conditions.
3. Intervention Phase – All participants received standardized theoretical training covering Leopold's Maneuvers and antenatal physical assessment protocols through printed materials, checklists, and a 30-minute instructor-led orientation.
• VR-Assisted Learning (Study Group): Students participated in structured VR sessions using Shinecon VR headsets adapted for study purposes. After a 10-minute orientation on equipment use and hygiene precautions, students engaged in:

1. Immersive Learning – Viewing pre-loaded 3D VR modules demonstrating Leopold's Maneuvers and guided antenatal assessment procedures (10 minutes).
2. Hands-On Practice – Simultaneous practice on high-fidelity manikins under researcher supervision, ensuring procedural accuracy, strict 10-minute time management, and immediate evaluation of psychomotor skills using Tools III and IV, as well as knowledge post-testing (Tool I) and the VR Usability Survey (Tool II).

The VR modules used were commercially available products adapted for this study, designed to provide immersive 3D demonstrations compatible with mobile VR headsets, offering a cost-effective, interactive learning environment **(Figure 1)**.

Figure 1. Shinecon VR

Control group (Traditional training) implementation

During the standardized demonstration phase, instructors provided detailed demonstrations on high-fidelity mannequins, covering all four grips of Leopold's Maneuvers as well as the antenatal physical assessment procedure. Each procedure was demonstrated twice, accompanied by verbal explanations highlighting key anatomical landmarks, with the total duration matched to the VR group's 30-minute exposure.

For the practice session, participants performed supervised re-demonstrations, receiving immediate corrective feedback, following checklist-guided performance, and using the same manikin models as the VR group. Each procedure was limited to 10 minutes. Upon completion, psychomotor competence was evaluated using Tools III and IV, and students completed the knowledge post-test (Tool I), consisting of a 12-item MCQ administered electronically within a 15-minute time frame.

Evaluation and follow-Up phase

One week after the intervention, clinical competency was assessed at the antenatal outpatient clinic affiliated with Suez Canal University Hospital. Pregnant women (gestational age 28–32 weeks) provided consent prior to evaluation. Both study and control group students were observed performing the procedures using validated checklists, with each assessment lasting 10 minutes. Additionally, the study group completed the VR Satisfaction Survey (Tool V) privately after the clinical evaluation **(Figure 2)**.

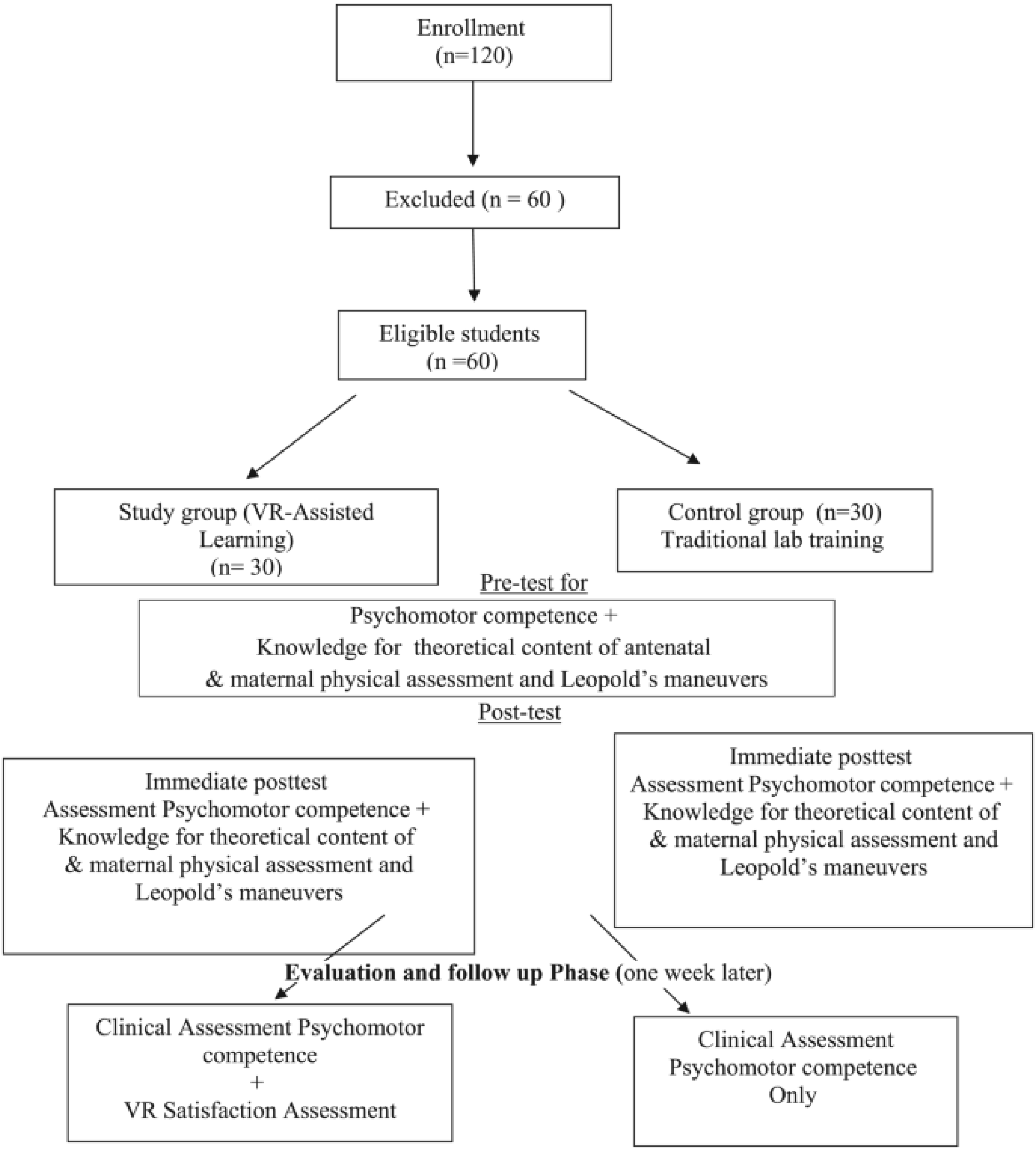

Figure 2. CONSORT

Statistical analysis

All data analyses were carried out using SPSS version 26 (IBM Corp.). Categorical variables, such as demographic characteristics, were summarized using frequencies and percentages. Differences in participants' prior VR experience were examined using cross-tabulations with the Chi-square (χ^2) test.

Continuous variables, including psychomotor competence scores, were presented as mean ± standard deviation (SD). Normality was assessed using the Shapiro-Wilk test, with p-values above 0.05 suggesting approximate normal distribution. Despite the modest sample size, no significant violations of normality were observed, allowing the use of parametric tests.

Within-group changes from pre- to post-intervention were evaluated using paired t-tests, while independent-samples t-tests were applied for comparisons between the study and control groups. Categorical data were analyzed via the Chi-square test. Statistical significance was set at $\alpha = 0.05$ (two-tailed), with $p < 0.01$ considered highly significant. All analyses were conducted with 95% confidence.

Results

Baseline characteristics of both groups are summarized in **Table 1**. The study and control groups were largely comparable, showing no statistically significant differences in age, gender, or prior VR exposure (all $p > 0.05$). The study group had a mean age of 20.9 ± 0.48 years, while the control group averaged 20.6 ± 0.55 years (p =

0.06). Females comprised the majority in both groups, with gender distribution not differing significantly (p = 0.27). Regarding VR experience, 86.7 percent of students in the study group and 60 percent in the control group reported no prior exposure, with this difference also not reaching statistical significance (p = 0.13).

Table 1. Demographic characteristics of the study samples (N = 60, 30 each)

Characteristics	Study group		Control group		X2	P
	N	%	N	%		
Age						
20 year	5	16.7	12	40.0	4.1	0.12
21 year	23	76.7	17	56.7		
22 year	2	6.7	1	3.3		
Mean ± SD	20.9 ± 0.48		20.6 ± 0.55		t = 1.9	0.06
Gender						
Male	3	10.0	6	20.0	1.1	0.27
Female	27	90.0	24	80.0		
Previous experience with virtual reality						
None	26	86.7	18	60.0	5.5	0.13
used once	1	3.3	4	13.3		
used several times	2	6.7	5	16.7		
used a lot	1	3.3	3	10.0		

No significant at $p > 0.05$. *Significant at $p < 0.05$. **highly significant at $p < 0.01$
Power = 95% Alpha level = 0.05

This figure illustrates the distribution of knowledge regarding maternal physical assessment and Leopold's maneuvers in both the study and control groups. During the pre-test, the majority of participants showed limited theoretical understanding, with 91 percent of the study group and 92 percent of the control group scoring at an unsatisfactory level. After the intervention, 97 percent of the study group achieved satisfactory knowledge, compared to 85 percent in the control group. While these results indicate an improvement in theoretical comprehension among the VR-trained students, the difference between groups was not statistically significant (p = 0.35), as depicted in **Figure 3**. It should be emphasized that this assessment pertains solely to theoretical knowledge and is separate from the psychomotor competence evaluations described below, which measure actual clinical skill performance.

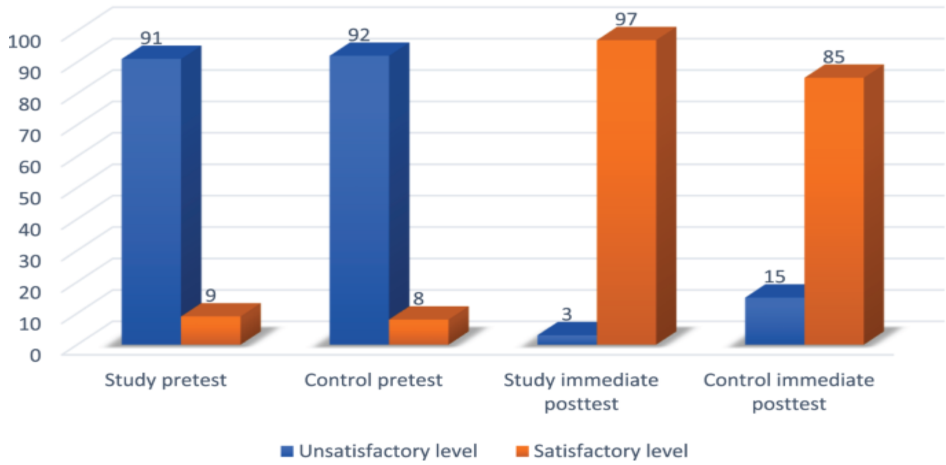

Figure 3. Knowledge levels of both groups at pre-test and immediate post-test across study phases

Table 2 displays the outcomes of psychomotor competence for Leopold's maneuvers at 2 time points. Students in the VR-assisted study group scored substantially higher, with mean values of 43.13 ± 1.46 immediately after the intervention and 42.6 ± 3.82 at the follow-up assessment, compared to the control group's scores of 36.53 ± 2.29 and 32.77 ± 4.28, respectively. These differences were statistically significant (p = 0.000), and the calculated effect sizes (3.6 for immediate post-test, 2.5 for follow-up) indicate a pronounced and lasting improvement among students who received VR training.

In a similar pattern, the study group outperformed the control group in maternal physical assessment. The VR-trained students achieved mean scores of 36.33 ± 1.81 immediately post-intervention and 37.6 ± 0.67 at follow-up, whereas the control group recorded 30.13 ± 3.98 and 27.3 ± 3.96, respectively. The differences were again highly significant (p = 0.000), with effect sizes ranging from moderate to very large (2.2 immediate post-test, 4.4 follow-up), reflecting meaningful skill acquisition and retention over time in the VR group.

Table 2. Scores of both groups at study phases in relation to psychomotor competence

Psychomotor Competence	Pre – test				Immediate Post - test				Follow up post – test			
	Study group		Control group		Study group		Control group		Study group		Control group	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Leopold's maneuver	11.77	3.20	3.27	2.73	43.13	1.46	36.53	2.29	42.6	3.82	32.77	4.28
Effect size	1.5				3.6				2.5			
	t = 1.62 *P* = 0.11 CI = 6.96 to 10.04				t = 5.309 p = 0.000* CI = 5.61 to 7.59				t = 9.385 *P* = 0.000* CI = 7.73 to 11.93			
Maternal physical assessment	9.03	2.18	3.97	2.94	36.33	1.81	30.13	3.98	37.6	0.67	27.3	3.96
Effect size	0.9				2.2				4.4			
	t = 0.80 *P* = 0.07* CI = 3.72 to 6.40				t = 6.66 *P* = 0.000* CI = 4.60 to 7.80				t = 13.7 *P* = 0.000* CI = 8.83 to 11.77			

No significant at $p > 0.05$. *Significant at $p < 0.05$. **highly significant at $p < 0.01$
Power = 95% Alpha level = 0.05

Figure 4 depicts the distribution of performance levels in Leopold's Maneuvers for both the study and control groups across the pre-test, immediate post-test, and follow-up assessments. At the initial assessment, the majority of students in both groups exhibited unsatisfactory performance (86.7 percent in the research group versus 83.3 percent in the control group), with no significant difference observed between them (p = 0.93). Following the intervention, 80 percent of students in the VR-assisted study group achieved a proficient level, compared to 46.7 percent in the control group, reflecting a statistically significant improvement (p = 0.001). By the one-week follow-up, proficiency in the study group increased to 93.3%, while the control group reached 60%, indicating a sustained and significant advantage for the VR-trained students (p = 0.001).

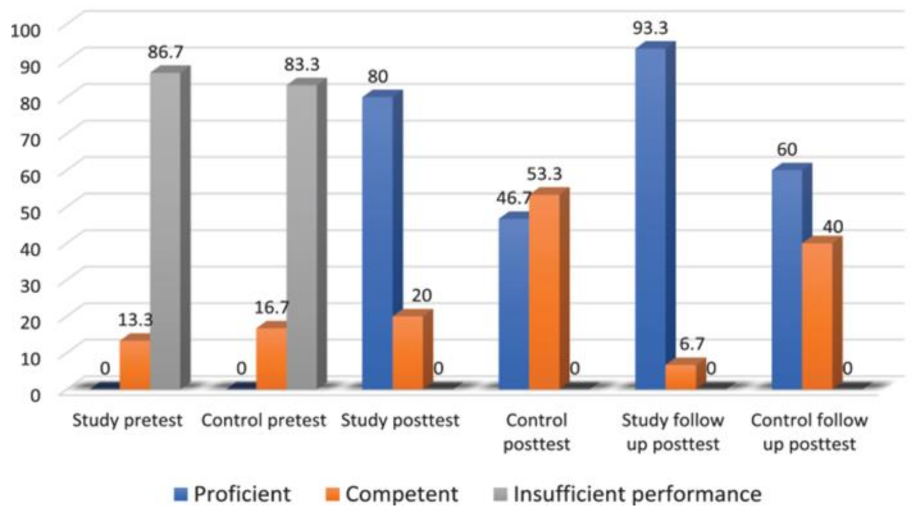

Figure 4. Levels of performance in specific psychomotor skills (Leopold's maneuver) across the different phases of the study

Figure 5 shows how students performed in maternal physical assessment across the pre-test, immediate post-test, and follow-up periods for both study and control groups. Initially, performance was poor in both groups, with no significant difference (p = 1.0). After the intervention, 90 percent of the study group, trained using virtual reality, reached a proficient level, whereas only 46.7 percent of the control group, trained via conventional manikin simulation, did so, revealing a statistically significant difference (p = 0.001). At the one-week follow-up, proficiency was maintained by all study group students (100%), while 60 percent of the control group achieved the same, again showing a significant difference between the groups (p = 0.001).

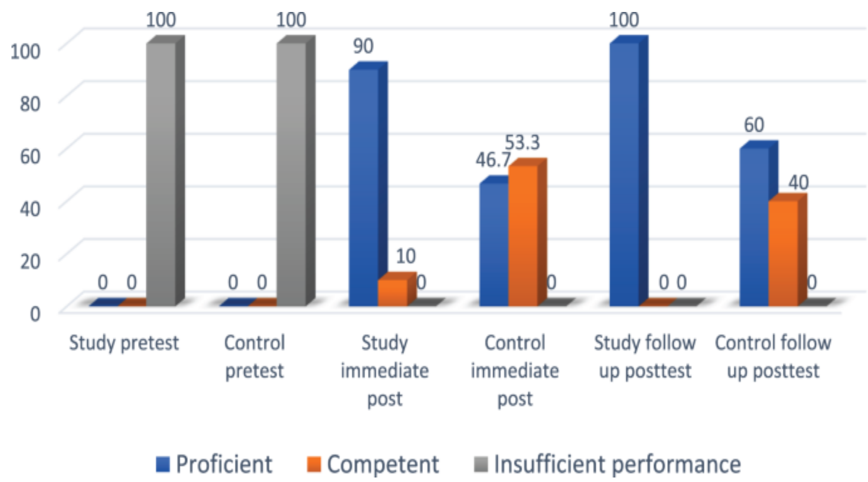

Figure 5. Levels of psychomotor performance (maternal physical assessment) throughout the study phases

Table 3 Results from the System Usability Scale (SUS) highlighted that students responded very positively to Virtual Reality-Assisted Learning (VRAL). Nearly all participants (96.7 percent) expressed enthusiasm for regular use, showing strong engagement. Most students (86.7%) felt the system was not overly complicated, and every participant (100%) found it intuitive and easy to learn. A large majority (93.3%) reported no need for external help to operate the VR setup, while 80% considered its functions well-coordinated. Additionally, 93.3% indicated the system was consistent, and 86.7% disagreed that it was cumbersome. Confidence with the VRAL was high, with 90% feeling self-assured in using it. However, only 40% believed that no prior knowledge was necessary, suggesting some students still perceived a slight preparatory requirement before starting.

Table 3. System Usability Scale (SUS) results for the study group (n = 30)

Items	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I would like to use VR simulation frequently	1 (3.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	29 (96.7%)
I found VR simulation unnecessarily complex	26 (86.7%)	4 (13.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
I found VR simulation easy to use	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100.0%)
I think I would need help to use VR simulation	28 (93.3%)	2 (6.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
The VR simulation functions were well integrated	0 (0.0%)	0 (0.0%)	0 (0.0%)	6 (20.0%)	24 (80.0%)
I found VR simulation inconsistent	28 (93.3%)	1 (3.3%)	1 (3.3%)	0 (0.0%)	0 (0.0%)
Most people would learn to use VR simulation quickly	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	30 (100.0%)
I found VR simulation cumbersome or awkward	26 (86.7%)	0 (0.0%)	3 (10.0%)	0 (0.0%)	1 (3.3%)
I felt confident using VR simulation	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (10.0%)	27 (90.0%)
I needed to learn a lot before using VR simulation	0 (0.0%)	12 (40.0%)	11 (36.7%)	6 (20.0%)	1 (3.3%)

No significant at $p > 0.05$. *Significant at $p < 0.05$. ** Highly significant at $p < 0.01$

Figure 6 presents the system usability ratings for the VR group. The data indicate that most participants (97%) achieved a grade A, reflecting superior performance, whereas only 3% attained a grade C, corresponding to average performance, following the use of virtual reality-assisted learning with VR glasses to develop psychomotor skills in abdominal maneuvers and maternal assessments.

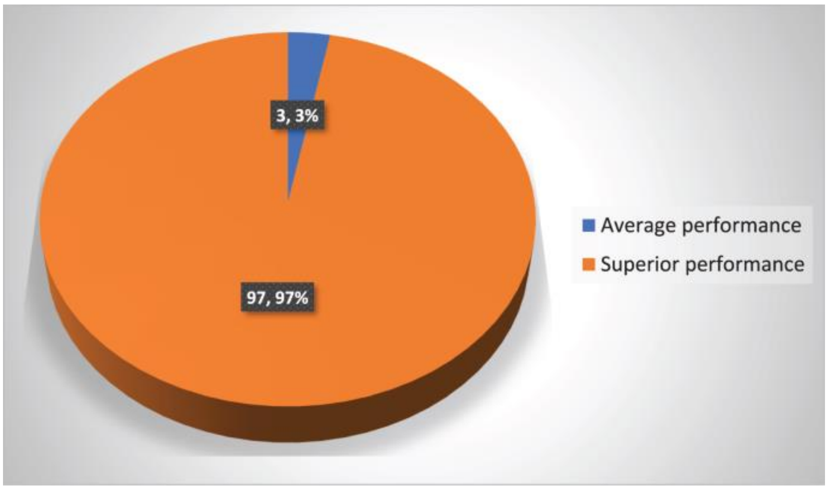

Figure 6. Overall system usability scores for the study group using VR-assisted learning (n = 30)

The distribution of satisfaction among the VR group regarding VR-assisted learning is presented in Table 4. Most participants (63.3 percent) reported being "Extremely satisfied" with the VR learning experience related to nursing and midwifery clinical scenarios. A smaller segment of the group (20%) expressed a neutral stance, while 16.7% indicated they were "Somewhat satisfied." Regarding their overall experience in the research, the majority of students (66.7 percent) were "Extremely satisfied," and 23.3% were "Somewhat satisfied," highlighting a highly favorable response to the VR-assisted learning program.

Table 4. Satisfaction levels of the study group towards VR simulation (n = 30)

Satisfaction Levels	Extremely Dissatisfied	Somewhat Dissatisfied	Neutral	Somewhat Satisfied	Extremely Satisfied
Using VR simulation to learn nursing/midwifery clinical scenarios	0 (0.0%)	0 (0.0%)	6 (20.0%)	5 (16.7%)	19 (63.3%)
Overall experience participating in the study	0 (0.0%)	0 (0.0%)	3 (10.0%)	7 (23.3%)	20 (66.7%)

Figure 7 illustrates that 76.6% of midwifery nursing students found performing Leopold's maneuver using virtual reality-assisted learning enjoyable, whereas 23.4% reported enjoying maternal physical assessment with virtual reality.

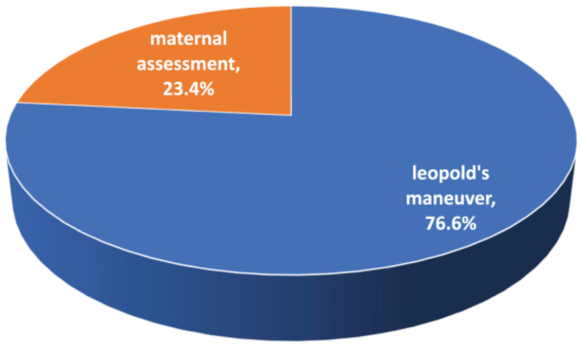

Figure 7. Proportion of study group participants (n = 30) identifying the most enjoyable aspects of VR simulation in developing psychomotor skills

Discussion

Virtual reality (VR) allows nursing students to immerse themselves completely in a simulated environment, offering a more realistic and engaging teaching method compared to conventional approaches. This method not only enhances students' psychomotor skills but also provides immediate feedback, supports constructive learning, and boosts their confidence without endangering pregnant women [20]. Consequently, various training strategies, including video-based VR simulations, have emerged in recent years to address evolving educational needs [21]. VR is increasingly considered a substitute for mannequin-based simulation, as it positively influences nursing students' knowledge, self-efficacy, communication skills, and clinical performance [22]. Therefore, this study aimed to assess the impact of integrating VR-assisted learning on improving psychomotor competence among midwifery nursing students.

Regarding the demographic characteristics of participants, no statistically significant differences were found between the study and control groups, supporting the consistency of the findings. This aligns with the results of [23], which also reported no significant socio-demographic differences between experimental and control groups, indicating sample homogeneity.

In terms of prior VR experience, most midwifery nursing students in the study had previous exposure to VR through VR goggles. This is likely because VR is an emerging technology, and many nursing students have already interacted with it. This finding is consistent with Bai & Manomozhi [24], who noted that the majority of students had prior experience using VR goggles. From the researcher's perspective, this familiarity may reflect the current generation's adaptation to artificial intelligence technologies.

Concerning the knowledge assessment of Leopold's maneuver, results showed that in the pre-test phase, most students in both study and control groups demonstrated low knowledge levels regarding the selected procedures. However, immediately following the training program, the majority of students exhibited a high level of knowledge. These findings are consistent with [25], which reported significant improvements in maternity nurses' CPR knowledge across pre-, post-, and follow-up evaluations ($p = 0.000$ for all items). Similarly, [26] observed a highly significant increase ($p < 0.001$) in knowledge scores related to cardiac arrest management during pregnancy after the intervention.

Regarding performance in Leopold's maneuver and antenatal maternal physical assessment, both groups showed inadequate performance in the pre-test phase (86.7% & 83.3%). Following the post-test, 80% of the study group and only 46.7% of the control group achieved satisfactory performance two weeks after completing the clinical training program. Students in the study group, who trained using VR glasses, demonstrated proficient performance in conducting Leopold's maneuver on pregnant women during follow-up assessments at the antenatal clinic. In contrast, the control group, trained with traditional manikin simulation in the laboratory, showed lower proficiency. Although traditional methods involve instructor demonstrations followed by student re-demonstration, this approach appears insufficient for fully meeting students' learning needs or ensuring skill retention. A significant difference was observed between the groups in performance related to Leopold's maneuver and antenatal maternal physical assessment.

Although knowledge scores did not differ significantly between the VR and control groups immediately after the intervention ($p = 0.35$), students trained with VR showed marked improvement in practical skills, especially in performing Leopold's maneuver and maternal physical assessment. This suggests that VR may be more effective in fostering hands-on skill development than in enhancing theoretical understanding. This observation is supported by systematic reviews indicating that VR substantially improves clinical performance (effect size $g = 0.682$), whereas its influence on knowledge acquisition is comparatively modest (effect size ≈ 0.237) [27].

The gains in performance may be attributed to the engaging nature of VR-based training, which captures student attention more effectively than conventional demonstration and re-demonstration methods. VR also allows repeated practice of clinical procedures without overwhelming students or inducing disinterest in traditional, often monotonous, teaching methods.

These findings are aligned with [23], who reported no immediate differences between experimental and control groups in teaching satisfaction ($p = 0.115$) or CPR performance ($p = 0.451$ for chest compressions; $p = 0.378$ for airway management). Nevertheless, at both immediate and one-month follow-up assessments, the VR-trained group achieved significantly better outcomes in CPR performance, including chest compressions ($p < 0.001$), airway management ($p < 0.001$), and overall teaching satisfaction ($p < 0.001$). Similarly, [28] found that VR instruction effectively delivered CPR skills in an engaging manner without reducing competency. Lee [22] also demonstrated that VR-based IV injection training led to higher clinical performance than traditional IV arm simulator training, and [29] similarly observed skill improvements through simulation methods. However, these results contrast with Chao *et al.* [30], who reported no significant differences in nursing students' procedural skills between 3D VR-based simulations and traditional simulation methods.

While the current study indicates that VR can significantly enhance midwifery students' practical performance in Leopold's maneuver and maternal physical assessment, broader evidence suggests that VR's benefits for procedural skill acquisition may be limited. For example, a meta-analysis by Kim *et al.* [31] comparing virtual simulations with traditional methods (manikins or real patients) found no overall advantage in procedural skill development ($SMD = -0.12$; 95% CI -0.47 to 0.23). Interestingly, nursing students in the VR subgroup showed smaller gains than those trained with conventional methods ($SMD = -0.55$; 95% CI -1.07 to -0.03; $p = 0.04$). This indicates that VR's primary value may lie in increasing motivation, engagement, and confidence rather than directly improving skill performance. Additionally, the novelty of VR might temporarily enhance performance due to heightened attention (Hawthorne effect), rather than reflecting a true instructional advantage. Consequently, VR should be applied as a complementary tool alongside established teaching methods to ensure sustained skill development, particularly for high-stakes clinical procedures like Leopold's maneuver.

These findings collectively highlight the considerable advantages of integrating virtual reality (VR) technologies to enhance midwifery nursing students' performance. VR provides an engaging learning environment that allows students to practice skills safely and enjoyably without fear of making errors. From the researcher's perspective, VR is essential for bringing students closer to real clinical settings, thereby offering meaningful improvements in clinical skill acquisition.

While the study demonstrates superior performance in Leopold's maneuver among VR-trained students, broader considerations must be addressed when adopting VR in diverse educational contexts, particularly regarding accessibility, scalability, and cost. Implementing VR in rural or underfunded schools presents substantial challenges. The high upfront costs for VR hardware and software development—often tens of thousands of dollars—can make it unattainable for many institutions. Even when VR equipment is available, supporting large student cohorts is difficult due to hardware constraints and the need for reliable high-speed internet, which many schools, especially in underserved regions, lack. Additionally, schools face ongoing challenges with limited technical support and the necessity of staff training to manage and maintain VR platforms effectively. Although solutions such as public–private partnerships, subsidies, and shared purchasing initiatives have been proposed to alleviate these barriers, successful integration requires careful planning, policy backing, and long-term commitment [32]. From the researcher's perspective, while VR shows clear promise, its sustainable implementation across varied educational settings demands addressing these structural, financial, and technical limitations.

Regarding student satisfaction with VR simulation, the majority of participants reported being "Extremely satisfied" with VR-based learning in midwifery clinical scenarios. More than three-quarters of students particularly enjoyed performing Leopold's maneuver using VR, while roughly one-quarter favored maternal physical assessment. This demonstrates a highly positive reception of VR as a teaching tool.

This high satisfaction may be explained by the limitations of traditional teaching methods, which can easily distract students and often result in knowledge retention loss. In contrast, VR encourages active engagement and interaction, which may strengthen long-term memory and create deeper learning impressions. These results are consistent with [23], who reported no significant difference in satisfaction between groups before the intervention ($p = 0.115$), but significant differences were observed both immediately and one month after the intervention ($p < 0.001$). Similarly, Bai & Manomozhi [24] found that most students expressed satisfaction following VR-based training, and [33] reported higher post-intervention satisfaction scores in VR groups compared to controls. Chang *et al.* [34] also confirmed that VR simulation enhances nursing students' satisfaction after completing training programs. From the researcher's perspective, the individual use of VR glasses likely contributed to increased self-confidence and satisfaction among midwifery nursing students.

Conversely, the findings of this study differ from [35], which reported no significant difference in satisfaction between nursing students trained via VR and those using traditional skills practice. From the researcher's perspective, VR may cause cybersickness—manifesting as nausea, dizziness, or headaches—which can negatively impact user satisfaction. Therefore, future research should examine potential adverse effects of VR, including visual strain and cognitive disorientation. Nevertheless, the current results highlight the important role of virtual reality-assisted learning in improving psychomotor performance among midwifery nursing students. Considering the consistently high levels of satisfaction reported in various studies, VR technology should be considered for integration into practical training across multiple nursing fields to enhance overall performance.

Recent literature also suggests that the benefits of VR extend beyond its immersive qualities, emphasizing the importance of instructional design features such as safe repetition, experimentation, and immediate feedback [36, 37]. VR provides a psychologically safe environment where students can repeatedly practice complex procedures, like Leopold's maneuver, without the risk of harming patients. Real-time feedback further supports the development of clinical competence. Thus, while the immersive nature of VR may boost engagement and motivation, sustainable learning outcomes are likely driven by active learning principles—including deliberate practice, feedback loops, and reflective practice—which are crucial in midwifery education for building both skills and confidence.

Limitations

This study has several limitations:

- The follow-up period was limited to one week post-intervention, restricting assessment of long-term skill retention; extended follow-up studies are needed to evaluate the durability of learning.
- Despite high success rates in some measures (e.g., 97%), the small sample size and recruitment from a single university limit the generalizability of the findings. Additionally, VR-related issues such as motion-induced cybersickness may have influenced learning outcomes.

• Assessment bias may have occurred because evaluators were not blinded to group allocation, potentially affecting subjective performance evaluations.
• Researchers administering the VR intervention underwent extensive technical training, making blinding to treatment allocation impossible.
• Prior VR experience was self-reported, introducing potential recall bias that may have affected accuracy.
• Similar limitations, including small sample sizes, single-center designs, and short follow-up, have been noted in other VR-based studies in nursing and medical education, highlighting the need for larger, multi-center trials with long-term evaluation [36, 37].
Despite these limitations, this study provides valuable insight into the potential of VR in midwifery education and serves as a foundation for future research using more robust methodologies and larger, diverse populations.

Conclusion

The study concluded that midwifery nursing students who participated in virtual reality-assisted training demonstrated superior psychomotor competence, improved performance, and higher satisfaction compared to those trained using traditional simulation methods. Although the VR group achieved higher knowledge scores, the difference was not statistically significant.

Recommendations

Based on the outcomes of this study, the following recommendations are suggested for the integration of VR in midwifery nursing education:
1. Combine VR with Traditional Training: Use Virtual Reality-Assisted Learning (VRAL) as a supplement to conventional manikin-based simulation. While VR offers immersive scenario-based practice that enhances decision-making and clinical reasoning, hands-on skills such as palpation and physical assessment are best developed through traditional simulation. A hybrid model allows students to gain the benefits of both approaches while catering to varied learning preferences.
2. Schedule Regular VR Sessions: Students should participate in multiple structured VR sessions—ideally three to five—distributed throughout the clinical training period. Weekly sessions are recommended to reinforce learning, allow reflection, and promote retention of both psychomotor and cognitive skills.
3. Incorporate Immediate Feedback: Each VR session should be followed by a guided debriefing and feedback from trained instructors. This immediate, formative feedback is crucial for correcting errors, reinforcing proper techniques, and increasing student confidence.
4. Provide Faculty Training: Educators should undergo focused hands-on workshops (2–3 days) before using VR in teaching. Training should include operating VR equipment, integrating VR into existing curricula, troubleshooting technical issues, and interpreting performance data. Collaborations with VR developers or simulation centers can enhance instructor readiness.
5. Pilot VR Before Full Implementation: Begin with a pilot phase to identify practical challenges, technical limitations, and student responses. This allows for adjustments tailored to the institution's resources and ensures smoother full-scale integration.
6. Align VR with Learning Goals: VR activities should be purposefully designed to meet clear educational objectives linked to course competencies and national standards. The use of VR should go beyond engagement, focusing on measurable improvements in clinical skills and decision-making.
7. Support Ongoing Research: Further studies on a larger scale are recommended to evaluate the long-term impact of VRAL on clinical competence and patient outcomes in actual healthcare settings, ensuring evidence-based adoption of the technology.

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