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The Effect of Virtual Simulation Software on Nursing Students' Academic Performance and Engagement

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Abstract

Purpose: This study aimed to achieve three core objectives: (a) to assess how Virtual Simulation Software (VSS) affects nursing students' theoretical knowledge and skill performance relative to traditional methods; (b) to evaluate how perceptions of VSS usefulness and ease of use shape intention to use it; and (c) to investigate how this intention influences learning engagement. **Research design, data and methodology:** A quasi-experimental pre-test/post-test control group design was adopted with a follow-up survey. Two classes of 40 second-year nursing students from a Chinese vocational college were divided into an experimental group using VSS and a control group with traditional training for ten weeks. Academic performance was measured through knowledge and skills tests, and student engagement and technology acceptance were evaluated via surveys. Data were analyzed using independent t-tests and Simple linear regression. **Results:** The results showed statistically significant improvements ($p < 0.001$) in theoretical knowledge and skill performance from pre-test to post-test in both the experimental and control groups. Regression analysis indicated that both perceived usefulness and ease of use of VSS positively influenced students' intention to use it, with perceived usefulness being a stronger predictor. **Conclusions:** These findings suggest that integrating VSS into nursing curricula can enhance student engagement and performance, validating VSS as a valuable addition to traditional training and providing practical insights for educators to improve nursing education quality.

Keywords: Virtual Simulation, Nursing Students, Academic Performance

JEL Classification Code: I21, I23, O33, L67, C93

1. Introduction

Nursing education has long faced the challenge of bridging the gap between theoretical learning and practical skill application. Traditional teaching methods, which rely heavily on lectures and limited hands-on clinical training, often restrict students' development of essential clinical competencies. Compounding this issue are limited access to clinical placements, ethical concerns in patient care training, and inconsistent real-world experiences—all of which further hinder skill acquisition and leave students unprepared for professional practice.

Against this backdrop, Virtual Simulation Software (VSS) has emerged as a potential solution. By offering interactive, risk-free clinical training, VSS is expected to enhance learning engagement and academic performance. However, despite its growing use in nursing education, there remains a lack of sufficient empirical research on its specific influence: existing studies rarely explore its comprehensive impact on nursing students' theoretical knowledge and skill performance simultaneously, and there is limited insight into how students' perceptions of VSS (ease of use and usefulness) shape their intention to adopt it, as well as how this intention affects multi-dimensional learning engagement (behavioral, emotional, and cognitive). Additionally, while VSS has been studied in other fields,

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systematic research on its application in nursing education—especially regarding its role in promoting evidence-based nursing practices—remains insufficient. These gaps limit the evidence-based integration of VSS into nursing curricula, creating a need for targeted investigation.

To address these gaps, this study adopts a quasi-experimental design with three core research objectives: (1) To determine the influence of VSS on nursing students' theoretical knowledge and skill performance compared to traditional methods; (2) To determine how nursing students' perceptions of ease of use and usefulness influence their intention to use VSS; (3) To determine how nursing students' intention to use VSS influences their learning engagement.

The significance of this study lies in its ability to address the limitations of traditional nursing education methods by integrating VSS with experiential learning theory, evidence-based nursing practice, and the Technology Acceptance Model (TAM). It empirically verifies the effectiveness of incorporating VSS into nursing education, providing a strong evidence base for future educational technology applications. The research outcomes will offer valuable insights and practical guidance to educators, curriculum designers, and researchers seeking to enhance nursing students' learning engagement and academic performance through effective VSS implementation. Furthermore, the study fills existing research gaps by clarifying VSS's positive influence on multi-dimensional student engagement and students' perceptions of VSS's usefulness and ease of use, thereby promoting the sustained adoption of VSS in nursing education contexts.

2. Literature Review

2.1Virtual Simulation Software (VSS) in Nursing Education

Virtual Simulation Software (VSS) refers to computer-based technologies designed to replicate real-world clinical scenarios in a virtual, immersive environment, allowing students to engage actively in interactive learning experiences (Cant & Cooper, 2014). VSS integrates advanced technologies, including 3D modeling, artificial intelligence (AI), virtual reality (VR), and multimedia components, to realistically simulate clinical environments. It enables nursing students to repeatedly practice clinical skills, decision-making, and critical thinking in a risk-free context, overcoming challenges such as time constraints, limited patient access, and patient safety concerns associated with traditional clinical training (Cook et al., 2011). Therefore, VSS has increasingly been recognized as a valuable educational tool, significantly enhancing the effectiveness and accessibility of nursing education (Foronda et al., 2018).

Virtual Simulation Software (VSS) offers four key advantages compared to traditional teaching approaches: it ensures safety by enabling risk-free practice in virtual environments, eliminating potential harm to real patients; provides flexibility through accessible anytime-anywhere learning adaptable to individual student needs; allows repeatability of skills and scenarios to reinforce learning outcomes; and demonstrates cost-effectiveness by reducing dependence on physical equipment, clinical spaces, and patient resources, thereby lowering long-term educational expenses.

Previous research consistently indicates that VSS significantly enhances multiple dimensions of nursing education. It improves knowledge acquisition and retention through interactive and contextualized learning; develops skills proficiency in critical clinical procedures such as intravenous catheterization and wound management (Foronda et al., 2016); increases confidence while reducing anxiety, thereby strengthening clinical readiness during transition to real settings and promotes engagement by motivating students and encouraging active participation (Foronda et al., 2018).

2.2 Theoretical Knowledge (TK) and VSS

Theoretical Knowledge (TK) in nursing constitutes the foundational theories and systematic understanding underpinning clinical procedures, pathological mechanisms, and nursing principles, serving as the scientific basis for professional practice. Research demonstrates that Virtual Simulation Software (VSS) significantly enhances knowledge acquisition, proving more effective than traditional classroom or lecture-based approaches in promoting mastery of theoretical content. This is substantiated by pre- and post-test comparisons, which consistently show measurable improvements in students' theoretical understanding following VSS-based training.

The educational efficacy of VSS is supported by established theoretical frameworks. Kolb's (2014) Experiential Learning Theory emphasizes that meaningful learning arises through active engagement and reflective practice. VSS aligns with this principle by providing an interactive platform where students apply theoretical concepts, conduct critical reflection, and develop practical competencies within simulated clinical contexts. Furthermore, Evidence-Based Practice (EBP), reinforced through VSS by enabling students to exercise evidence-informed clinical decision-making in a controlled environment, thereby bridging theoretical knowledge with research-grounded practice.

H1 Virtual Simulation Software (VSS) significantly improves nursing students' Theoretical Knowledge (TK) compared to the control group.

H2 Virtual Simulation Software (VSS) significantly improves nursing students' Theoretical Knowledge (TK) compared to the pre-test

2.3 Skill Performance (SP) and VSS

Skill Performance (SP) refers to the practical application of clinical procedures in nursing practice, including psychomotor skill proficiency, operational standardization, and the rationality and timeliness of clinical decision-making (Bland et al., 2011).

As a skill training tool, research demonstrates that students trained with VSS show significantly better operational performance compared to those receiving only traditional training (Padilha et al., 2019). Additionally, the same group of students exhibits marked improvement in skill assessment scores following VSS intervention (Foronda et al., 2016).

The effectiveness of VSS in skill development is supported by established learning theories. Situated Learning Theory emphasizes that learning should occur in authentic contexts, and VSS promotes skill transfer to real-world settings through highly simulated clinical environments). Furthermore, Simulation Training Principles help students develop muscle memory and automated responses through high-fidelity and repeatable simulated operations, thereby enhancing execution efficiency and stress resistance in clinical practice (Cook et al., 2011; Foronda et al., 2018).

H3 Virtual Simulation Software (VSS) significantly improves nursing students' Skill Performance (SP) compared to the control group

H4 Virtual Simulation Software (VSS) significantly improves nursing students' Skill Performance (SP) compared to the pre-test.

2.4 Perceived Ease of Use (PEOU) and Perceived Usefulness (PU)

The Technology Acceptance Model (TAM), developed by Davis (1989), identifies PEOU and PU as key factors influencing technology adoption. In healthcare education, studies show that PEOU positively influences PU (H5). For nursing education, intuitive design and ease of navigation in Virtual Simulation Software (VSS) increase perceived usefulness by reducing cognitive load and enhancing usability (Foronda et al., 2018).

H5 Nursing students' Perceived Ease of Use (PEOU) significantly influences their Perceived Usefulness (PU) toward Virtual Simulation Software (VSS).

2.5 Perceived Usefulness (PU) and Intention to Use (ITU)

According to TAM, PU directly strengthens ITU (H6), supported by empirical studies in e-learning and simulation. Evidence from nursing education confirms that higher PU correlates with greater willingness to adopt simulation tools (Padilha et al., 2019).

H6 Nursing students' Perceived Usefulness (PU) significantly influences their Intention to Use (ITU) Virtual Simulation Software (VSS).

2.6 Perceived Ease of Use (PEOU) and Intention to Use (ITU)

TAM posits that PEOU not only affects PU but also directly increases ITU (H7). Research shows that user-friendly systems elevate adoption likelihood (Cook et al., 2011). In nursing education, students' technical comfort with VSS reduces barriers to use (Aebersold & Tschannen, 2013).

H7 Nursing students' Perceived Ease of Use (PEOU) significantly influences their Intention to Use (ITU) Virtual Simulation Software (VSS).

2.7 Intention to Use (ITU) and Engagement

Engagement encompasses cognitive, emotional, and behavioral involvement in learning. Strong ITU predicts higher motivation and active participation in VSS-based activities (H8). Empirical studies link ITU to actual usage, which promotes deeper engagement in simulated learning environments (Aebersold & Tschannen, 2013).

H8 Nursing students' Intention to Use (ITU) significantly influences their Engagement with Virtual Simulation Software (VSS).

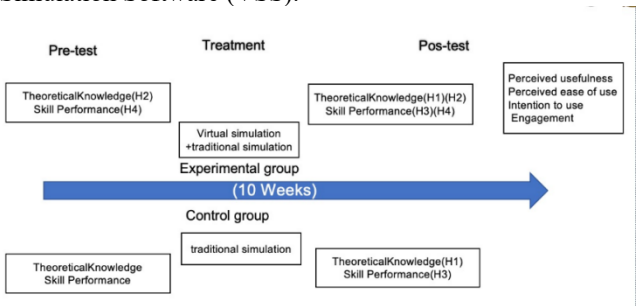

Figure 1: The Research Framework of this article.

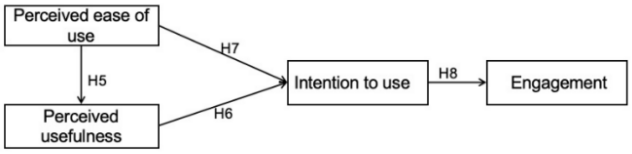

Figure 2: Simple Linear Regression Model

3. Research Methods and Materials

3.1 Research Design

This study consists of two phases:

Phase 1: One class was selected as the control group, while the remaining classes were designated as the experimental group. During the experiment, an additional class was randomly selected to participate in the quasi-experiment.

Phase 2: After the experiment concluded, a survey was conducted among all experimental group classes that had used the technology to gather further insights , aiming to promote the adoption of the technology.

Data collection follows a pre-test-post-test structure. Before the intervention, baseline assessments of theoretical knowledge, skill performance, and engagement are conducted in both groups. After the 10-week intervention, post-tests measure these variables again, along with additional assessments of Technology Acceptance Model (TAM) variables—Perceived Ease of Use (PEOU), Perceived Usefulness (PU), and Intention to Use (ITU)—within the experimental group. The comparative analysis between groups enables the evaluation of VSS's effectiveness in improving students' academic outcomes and technology acceptance.

3.2 Research Treatment

Week 1: Train students on virtual simulation technology, explain relevant evidence-based nursing practices and TAM theory, and conduct the pre-test to assess their initial abilities and technology perceptions.

Weeks 2-9: Follow the weekly plan to gradually enhance students' engagement, evidence-based nursing skills, and technology acceptance through scenario-based exercises, guided reflections, and feedback collection.

Week 10: Conduct the post-test to evaluate students' academic performance, compare it with pre-test data, analyze the overall effectiveness of the intervention, and summarize the course outcomes.

3.3 Population and Sample

The target population comprises approximately 1,200 second-year nursing students at Liaoyang Vocational College of Technology, representing higher vocational nursing education to assess Virtual Simulation Software (VSS) impacts. Purposive sampling was used to select students with diverse academic levels and backgrounds, ensuring sample representativeness, with each class containing 40 students and t-tests applied to detect group differences. Simple linear regression (SLR) analyzes relationships between engagement (dependent variable) and technology acceptance constructs (independent variables: perceived ease of use, usefulness, intention to use) to quantify their influence on learning outcomes.

This study employed Nursing Licensing Examination (NLE) scores as a core variable for assessing nursing students' academic performance. The NLE is a nationally standardized examination administered by the Chinese government to evaluate candidates' theoretical knowledge and clinical competencies required for nursing practice.To evaluate clinical skills, this study adopts the Objective Structured Clinical Examination (OSCE), a globally recognized assessment method for competency-based evaluations.

The second instrument was a structured questionnaire to collect data on nursing students' engagement and technology acceptance regarding Virtual Simulation Software (VSS).

This study utilized G*Power software to determine the required sample size. A power analysis for simple linear regression was conducted using F-tests under the fixed model (R^2 deviation from zero) with the following parameters: significance level (α) = 0.05, statistical power (1 - β) = 0.90, and number of predictors = 3. **G*Power calculated a minimum required sample size of 99 participants**. Following the experiment, a survey was conducted among the experimental group and five additional classes, bringing the total number of participants to 185, far exceeding the required sample size.

3.4 Sampling Techniques

This study employed purposive sampling, a non-probability sampling method, to select participants based on predefined characteristics (Padilha et al., 2019). The participants are sophomore nursing students from six classes. Class 6 (n=40) was assigned to the experimental group, while Class 5 (n=40) served as the control group.The sample Size: 80

The questionnaire consists of multiple sections, each designed to measure key variables using a five-point Likert scale (1=Strongly Disagree, 5 = Strongly Agree). All questionnaire items are adapted from validated instruments

in previous studies to ensure reliability and validity. The questionnaire primarily focuses on two areas: student engagement and technology acceptance.

4. Results and Discussion

The results showed that the theoretical knowledge score of the experimental group (M = 87.5, SD = 7.41) was significantly higher than that of the control group (M = 69.6, SD = 4.60), with a statistically significant difference (t(78) = 13.05, p < .001, Cohen's d = 2.92). This indicates that the experimental group achieved a substantial improvement in theoretical knowledge with a large effect size (d > 2.0). In addition, the skill performance score of the experimental group (M = 87.5, SD = 7.56) was also higher than that of the control group (M = 84.1, SD = 6.42), with a statistically significant difference (t(78) = 2.19, p = .032, Cohen's d = 0.49), suggesting that the experimental group outperformed the control group in skill performance, although the effect size was small. These findings demonstrate that the teaching intervention combining virtual simulation and traditional simulation significantly improved students' theoretical knowledge and had a positive, albeit relatively smaller, impact on skill performance.

Table 1: Statistics on the number of post-test results for the experimental group and the control group.

Variable	Experimental Group (n=40) (M±SD)	Control Group (n=40) (M±SD)	t	df	p	Cohen's d
Theoretical Knowledge (TK)	87.5±7.41	69.6 ±4.60	13.05	78.0	<0.001	2.92
Skill Performance (SP)	87.5±7.56	84.1 ±6.42	2.19	78.0	0.032	0.49

For theoretical knowledge, the experimental group showed a significant improvement: pre-test (67.1±4.06) vs. post-test (87.5±7.41), with statistically significant differences (t(39)=-17.18, p<0.001, Cohen's d=-2.72). In contrast, the control group had a smaller improvement: pre-test (67.5±3.60) vs. post-test (69.6±4.60), with marginal significance (t(39)=-2.18, p=0.036, Cohen's d=-0.34), indicating limited effects of traditional teaching on theoretical knowledge.

For skill performance, both groups improved significantly. The experimental group scored 72.5±6.30 (pre-test) vs. 87.5±7.56 (post-test) (t(39)=-9.39, p<0.001, Cohen's d=-1.49). The control group improved from 71.6±7.45 (pre-test) to 84.1±6.42 (post-test) (t(39)=-7.68, p<0.001, Cohen's d=-1.21), showing traditional teaching also enhanced skills with a large effect size.

Table 2: Statistics on the number of TK and SP in pre-test and post-test for two group

Variable	Experimental Group (n=40) (M±SD)	Control Group (n=40) (M±SD)	t	df	p	Cohen's d
Experimental Group	Theoretical Knowledge (TK)	67.1±4.06	87.5± 7.41	17.18	9.0	<0.001
	Skill Performance (SP)	72.5±6.30	87.5± 7.56	9.39	9.0	<0.001
Control Group	Theoretical Knowledge (TK)	67.5±3.60	69.6± 4.60	-2.18	39.0	0.036
	Skill Performance (SP)	71.6±7.45	84.1± 6.42	-7.68	39.0	<0.001

A series of simple linear regression analyses examined the predictive relationships in the research model, with results validated by G*Power - calculated sample size (N = 185) ensuring statistical power. As shown in the path coefficient table, Perceived Ease of Use (PEOU) strongly predicted Perceived Usefulness (PU) (b = 0.969, SE = 0.0203, t = 47.67, p < .001, R^2 = 0.925), and PU further predicted Intention to Use (ITU) (b = 0.946, SE = 0.019, t = 47.76, p < .001, R^2 = 0.926). PEOU also directly predicted ITU (b = 0.920, SE = 0.03, t = 34.12, p < .001, R^2 = 0.864). Finally, ITU significantly predicted Engagement (E) (b = 0.90, SE = 0.0207, t = 43.66, p < .001, R^2 = 0.91). All path coefficients were statistically significant (p < .001), with no multicollinearity (VIF = 1.00) and minimal autocorrelation (Durbin - Watson ≈ 2). These findings confirm that perceived ease of use enhances usefulness and usage intention, which ultimately drives higher learning engagement among nursing students using virtual simulation software.

Table 3: The result of simple linear regression analysis

	B	SE	t	p
PEOU→PU	0.969	0.0203	47.67	<.001
PU→ITU	0.946	0.019	47.76	<.001
PEOU→ITU	0.920	0.03	34.12	<.001
ITU→E	0.90	0.0207	43.66	<.001
PEOU→PU	0.969	0.0203	47.67	<.001

5. Conclusions

Virtual Simulation Software (VSS) demonstrates significant positive impacts on nursing students' academic performance, learning engagement, and technology acceptance. The experimental group (VSS combined with traditional simulation training) significantly outperformed the control group in theoretical knowledge (87.5 ± 7.41 vs. 69.6 ± 4.60; $t(78) = 13.05$, $p < 0.001$, $d = 2.92$), with a 20-point improvement compared to only a 2-point gain in the control group. Although the difference was less pronounced in skill performance, the experimental group still achieved higher scores (87.5 ± 7.56 vs. 84.1 ± 6.42; $t(78) = 2.19$, $p = 0.032$, $d = 0.49$). Both groups showed substantial skill improvement, confirming the essential role of hands-on training, while VSS provided an additional cognitive advantage. These findings align with prior research (Cant & Cooper, 2014; Thomas et al., 2016) and Experiential Learning Theory (Kolb, 2014), supporting the value of hybrid simulation approaches.

Regression analyses revealed that Perceived Usefulness (PU) strongly predicted Intention to Use (ITU) ($\beta = 0.64$, $p < 0.001$), whereas Perceived Ease of Use (PEOU) had a smaller direct effect ($\beta = 0.35$, $p < 0.01$) and also exerted an indirect influence through PU ($\beta = 0.52$, $p < 0.001$). These results are consistent with the Technology Acceptance Model (Davis, 1989) and subsequent studies, indicating that nursing students prioritize practical benefits over usability. Furthermore, Intention to Use (ITU) significantly predicted Learning Engagement (LE) ($B = 0.90$, $SE = 0.0207$, $t = 43.66$, $p < 0.001$), accounting for 91% of the variance ($R^2 = 0.91$), underscoring that motivation to use VSS fosters deeper behavioral, emotional, and cognitive involvement.

Additional notable findings include variability in technology adoption influenced by digital literacy, the critical role of instructor guidance, enhanced student confidence and reduced anxiety, potential interdisciplinary applications, and higher levels of emotional and cognitive engagement compared to behavioral engagement. For practical implementation, VSS should be integrated into blended learning models to enhance engagement and performance. Educators should emphasize its practical benefits, ensure user-friendly design, and provide adequate training and support. Structured VSS sessions and debriefing can help bridge theory-practice gaps, while institutional and policy support is essential for sustainable integration.

Future research should focus on longitudinal studies to assess long-term effects, expand to diverse populations and cultural contexts, compare various simulation technologies (e.g., VR, AI), examine the role of instructor involvement, and explore psychological factors influencing technology adoption. Additionally, future studies should evaluate real-world clinical performance and patient outcomes. In conclusion, VSS significantly improves nursing students' academic outcomes, engagement, and technology acceptance. By enhancing theoretical learning and clinical readiness, it serves as a valuable complement to traditional teaching methods. Future efforts should prioritize long-term integration, instructor training, and cross-disciplinary applications to maximize its educational potential.

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