Case-Based VR-FL Versus Traditional Case Teaching: An Evaluation of Learning Achievement and Self-Efficacy among Nursing Students

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***Abstract*—The conventional model of nursing education faces considerable obstacles due to the rapid advancements in medical technology. Although innovative solutions such as virtual reality (VR), flipped learning (FL), and case-based learning have been proposed, there is a significant lack of research concerning the integration of these methodologies. The purpose of this study was to assess the effectiveness of a combined approach utilizing case-based learning, virtual reality (VR), and flipped learning (FL)—designated as Case-based VR-FL—on nursing students' learning outcomes and self-efficacy in the context of pressure ulcer prevention. A quasi-experimental study was conducted at a medical vocational college, involving 133 nursing students who were assigned to either an experimental group (n=67) or a control group (n=66). The experimental group received instruction through the Case-based VR-FL approach, while the control group engaged in traditional case-based teaching. Knowledge regarding pressure ulcer prevention was evaluated through pre- and post-tests, and a self-efficacy survey was administered. The experimental group exhibited significantly higher post-test scores and demonstrated improved self-efficacy, particularly in terms of confidence and willingness to apply their knowledge. The Case-based VR-FL approach significantly enhances nursing students' knowledge and self-efficacy related to pressure ulcer prevention. Future research should aim to incorporate qualitative data to further enrich and deepen the understanding of these findings.**

Keywords—Virtual Reality (VR), Flipped Learning (FL), Case-based learning, self-efficacy, nursing students

I. INTRODUCTION

The traditional nursing education model is increasingly revealing its inherent limitations due to the evolution of nursing education and advancements in medical technology. It struggles to meet the diverse and heightened demands of contemporary nursing professionals regarding knowledge systems, practical skills, and overall quality [1]. Virtual reality technology (VR) and flipped learning (FL) have presented nursing education with opportunities to navigate both unprecedented developmental prospects and considerable challenges in this transformative era [2].As a powerful pedagogical approach, the case-based method can enhance students' engagement and creativity through the examination of specific case studies [3]. However, whether a teaching model that organically integrates these three elements can significantly enhance nursing students' learning achievements and self-efficacy remains to be validated through empirical research. Consequently, this study seeks to integrate these three instructional strategies to investigate their impact on nursing students' learning performance and self-efficacy. In order to evaluate the effects of this learning approach, we will focus specifically on the following research questions: What are the differences between the Case-based VR-FL approach and the traditional case teaching approach in terms of nursing students' learning achievements and self-efficacy?

II. LITERATURE REVIEW

Contemporary learning theory emphasizes the importance of active, context-driven knowledge construction through experiential engagement [4][5]. VR serves as a prime example of this in nursing education by simulating high-risk clinical environments, such as operating rooms, which enables safe skill practice, refinement of clinical judgment, and internalization of concepts, all while reducing costs and enhancing competency [6]. Blended models now integrate VR with flipped learning: students first engage in self-directed learning of theory via digital platforms, and subsequently apply their knowledge in collaborative VR simulations. This dual approach not only strengthens practical skills but also sharpens clinical reasoning and increases student engagement [7][8][9]. Case-based learning further bridges the gap between theory and practice through authentic clinical narratives, such as obstetric simulations that require the synthesis of physiology, ethics, and communication into comprehensive care plans [10]. While VR, flipped learning, and case-based methods have each been individually validated, their systematic integration remains relatively unexplored. This gap underscores the necessity for unified frameworks that combine self-paced virtual learning, immersive simulation, and clinical problem-solving. Our study proposes an innovative model that weaves together these evidence-based strategies to accelerate skill acquisition and cultivate adaptive expertise for dynamic healthcare

environments. By addressing the fragmentation present in current research, this holistic approach aims to transcend isolated methods and effectively bridge the theory-practice divide in nursing education.

III. Method

A. Participants

This study was conducted at a medical vocational college in China, targeting second-year nursing students as the experimental subjects. The study design included an experimental class with 67 students and a control class with 66 students. The same teacher taught the experimental and control groups using identical learning materials. However, the experimental group used the Case-based VR-FL approach while the control group used the Case-based approach.

B. Data Collection

Two clinical nursing educators, each possessing more than two decades of experience, created pre- and post-assessments focused on the prevention of pressure ulcers. These assessments comprised multiple-choice questions, each scored on a 100-point scale, and exhibited strong reliability, with KR20 coefficients of 0.75 and 0.82, respectively. Furthermore, a self-efficacy survey, modified from the work of Pintrich et al. [11], included 12 items evaluated using a 5-point Likert scale and demonstrated satisfactory reliability, indicated by a Cronbach's alpha of 0.86.

C. Data Analysis

Quantitative data were collected through the Questionnaire Star digital platform, which facilitated the administration of survey questions and the subsequent collection, storage, and exportation of data to an Excel spreadsheet. This procedure constituted the preliminary phase of data analysis. The collected data were then analyzed using SPSS software (version 27.0), after which the Mann–Whitney U test was employed to examine potential differences in learning achievement, and an Independent t-test was conducted to assess self-efficacy between the two participant groups.

D. Experimental Procedure

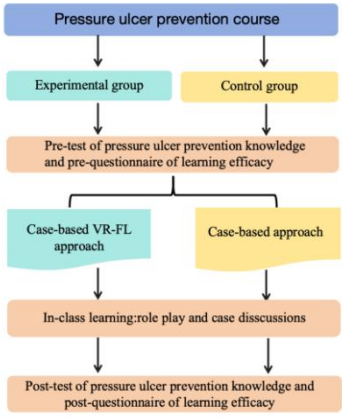

Fig. 1. Experimental procedure.

As shown in Figure 1, the study uses comparative experimental designs to investigate the effects of VR-FL application in nursing education by comparing the experimental group and the control group with case teaching methods. During the previous semester, students in experimental and control groups systematically learned the knowledge of the prevention of pressure ulcers. In order to further study and improve their ability to apply this knowledge in real situations, a comprehensive practical application course was offered during this semester.

At the beginning of the experiment, two groups received pre-test to gain a complete understanding of the knowledge about pressure ulcers. This step has helped us to ensure a consistent starting point for experiments and to provide accurate benchmarks for subsequent teaching experiments.

Before the class, for experimental group students, we provided micro-course materials on pressure ulcer prevention with the online platform and organized VR simulation exercises on the V Care virtual experiment software platform. VR simulation exercises enable students to experience pressure ulcer prevention processes in simulated environments, thereby deepening their understanding and knowledge memory.

Fig. 2. Instructional videos on pressure ulcer prevention

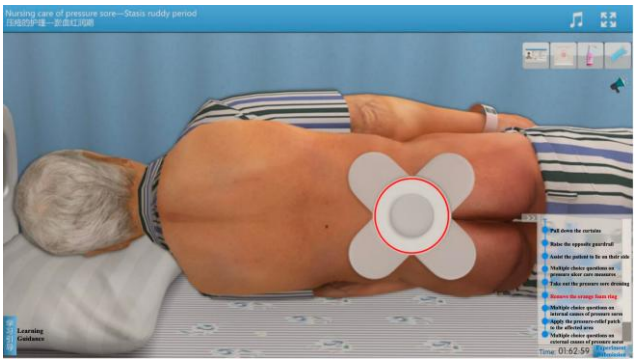

Fig. 3. The VR simulation for the pressure ulcer prevention

Both experimental and control groups experience case-based group role-playing and teacher-student discussions (Figure 4). Students were divided into groups, and each group was to play a role in a specific case of pressure ulcer prevention by simulating a scenario in the real workplace. Through role-play and discussion, students were able to better

understand the practical application of pressure ulcer prevention and practice teamwork and communication skills.

Fig. 4. Instructor and students engage in role-play and discussion

In order to assess the effectiveness of the two teaching models, we administered a post-test on knowledge of pressure ulcer prevention to both classes at the end of the experiment. A questionnaire of self-efficacy was also administered to assess the students' confidence in the ability to practice pressure ulcer prevention after the course.

IV. Results

A. Learning Achievements of Pressure Ulcer Prevention Knowledge

In the Mann – Whitney U test comparing pre-test knowledge (Table 1), the experimental group (Mean = 81.79, SD = 13.69) and control group (Mean = 79.39, SD = 12.87) showed similar performance, with no significant difference ($U = 1981$, $z = -1.069$, $p = 0.285$). Thus, there was no statistically significant difference in pre-test scores between the groups at the start, allowing for post-intervention comparison.

TABLE I. THE RESULTS OF THE MANN-WHITNEY FOR THE PRESSURE ULCER PREVENTION KNOWLEDGE PRE-TEST.

Groups	Pressure ulcer prevention knowledge pre-score					
	N	*Mean Rank*	*Sum of Ranks*	*U*	*Z value*	*P*
Experimental group	67	70.43	4719	1981	-1.069	0.285
Control group	66	63.52	4192			

The results of the Mann – Whitney U test for the pressure ulcer prevention knowledge of the two groups are shown in Table 2. The score of the experimental group (Mean = 89.85; SD = 13.64) was significantly higher than that of the control group (Mean = 81.79; SD = 19.99). This indicates that after adopting case-based VR-FL in course training, the learning achievement surpassed that of the case-based group.

TABLE II. THE RESULTS OF THE MANN-WHITNEY FOR THE PRESSURE ULCER PREVENTION KNOWLEDGE POST-TEST.

Groups	Pressure ulcer prevention knowledge post-score					
	N	Mean Rank	Sum of Ranks	U	Zvalue	P
Experimental group	67	75.51	5059	1641	-2.679	0.007
Control group	66	58.36	3851			

***p<0.01

B. Learning Self-efficacy

The investigation into students' learning self-efficacy encompassed three dimensions: Interest, Confidence, and Willingness to apply. Independent t-tests were employed to evaluate the impact of the Case-based VR-FL approach on these dimensions. As indicated in Table 3, statistically significant differences were observed in the areas of Confidence ($t=-3.21$, $p<0.05$) and Willingness to apply ($t=-2.32$, $p<0.05$); however, no significant difference was detected in the dimension of Interest ($t=-0.21$, $p>0.05$).To synthesize the effects of the learning approaches on students' perceptions of learning self-efficacy, the case-based VR-FL approach demonstrated significant positive impacts on students' perceptions of their learning self-efficacy, particularly in terms of confidence and willingness to apply.

TABLE III. THE T-TEST RESULTS OF THE TWO GROUPS' PERCEPTIONS OF LEARNING SELF-EFFICACY

Variable	The T-test results of the two groups' perceptions of learning self-efficacy						
	group	N	Mean	SD	t	d	P
Interest	Experimental group	67	4.79	0.82	-0.21	-0.04	0.83
	Control group	66	4.81	0.74			
Confidence	Experimental group	67	4.53	0.67	-3.21	-0.56	0.002
	Control group	66	4.88	0.53			
Willingness to apply	Experimental group	67	4.69	0.58	-2.32	-0.41	0.002
	Control group	66	4.93	0.57			

**p<0.05

V. Discussion

By analyzing the results of the pre-test and post-test, we found that there was no significant difference between the experimental group and the control group regarding pre-test scores on the knowledge of pressure ulcer prevention. This baseline consistency provided a reliable benchmark for our subsequent comparison of the learning effectiveness of the two groups. However, in the post-test, the experimental group scored significantly higher than the control group, a finding that strongly indicates that the use of a case-based VR-flipped learning (Case-based VR-FL) has a clear advantage in enhancing students' knowledge acquisition.The theory of constructivist learning emphasizes the promotion of deep learning through contextual simulation and practical experienc[12]. In this study, students in the experimental group were immersed in a simulated pressure ulcer prevention scenario through a case-based VR flipped approach, allowing them to experience and practice the knowledge firsthand, thus demonstrating higher knowledge acquisition in the post-test.

In the investigation of students' self-efficacy for learning, we found that the case-based VR-FL teaching method had a significant positive impact on students' confidence and their willingness to apply knowledge. However, there was no significant difference between the two groups regarding the dimensions of interest and willingness to apply. Specifically, there was no notable difference between the two groups in terms of "interest." Bandura's self-efficacy theory underscores the crucial influence of an individual's beliefs about their ability to perform a specific task (i.e., self-efficacy) on behavioral choices and levels of effort[13]. In this study, the case-based VR-FL teaching method significantly enhanced students' self-efficacy, aligning with Bandura's theory. Students

continued to experience success through simulated practice in the virtual environment, which bolstered their confidence in their ability to acquire and apply knowledge related to pressure ulcer prevention[14]. Furthermore, contextual learning theories [15] emphasize that learning should be closely aligned with real or simulated situations to promote understanding and application of knowledge. In this study, the immersive learning environment facilitated by virtual reality (VR) technology simulated a real-life scenario for pressure ulcer prevention, allowing students to learn and practice in a nearly authentic clinical setting. This significantly enhanced their willingness to apply the knowledge they acquired in practical situations.

VI. Conclusion

This research examined the efficacy of Case-based Virtual Reality Flipped Learning (Case-based VR-FL) in improving students' knowledge acquisition and self-efficacy regarding pressure ulcer prevention through a comparative experimental design. The results demonstrated that participants in the experimental group achieved significantly higher knowledge acquisition in the post-test compared to those in the control group, indicating that the Case-based VR-FL instructional approach provides substantial benefits for enhancing knowledge acquisition. Additionally, this method significantly bolstered students' self-efficacy and their readiness to apply the acquired knowledge; however, no notable differences were found between the two groups concerning their interest levels. It is essential to recognize that the study may have included a limited sample size, which could constrain the generalizability of the findings. Furthermore, the research lacked qualitative data support, as reliance on quantitative data alone poses challenges in thoroughly exploring students' learning processes, individual experiences, and potential influencing factors. In contrast, qualitative data could yield richer and more nuanced insights, thereby enabling a more comprehensive understanding of the learning outcomes associated with Case-based VR-FL. Therefore, future investigations should strive to integrate qualitative data to complement and enhance the insights derived from quantitative analyses.

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