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Original Article

Evaluation of a Virtual Reality Simulation to Improve Problem-Based Learning for Neurologic Examination in Nursing Students

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Abstract

Background: In the era of the fourth industrial revolution, there is a requirement of innovative strategies to enhance nursing students' learning transfer. Virtual Reality Simulation Problem-Based Learning (VRS-PBL) has been validated to be an advantageous strategy that can improve knowledge, clinical performance, and self-efficacy. We aimed to identify the effectiveness of VRS-PBL for improving nursing students' neurologic examination.

Methods: Data were collected in 2021. Seventy-six participants were recruited via the convenience sampling. Students in the control group underwent conventional lecture and demonstration of neurological assessment prior to practicum, whereas students in the experimental group underwent VRS-PBL once a week for 2 weeks (60 minutes per session).

Results: Compared with the control group, the academic self-efficacy ($t = -2.80$, $P = .007$) and neurological examination performance ($t = -11.62$, $P < .001$) of the nursing students increased significantly in the experimental group. On the other hand, there was no significant difference between the two groups of the transfer motivation ($t = -1.76$, $P = .082$).

Conclusion: The nursing students integrated the knowledge and skills learned through VRS-PBL, and improved the effectiveness and efficiency of their learning. VRS-PBL that reflects various clinical situations can be used as a foundation for establishing effective teaching strategies to improve nursing competency from novice to expert nurses.

Keywords: Neurologic examination; Nursing education; Problem-based learning; Virtual reality

Introduction

Nursing is a practical discipline that requires appropriate knowledge, skills, and attitudes related to health to be used in clinical practice (1, 2). Accordingly, for nursing students to develop the ability to integrate the knowledge learned from the curriculum, educators should provide students with opportunities to experience various nursing situations so that they can effectively apply them to clinical practice (3, 4). Meanwhile, clinical practice is mostly indirect observing rather than directly performing nursing duties due to the nursing environment in which patient safety and protection of the health rights of the patient is strengthened (5). Moreover, due to the COVID-19, most nursing education institutions are providing non-face-to-face education, and medical institutions are permitting limited clinical practice. As an alternative to supplement these limitations in nursing education, efforts to use VR simulation and evaluate its educational effects are increasing (6). As the difficulty of clinical practice is increasing due to COVID-19, virtual reality (VR) simulation-based education is emerging as an alternative for nursing students and to provide sufficient nursing training to them as professionals.

Virtual Reality Simulation Problem-Based Learning (VRS-PBL) enables learners to communicate with patients, make decisions, and control movements in VR similar to the real environment (7). VRS-PBL is not limited by time and place, and in terms of educational performance, it enables students to immerse themselves in learning, repetitive training, self-directed participation, and immediate feedback (8). VRS-PBL improves critical thinking and clinical reasoning through PBL, while restricting students from potentially harming the patients through simulation in a safe environment. It provides an opportunity to enhance problem-solving ability and clinical performance in practical situations (9, 10). VRS-PBL has been validated to be an advantageous learning strategy that can improve knowledge, clinical performance, and self-efficacy of nursing students and contribute to patient safety through nursing competency reinforcement (11-15). Especially, the previous study in which learners who performed physical assessment through simulation before the clinical practice gained confidence in performing the physical assessment (16) and similar studies wherein medical skills training was provided using VR simulation-based education in the healthcare setting and the results showed improved acute stroke assessment ability or neurological skill performance of the learners (17).

In the era of the fourth industrial revolution, a paradigm shift in nursing education is being emphasized and the demand for the use of VR technology is increasing (18). However, VR simulation-based education in nursing practice in Korea is insufficient and primarily focused on topics related to respiratory and circulatory systems. Therefore, it is required that simulation learning is applied in various topics including the nervous system (19). In particular, since neurological changes in patients can progress rapidly and cause irreversible brain damage, an accurate neurologic assessment ability through the experience of nursing assessment of various patient conditions is essential for early detection, and this is considered as the beginning of treatment (20, 21). Moreover, in patients with brain injury, continuous neurological monitoring and nursing management are important, and since the respiratory and cardiovascular systems are controlled by nerves, neurologic examination performance is an important skill required by nurses. The study was conducted to confirm the effect of VRS-PBL for neurologic examination on academic self-efficacy, transfer motivation, and neurologic examination performance of nursing students. The specific research hypotheses were as follows:

1) Hypothesis 1: The nursing students who participated in VRS-PBL will exhibit improved academic self-efficacy as compared to the nursing students who participated in the conventional education.

2) Hypothesis 2: The nursing students who participated in VRS-PBL will exhibit improved transfer motivation as compared to the nursing students who participated in the conventional education.

3) Hypothesis 3: The nursing students who participated in VRS-PBL will exhibit improved neurologic examination performance as compared to the nursing students who participated in the conventional education.

Materials and Methods

This investigation was a quasi-experimental control group pretest–posttest study. Second-year nursing students enrolled at a nursing college in South Korea were selected through convenience sampling. Participants were recruited through the campus bulletin board.

The inclusion criteria were as follows: 1) students taking health assessment practice courses in the first semester of their second year, 2) students who understand the purpose of the research and agree to participate in the study. The exclusion criteria were as follows: 1) students who had prior experience of the nervous system assessment program used in this study.

The sample size was calculated using the G*Power 3.1 program. In the comparison between the independent two groups, the minimal number of participants was evaluated using a two-tailed test, with significance level of 0.05, effect size of 0.7, and power of 0.80. The effect size was selected since it showed the maximum effect among the effect sizes of 0.33–0.75 in Shin et al. (22)'s study that evaluated the effect of applying a web-based nervous system assessment program to nurses. As a result, at least 68 samples were required. Finally, 76 students were selected in consideration of the dropout rate of 10%. Data from 38 nursing students in experimental group and 38 nursing students in control group were used for final analysis, with no dropouts (Fig. 1).

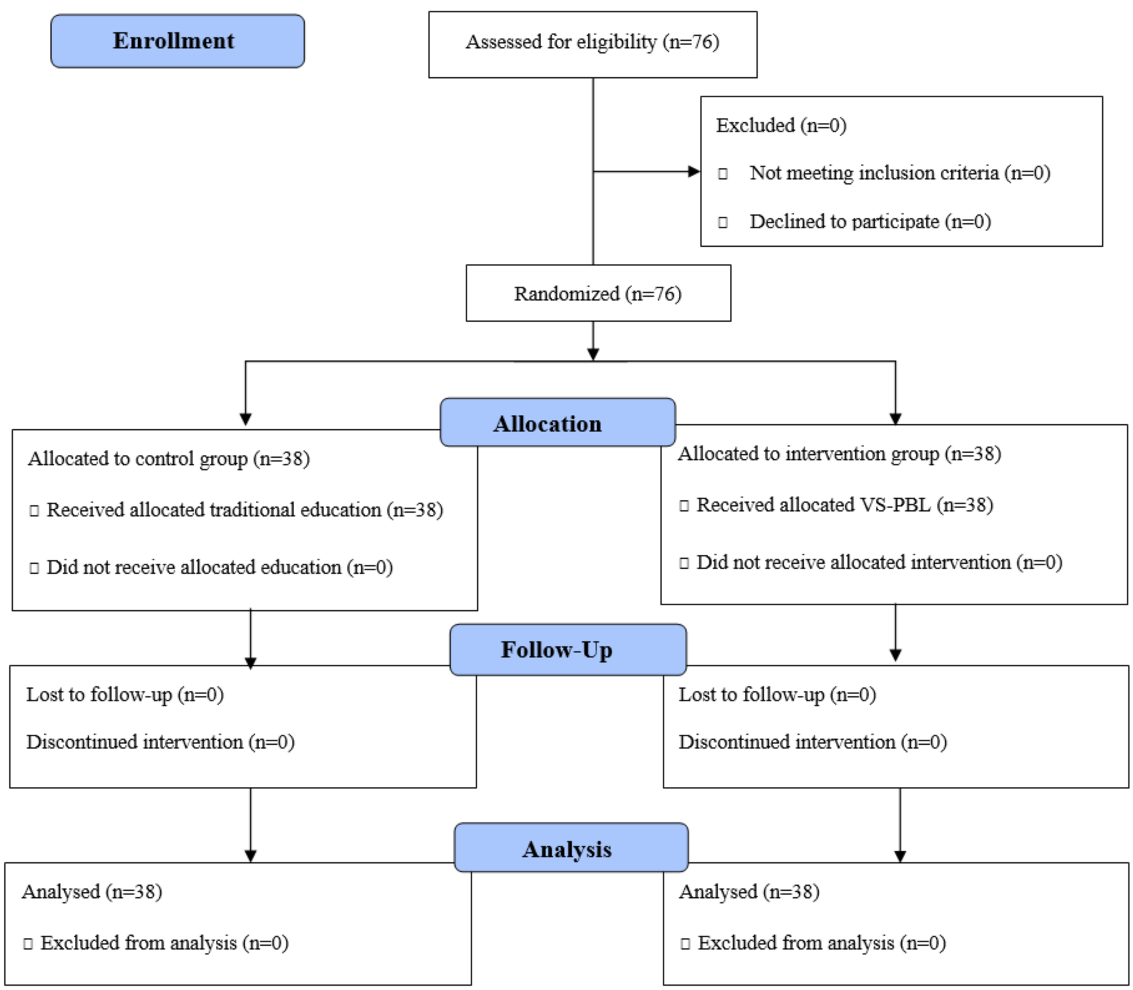

Fig.1: Consort flow diagram

VRS-PBL

VRS-PBL was used VR Simulation: Neurological Examination developed by Newbase Co., Ltd. It was developed by applying the Intervention Mapping Protocol (IMP) (23). IMP consists of six steps: 1) needs assessment, 2) goal setting, 3) intervention method and strategy selection, 4) program content development, 5) program implementation plan, and 6) evaluation plan.

In the first stage, the literature review and interviews were conducted to identify the educational needs of nursing students. In the second stage, the goals to be achieved were set through the application of the program. Among the 12 learning outcomes presented by the Korean Accreditation Board of Nursing (KABN), "applied integrated nursing skills" and "improved clinical reasoning ability" were selected (24). The third step involves the selection of a process that can achieve behavioral change. Additionally, it was made sure that nursing students could participate in VRS-PBL using electronic devices (smartphones, tablets, and computers). The fourth step was conducted using clinical data, simulation guidelines, and literature. In this stage, the questions were corrected and supplemented through item verification by an expert group consisting of two clinical nurses, one neurologist, and two nursing professors (those who have experience in operating clinical simulation courses and developing scenarios). Only cases with a Content Validity Index of ≥0.8 were selected. VRS-PBL consisted of three items: GCS, pupillary light reflex, and muscle strength. In the fifth step, the program was implemented in nursing students in the first semester of 2021 health assessment practice course. In the sixth step, each student's nursing competency and program operation ability were analyzed for evaluation and feedback. The data of approximately 100 relevant patients are presented at random, allowing patient evaluation through various problems. Students can receive immediate feedback regarding their performance in each case within the program.

Nursing students' academic self-efficacy, transfer motivation, and neurologic examination performance were evaluated to investigate the differences in them before and after program. Program operation evaluation was conducted by receiving feedback on the benefits and drawbacks of participating in the program using a questionnaire.

Measures

The participants' general characteristics were investigated as variables such as age, gender, satisfaction with the nursing major, satisfaction with health assessment class, and prior knowledge of the nervous system.

The academic self-efficacy measure developed and adapted already (25, 26) was used after gaining the developer's approval. This tool consists of 10 items, based on a 7-point Likert scale. The scores range from 10 to 70, with higher scores indicating higher academic self-efficacy. The reliability in terms of Cronbach's α was .95 in a study (26) and .94 in this study.

The transfer motivation measure (25, 26) was used after gaining developer's approval. It is a 10-item 7-point Likert scale, and the scores range from 10 to 70, with higher scores indicating higher transfer motivation. The Cronbach's α value was .94 in a study (26) and .90 in this study.

Neurologic examination performance was evaluated using VR Simulation: Neurological Assessment developed by Newbase Co., Ltd. There were 10 items, including three Glasgow Coma Scale (GCS) items, three pupillary light reflex items, and four muscle strength items. Twenty items were evaluated by measuring two cases for each item. The scores range from 0 to 20, and the higher the score, the higher is the ability to assess the nervous system.

GCS

GCS is a reliable clinical scale used to assess a patient's state of consciousness (27). It was examined by evaluating three items: eye opening, verbal, and motor response. For this, the icons (call, speak, motion instruction, pain stimulus) aligned on the left side of the program were used. It can be evaluated by examining their response to the verbal stimulus provided by clicking the talk icon. If the patient is not awake or does not follow movement instructions, the patient's response to pain can be assessed by clicking on the pain stimulus icon. Each item is scored between 3 and 15 points, with 1–4 points for eye opening, 1–5 points for verbal response, and 1-6 points for motor response (Fig. 2).

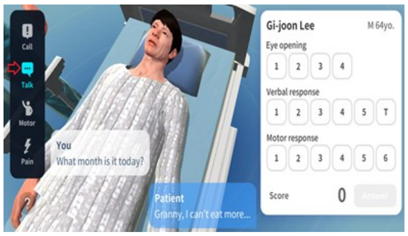

Fig. 2: Glasgow coma scale

Pupillary light reflex

Pupillary light reflex test is performed to determine whether the brainstem region that controls consciousness is functioning normally (28). Three items including pupil size, shape, and response to light are evaluated. To evaluate it, the icons arranged on the left side of the program (left/right examination) are used. Clicking the icon on the relevant area creates a circle figure and penlight icon of various sizes. The size of the pupil can be measured using a circular ruler, and the reaction to light can be observed by illuminating one pupil directly with the penlight. The pupil size ranges from 3 to 8 mm, and the pupillary response can be assessed as prompt, sluggish, fixed, and hippus (Fig. 3).

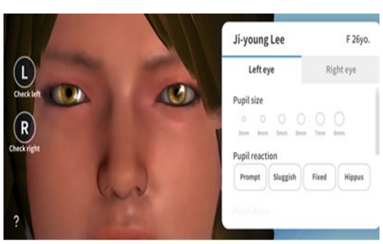

Fig. 3: Pupillary light reflex test

Muscle strength test

Muscle strength test is a screening method performed to evaluate the function of major motor pathways of each nerve segment (29). It evaluates the patient's range of motion by checking the force they can apply against gravity and resistance. Four items (left/right arm, left/right leg) can be evaluated. To assess the muscle strength of the extremities, when one clicks the test site aligned on the left side of the program, various examiner instructions are displayed. For example, if the left arm is selected, instructional phrases such as "raise the left arm" and "move the left arm" are displayed, and by selecting the corresponding phrases, the patient's movement can be observed. When the patient's arms and legs are lifted according to the instructions, the program automatically recognizes them and the examiner presses them. If the patient can withstand this force, it is evaluated, as "active movement was possible." The muscle strength is evaluated on a scale of 0–5 depending on the response of the patient (Fig. 4).

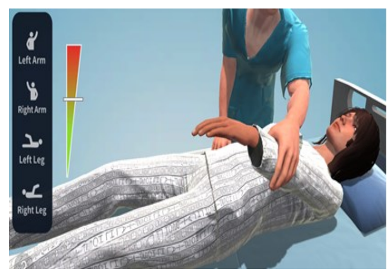

Fig. 4: Muscle strength test

Intervention

One week before the intervention, the experimental and control groups were educated for 2 hours on anatomy, physiology, assessment of nervous system, and the application of nursing courses based on various clinical cases by the researcher. On the first day, the two groups were given a pretest using self-reported questionnaires on academic self-efficacy and transfer motivation. For evaluating neurologic examination performance, the two groups were educated and given a demonstration for 20 minutes regarding VRS-PBL. Neurologic examination performance was evaluated using two virtual cases randomly distributed according to each item (GCS, pupillary light reflex, and muscle strength) through VRS-PBL. A follow-up survey was conducted in the health assessment laboratory according to a previously announced schedule 2 days after the intervention was completed. The evaluation was conducted by a research assistant for about 10 minutes. To prevent diffusion of the experiment, the evaluations of the experimental and control group students were conducted on different schedules, and at a time, 4–5 students from each group were evaluated in the health assessment laboratory. The experimental group students were evaluated in terms of individual practice using individual electronic devices, once a week (on the 4th and 8th days) for 2 weeks and a total of 2 times (60 minutes each time). A follow-up survey was conducted in the health assessment laboratory according to a previously announced schedule 2 days after the intervention was completed. Academic self-efficacy and transfer motivation were investigated using a self-reported questionnaire, and neurologic examination performance was conducted in the same way as in the pretest using the VRS-PBL.

Data collection

Data collection was conducted from May 31 to June 18, 2021. The researcher explained the necessity, method, and procedure of the study, so that participants could fully consider whether to participate. Participants provided written informed consent process prior to eligibility. Considering that the participants were students, consent was obtained by trained research assistants.

Data analysis

The data were analyzed using the SPSS WIN 26.0 software (IBM Corp., Armax, NY, USA), and the general characteristics were analyzed using descriptive statistics, independent t-test, and χ^2 test. The effects of VRS-PBL were analyzed using a paired *t*-test. All statistical significance levels were set to .05.

Ethical considerations

The study was conducted according to the principles laid down in the Declaration of Helsinki and approved by the Institutional Review Board at the university where the researcher was affiliated (No. 1041223-202105-HR-01).

Results

General characteristics

The general characteristics are shown in Table 1. The average age of the experimental group was 20.63 years and that of the control group was 20.23 years. In terms of gender, 32 (84.2%) and 33 (86.8%) female students were in each group.

Table 1: General characteristics (N=76)

Variables	*Categories*	*Exp. (n=38)*	*Cont. (n=38)*	*χ^2 or t*	*P*
		n (%) or Mean ± SD			
Age (yr)		20.63 ± 0.75	20.32 ± 0.66	1.95	.056
Gender	Male	6 (15.8)	5 (13.2)	0.11	.774
	Female	32 (84.2)	33 (86.8)		
Satisfaction with the nursing major	Satisfied	15 (39.5)	18 (47.4)	0.48	.785
	Moderately satisfied	16 (42.1)	14 (36.8)		
	Unsatisfied	7 (18.4)	6 (15.8)		
Satisfaction with health assessment class	Satisfied	22 (57.9)	19 (50.0)	1.89	.450†
	Common	15 (39.5)	15 (39.5)		
	Unsatisfied	1 (2.6)	4 (10.5)		
Prior knowledge of the nervous system		9.47 ± 1.11	9.68 ± 0.74	-0.97	.334

Exp. = experimental group; Cont. = control group - Table Footnotes - †Fisher's exact test

Effects of VRS-PBL

As shown in the Table 2, the experimental group had academic self-efficacy higher than the control group (t = -2.80, *P* = .007). The experimental group had neurologic examination performance higher than the control group (t = -11.62, *P* < .001).

Table 2: Comparison of variables between the two groups (N = 76)

Characteristics	*Groups*	*Pretest*	*Posttest*	*t*	*P*
		Mean ± SD			
Academic self-efficacy	Exp.	46.84 ± 4.29	49.16 ± 4.25	-2.80	.007
	Cont.	47.87 ± 3.11	48.03 ± 3.03		
Transfer motivation	Exp.	57.87 ± 6.78	60.39 ± 6.06	-1.76	.082
	Cont.	57.45 ± 7.35	58.05 ± 8.13		
Neurological assessment performance	Exp.	13.45 ± 2.02	18.92 ± 1.62	-11.62	< .001
	Cont.	12.68 ± 1.45	14.79 ± 2.09		
Glasgow coma scale	Exp.	3.87 ± 0.91	5.47 ± 0.98	-7.35	< .001
	Cont.	3.58 ± 0.68	4.39 ± 1.13		
Pupillary light reflex	Exp.	4.24 ± 1.02	5.82 ± 0.39	-6.43	< .001
	Cont.	4.21 ± 0.84	4.63 ± 1.15		
Muscle strength	Exp.	5.43 ± 1.26	7.63 ± 0.91	-8.50	< .001
	Cont.	4.89 ± 1.13	5.76 ± 1.17		

Exp. = experimental group; Cont. = control group

Discussion

This study was conducted to confirm the effect of VRS-PBL for neurologic examination, and it was confirmed that the academic self-efficacy and neurologic assessment performance of the nursing students who underwent VRS-PBL were improved compared to those of the students in the control group.

First, VRS-PBL was developed based on the IMP, which has been widely used in healthcare settings to plan changes in the behavior and practice of healthcare professionals (23, 30). This framework delineates a systematic, theory- and evidence-based approach for establishing the rationale underlying programs aimed at changing healthcare practice (30). VRS-PBL uses the characteristic three-dimensional, sensory, and immersing environment of VR that responds to the behavior of the user in an interactive way (31). Therefore, it is useful for nursing students since it enables them to experience nursing without time- and place-related restrictions through various cases in VR in a manner similar to that of clinical practice; additionally, many students can participate in the program simultaneously. Furthermore, VRS-PBL uses PBL as an intermediate that links learning and improvement of critical thinking and clinical reasoning and simultaneously improves problem-solving ability and clinical performance through simulation (9, 10). However, learners experience unfamiliarity and difficulties when they first experience VR simulation-based education, and depending on the level of the learner, the use of English and medical terms in the program may act as a language barrier (32). Therefore, in future studies a qualitative analysis of nursing students' learning experience should be performed to evaluate the learners' perspective in relation to VRS-PBL application.

Nursing students who participated in VRS-PBL had significantly improved academic self-efficacy than the students in the control group. This is consistent with the previous study in which learners who performed physical assessment through simulation before the clinical practice gained confidence in performing the actual physical assessment (16). These results seem to support the argument that simulation-based education provides confidence by improving students' decision-making ability for providing patient care (33). In particular, by using VR technology to analyze and interpret various cases in times when face-to-face education is difficult due to the COVID-19, it is possible to acquire nursing knowledge and skills related to a learning experience that can be directly trained and improve nursing competency (34). In light of nursing education, the development and application of VRS-PBL in present times will prove to be beneficial in improving the performance of novice nursing students.

Moreover, the neurologic examination performance of the nursing students who underwent VRS-PBL significantly improved compared to that of the control group students. This is supported by previous studies wherein medical skills training was provided using VR, simulation-based education in the healthcare setting and the results showed improved acute stroke assessment ability or neurological skill performance of the learners (17). Based on these results, it is suggested to conduct future studies on whether the improved neurologic examination performance of the nursing students gained through a VR-based learning environment such as VRS-PBL is transferred to actual patient care.

However, this study has limitations in generalizing the results because the participants were conveniently sampled from nursing students who participated in the health assessment course according to the baccalaureate curriculum rather than being randomly assigned. Future randomized control trials are required to investigate the effect of VRS-PBL on various aspects of nursing students' performance. In addition, a student's average GPA (grade point average) can be a confounding factor for research, as students with high GPA can expect better performance on the VRS-PBL. Therefore, future research should be continued considering variables that may affect the participant's performance.

Conclusion

This study is meaningful since it compared learning effects in nursing students who received lecture-based education and in those who underwent VRS-PBL. The study supports that novice-nursing student's gain and develop nursing knowledge and skills of patient care through an experiential and clinical situation-based learning in proper educational strategies. Ultimately, VRS-PBL helps to achieve learning transfer by allowing systematic nursing education that transfers theoretical knowledge to practical skills. It was confirmed that the nursing students integrated the knowledge and skills learned through VRS-PBL, and improved the effectiveness and efficiency of their learning. VRS-PBL that reflects various clinical situations can be used as a foundation for establishing effective teaching methods to improve nursing competency from novice to expert nurses.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interest.

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