

The Impact of Virtual Simulation in Capstone Design: Enhancing Communication, Critical Thinking, and Team Efficacy

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Abstract: This study aimed to investigate the impact of a virtual simulation case integrated into a capstone design course on enhancing nursing students' skills. The study utilized a one-group repeated measures design, focusing on 59 second-year nursing students from the researcher's university, selected through convenience sampling. The core of the methodology was to integrate a virtual simulation case into a capstone design class as part of the nursing course. This innovative approach aimed to assess and enhance students' communication skills, critical thinking, and team efficacy. Measurements were taken before and after the class to assess progress. The data analysis involved t-tests and descriptive statistics. Post-class assessments revealed improvements in communication skills, critical thinking, and team efficacy, although these were not statistically significant. Notably, significant gains were observed in the subdomains of 'intellectual passion/curiosity' and 'systematicity'. These results suggested potential benefits of virtual simulations in nursing education, particularly in fostering specific aspects of critical thinking. It was crucial for instructors to effectively utilize teaching methods, such as capstone design, to enhance students' practical competence. This study suggests the potential of virtual content in nursing education to enhance students' communication skills, critical thinking, and team efficacy by providing interactive experiences that simulate real-world environments. It is essential for instructors to be able to effectively utilize teaching methods, such as capstone design, to enhance students' practical competence. This approach can contribute to improving the quality of nursing education by expanding practical opportunities for nursing students.

Keywords: Capstone Design, Nursing Education, Communication Skills, Critical Thinking, Clinical Virtual Simulation

1. Introduction

During the coronavirus pandemic, nursing education has encountered a major challenge in providing hands-on training due to limited access to real patients. Nursing education has encountered numerous challenges during the pandemic. Nursing schools have faced challenges in securing clinical practicum sites, developing alternative teaching strategies, and utilizing virtual learning environments. They also had to establish new guidelines and policies to ensure the safety of faculty and students. Students faced challenges due to reduced clinical opportunities, limited in-person instruction, and the shift to a virtual learning environment. This transition made it difficult for them to interact with real patients and acquire practical skills. Faculty have made significant changes to their teaching methods and curriculum to develop remote teaching approaches to achieve learning objectives. This has placed pressure on the

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development of new educational technologies, necessitating extra effort and resources. During this transition, traditional simulations using high-fidelity mannequins were limited in the number of scenarios available, and face-to-face learning presented challenges in ensuring student safety in the context of infectious diseases[1]. Advancements in digital and virtual technologies have led to the development of clinical virtual simulation methods that utilize virtual patients displayed on a screen[1]. This study aims to explore an alternative strategy.

Concerns about the spread of infectious diseases have restricted the chances for nursing students to have direct contact with clients. To address this issue, the field of nursing education has utilized online content for practical training. However, at that time, instructors were not adequately prepared and had to expand the internet infrastructure for educational purposes[2]. Students also need access to computers, the internet, and mobile devices to receive education at home[2]. This has created another educational gap and raised the issue of adapting to and immersing in new teaching methods. This has been significant impact of the pandemic on nursing students[3].

Various learning methods have been tried in nursing education to overcome this challenge. Capstone design is a teaching and learning method in which learners integrate knowledge acquired through lectures and present their findings[4]. It is considered an effective teaching strategy for strengthening practical skills. To effectively implement the capstone design method, the class operation plan should incorporate the following elements: industry linkage, the design and production process, and adaptability to the field. For this to work, the instructor must include these key elements and guide students in solving the challenges presented, as well as prototyping the outcome of their learning[4].

Capstone designs that emphasize problem-solving processes have proven to be effective for intentional learning, addressing areas of weakness in nursing education to prepare new nurses[5]. Previous studies on the application of capstone design have reported that students are highly motivated to pursue a career after gaining experience in solving real-world problems within their field of study[6]. Furthermore, their ability to solve real-world problems is significantly enhanced through the application of their knowledge in their respective fields[4][7]. To achieve this, capstone design classes should be based on collaborative learning, where learners take the initiative to design a problem, integrate information, and complete the learning process to solve the problem[8]. This also ties into students' sense of achievement[7].

For nursing students to effectively apply the nursing process to clients, they require ample case practice. For this training, client cases should be included in the curriculum. By using cases, nursing students can practice their communication competency and critical thinking processes to solve nursing problems and address health issues. To access these cases, it is also necessary to have a safe and successful problem-solving experience through a well-balanced team-based learning approach[9]. A capstone design class is an educational approach that equips learners with a problem-solving process.

In Korea, the capstone design pedagogy has been utilized in engineering, design, and management for practice-oriented education since its inception[10]. This approach has yielded valuable knowledge assets derived from practical experience. In the field of nursing, there is a collaboration with the industry through various means such as case studies, program, and policy analysis[3][11]. The outcomes of these classes include the development of case studies, enhancement of problem-solving and critical thinking abilities, and improvement of technical skills. However, there is a lack of scientific evidence on the various variables compared to the demand for conducting different trials.

Virtual content has been widely used in nursing education as an alternative to real patients, offering realistic scenarios and enhancing patient and student safety[12]. When using virtual simulation content, several factors need to be considered. Sessions should be a minimum of 30 minutes long, and feedback should be provided after each scenario run[13]. Instructors should strive to minimize the cognitive load on learners, as doing so will improve content delivery and enhance students' clinical reasoning[13].

Developing virtual content based on capstone design for each class requires collaboration and funding

from multiple sources. This limitation affects the amount of content that can be created. Incorporating commercially linked content can be challenging. Therefore, utilizing pre-existing content is an effective approach for class operation. Therefore, in this study, we utilized the "Virtual Healthcare Experience of Ryerson University, Centennial College & George Brown College," which is available as a free version[14] and analyzed the learning outcomes associated with its use.

This study aimed to investigate the impact of incorporating virtual content into an undergraduate design-oriented nursing process on nursing students' communication competency, critical thinking dispositions, and team efficacy. This study provides information for the development and improvement of similar courses. The aim of this study is to examine the effects of implementing a "capstone design class using virtual simulation" as an intervention on nursing students' communication competence, critical thinking disposition, and team efficacy.

The hypotheses of this study are as follows:

- Nursing students will improve their communication after the intervention.
- Nursing students will improve their critical thinking after the intervention.
- Nursing students will improve their team efficacy after the intervention.

2. Research Methodology

2.1 Research Design

The present study is a one group pre-post design study conducted to determine the effectiveness of a capstone design in a nursing process for second-year nursing students in improving their communication competency, critical thinking skills, and team efficacy. This study design was necessary due to practical constraints, such as participant availability and resource limitations. The absence of a control group may impact the validity of the findings by limiting the ability to attribute observed changes solely to the intervention. However, the aim of the study was to examine early indicators of the effectiveness of virtual simulation in a specific educational context, rather than to establish definitive causality. We selected a one-group pre-post design because it enabled us to closely monitor the impact of the intervention on the same group of participants over time. This design was considered the most suitable and feasible for the exploratory nature of the study and the context in which it was conducted.

2.2 Respondents of the Study

The study was conducted by conveniently sampling students from the researcher's university. The selection criteria for the subjects were students who had finished their first-year prerequisite courses and were currently enrolled in their second year of nursing. While convenience sampling may introduce biases and limitations, such as a lack of representativeness of the broader population, this sampling method was primarily chosen due to logistical constraints and accessibility. The selection of second-year nursing students was intentional. They have a strong educational background that enables them to actively participate in the capstone design course. However, they are still early enough in their training to gain significant benefits from the intervention. Their level of experience is an important factor to consider because it can impact their fundamental skills in communication, critical thinking, and team effectiveness. This decision affects the generalizability of study results because more experienced students may respond differently to the intervention. Initially, 67 out of 72 second-year nursing students at a university in Region C expressed their willingness to participate in the study.

Prior to conducting this study, the researcher participated in an on-campus workshop on research ethics education and capstone design pedagogy. The researcher explained to the participants that the

survey results would not be used for any purpose other than the study. They were also informed that they had the option to withdraw from the study at any time. Furthermore, it was emphasized that their participation in the study would not have any impact on their evaluations. After distributing the study manual, the study description was reviewed to ensure all contents were included, eight individuals were excluded who declined to participate, and ultimately 59 subjects who willingly agreed to take part in the study were selected. The necessary sample size for this study was determined using G Power 3.1.9.1 software. Using a t-test and selecting "Means: signed rank test (one sample case)" with an effect size of 0.5, α of 0.05, and a power ($1-\beta$) of 0.95, the appropriate number of subjects was calculated to be 47.

2.3 Data Gathering Procedures

2.3.1 Pretest

The researcher investigated basic demographics, such as age and gender, of the subjects. Additionally, a preliminary survey was conducted using a questionnaire to assess communication competency, critical thinking tendencies, and team efficacy.

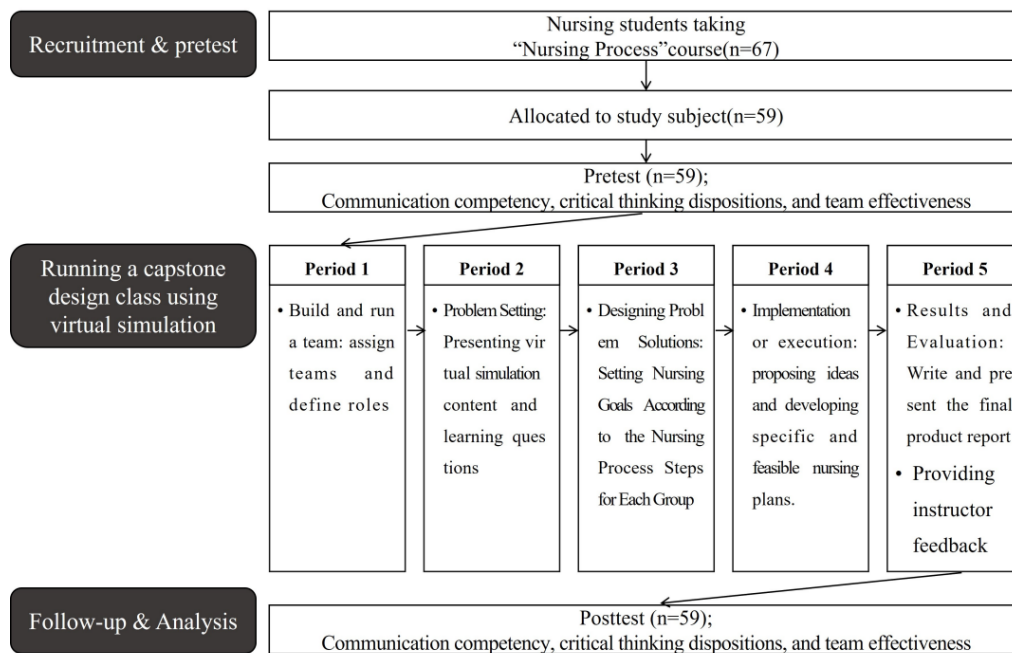
2.3.2 Experimental Treatment

The nursing course is a mandatory course for nursing majors, and it is a 2-credit, 2-hour course. Before conducting the preliminary survey, the subjects received a theoretical lecture on the five stages of the nursing process: nursing definition, nursing diagnosis, nursing planning, nursing implementation, and nursing evaluation. Following the lecture, a class was conducted using a capstone design. After promoting conceptual understanding of each stage of the nursing process through theoretical learning, the general capstone design class implemented a method that involved team formation, topic selection, product generation, and evaluation. Teams were randomly selected, and the instructor provided a virtual case for topic selection and learning progression. The virtual case provided to the students was selected from the content of 'The Virtual Healthcare Experience portal (<https://games.de.torontomu.ca/hospital/map.html>)'[14]. The virtual simulation used in this study was cloud-based system that simulates interactive case-based scenarios through a video-based interface [14][15]. Instead of using computer-generated graphics, the videos feature actors depicting clinician-patient interactions. The simulation occurs in a virtual hospital that offers simulation content encompassing a range of clinical scenarios. The Virtual Healthcare Experience Portal was developed in collaboration with faculty from Ryerson University, Centennial College, and George Brown College. The tool is a free resource hosted by Ryerson University under a Creative Commons license[14][15]. The case of appendicitis in the pediatric ward was chosen based on the students' level of understanding. The patient case involved a virtual simulation in which an actor re-enacted the patient's situation, including postoperative care, pain, and infection following appendicitis surgery.

Before implementing the virtual simulation with students, the instructor consulted a head nurse on a surgical ward to ensure its suitability for the local context. The virtual content was rated as similar to the clinical site, except for the fact that the students' native language was Korean, and the videos were in English. This was done in consideration of the capstone class's connection to the industry.

To facilitate this, the instructor directed students to an Internet address where they could access virtual simulations. The instructor also provided them with relevant information, such as explanations of complex terms, to help them fully engage in the virtual simulation experience.

The students worked in teams to solve the video and learning problems provided by the virtual case. They then submitted a case report for the nursing course to receive feedback from the instructor.



[Fig. 1] Flow Chart of this Study

2.3.3 Posttest

After receiving feedback from the instructor, a post-survey was conducted. The same questionnaire used in the pre-survey was used to measure communication competency, critical thinking skills, and team efficacy after completing the nursing course with capstone design.

The detailed procedure of this study is presented in [Fig. 1].

2.4 Research Instrument

2.4.1 Communication Competency

The communication competence item used an instrument that has been consistently utilized in previous studies to assess communication competence in college students[16]. The subjects in this study are nursing students, so the selected instrument aligns with the measurement tools typically used for college students. Previous studies have shown a reliability of 0.83[17].

It consists of 7 items, including "nodding my head or making an expression of understanding while listening to the other person." It is rated on a 5-point Likert scale. In this study, the reliability was found to be Cronbach's $\alpha = 0.83$.

2.4.2 Critical Thinking Dispositions

The Critical Thinking Disposition Questionnaire consisted of 27 questions and included 7 sub-domains[18]. This tool is suitable for evaluating nursing students' inclination for critical thinking in a nursing context. These subscales include intellectual passion/curiosity (5 items), cautiousness (4 items), self-confidence (4 items), organization (3 items), intellectual fairness (4 items), healthy skepticism (4 items), and objectivity (3 items). Participants rated each item on a scale from 1 (not at all) to 5 (very much so), with higher scores indicating stronger critical thinking tendencies[18]. The reliability of this instrument was Cronbach's $\alpha = .85$ at the time of development, and Cronbach's $\alpha = .88$ in this study.

2.4.3 Team Efficacy

Team efficacy was measured using the 8-item Collective Effectiveness Characteristics subscale, which was originally developed by Marshall (2003) and modified and supplemented by Kwon et

al.[19][20] At the time of its development, the tool was used as a measurement instrument in a study to investigate proactivity in problem-solving[19]. Therefore, it was suitable for assessing team efficacy in this study, which focused on problem-solving in a capstone design class. This instrument consists of 8 items. Each item is scored on a 5-point Likert scale, with higher scores indicating greater team efficacy. In Kwon's (2000) study, the reliability of the instrument was Cronbach's α of .96[20], and in this study, Cronbach's α = .94.

2.5 Statistical Tool for Data Analysis

The collected data were analyzed using the IBM SPSS Statistics for Windows, Version 22.0 program. The general characteristics of the subjects were analyzed using real numbers and percentages. Additionally, the reliability of the research instrument was calculated using Cronbach's α coefficient. Differences before and after the experimental treatment for each variable were analyzed using a paired t-test.

3. Results

3.1 Demographic Characteristics of Study Subjects

The demographic characteristics of the subjects are presented in [Table 1]. The average age of the 59 subjects was 22.51 ± 5.20 years, with 17 (28.81%) males and 42 (71.19%) females.

[Table 1] Demographic characteristics of study subjects

Characteristics	Category	M \pm SD or N(%)
Age		22.51 \pm 5.20
Gender	M	17(28.81)
	F	42(71.19)

3.2 Hypothesis Testing Results

3.2.1 Communication competency before and after the Capstone Design Class Using Virtual Simulation

[Table 2] presents the results of measuring the subjects' communication competency before and after the capstone design class using virtual simulation. The subject's level of communication competency improved from $4.09 \pm .494$ before the class to $4.30 \pm .560$ after the class, but there was no statistically significant difference ($p = .076$).

[Table 2] Communication competency before and after the Capstone Design Class Using Virtual Simulation

Variable	Pretest	Posttest	t	p
	M \pm SD			
Communication competency	4.09 \pm .494	4.30 \pm .560	-1.804	.076

3.2.2 Critical Thinking Disposition before and after the Capstone Design Class Using Virtual Simulation

The results of the measurement before and after the Capstone design class, which applied virtual simulation to enhance the subject's critical thinking disposition, are presented in [Table 3]. The subject's level of critical thinking disposition (total) improved from $3.74 \pm .428$ points before the class to

3.90±.453, but the difference was not statistically significant. As a result, the average scores of the study subjects improved in all areas except prudence, but the difference was not statistically significant.

Among them, ‘Intellectual passion/curiosity’ was measured at 3.52±.691 before class and 3.90±.453 after class, indicating improvement (p<.05). Additionally, the ‘Systematicity’ increased from 3.38±.727 before class to 3.67±.677 after class (p<.05). These results indicate a statistically significant difference. However, apart from these two items, the increase in scores was not statistically significant in any of the other subdomains.

[Table 3] Critical Thinking Disposition before and after the Capstone Design Class Using Virtual Simulation

Variable	Category	Pretest	Posttest	t	p
		M±SD			
Critical Thinking Disposition(total)		3.74±.428	3.90±.453	-1.859	.068
	Intellectual Passion/Curiosity	3.52±.691	3.90±.667	-3.090	.003
	Prudence	3.51±.727	3.51±.653	.035	.972
	Confidence	3.69±.628	3.88±.647	-1.650	.104
	Systematicity	3.38±.727	3.67±.677	-2.150	.036
	Intellectual Fairness	4.09±.543	4.21±.577	-1.078	.285
	Healthy skepticism	3.72±.671	3.93±.599	-1.664	.101
	Objectivity	4.20±.514	4.26±.535	-.581	.564

3.2.3 Team Efficacy before and after the Capstone Design Class Using Virtual Simulation

The results of the measurement before and after the Capstone design class, which utilized virtual simulation to evaluate team efficacy, are presented in [Table 4]. The level of team efficacy among the subjects improved from 4.29±.593 before the class to 4.34±.668 after the class, but there was no statistically significant difference(p=.627).

[Table 4] Team efficacy before and after the Capstone Design Class Using Virtual Simulation

Variable	Pretest	Posttest	t	p
	M±SD			
Team efficacy	4.29±.593	4.34±.668	-.489	.627

4. Discussion

This study aimed to investigate the impact of a capstone design class that used virtual simulation content on the communication skills, critical thinking disposition, and team efficacy of nursing students. The study results indicated that the participants' communication skills, critical thinking disposition, and team efficacy scores improved. However, these improvements were not statistically significant, except for certain subdomains.

In this study, there was no significant improvement in communication skills. The use of virtual content in this study is believed to have limited the students' ability to improve their skills due to its restricted communication within a specific context. Many virtual scenarios currently in use typically offer a limited range of communication experiences and expanding them requires a significant amount of time and effort[21]. An alternative to this is to use generative AI. Since the emergence of ChatGPT, the utilization of generative AI has significantly increased over the past year. In Korean nursing education, it has been reported that the system generates an infinite number of suitable cases for learning through simple operations and responds to the learner's language in real time without restricting the scope of the conversation, thus providing prompt feedback[22]. If such an educational system is implemented

effectively, it is believed to help students enhance their communication skills.

The study did not demonstrate effectiveness in the sub-domains of critical thinking disposition, including prudence, confidence, intellectual fairness, healthy skepticism, and objectivity. A study applying the same tool to intensive care nurses[23] reported that it was difficult to maintain systematicity in responding to rapid responses due to the nature of the intensive care unit as a reason for low systematicity, and that experience in communicating with various medical staff improved intellectual fairness. In the present study, it is believed that systematicity was improved due to the guaranteed time allowance in the learning process compared to the clinical process. In addition, since students do not have clinical experience yet, it is believed that they need to be provided with various communication opportunities to improve intellectual fairness.

Among the critical thinking dispositions, 'Intellectual passion/curiosity' and 'Systematicity' were found to have a statistically significant impact. In a previous study comparing the critical thinking disposition of nursing students, the total score for critical thinking disposition improved from $3.74 \pm .428$ to $3.90 \pm .453$ before the class. This improvement was like the level of critical thinking disposition observed in the subjects of the current study[24]. Chaung (2020) reported that intellectual passion/curiosity, organization, and objectivity were among the domains of critical thinking dispositions that increased with grade level[24]. This improvement was attributed to the implementation of teaching and learning methods that incorporated practical problem-solving exercises into the curriculum for third and fourth-year students[24]. In this study, as the subjects were second-year students who had not yet experienced fieldwork, it is likely that the virtual simulation content applied to the nursing curriculum elicited a sense of realism in the students and increased their intellectual passion and curiosity. In addition, the process of forming teams and solving realistic problem situations, even if limited by the procedures of the capstone class, may have contributed to the students' sense of organization.

Virtual simulation can prepare students for the clinical environment by providing safe practice in complex clinical situations[12]. However, to ensure student learning outcomes, it is necessary to overcome the challenges of student management and debriefing when utilizing virtual simulation[12]. In this study, students' enthusiasm/curiosity for virtual simulation improved statistically significantly after the class, which is believed to be a result of the virtual simulation's ability to ensure safety and the instructor's active feedback as part of the capstone class. However, the use of North American content for Korean students may have made it more difficult for them to feel comfortable or learn enough depending on their level of English. A study of students who experienced virtual simulation during the pandemic also found that Korean students improved their confidence and competence in training using an English-language virtual simulation program[25]. However, like the results of this study, they reported that improvements were needed in language barriers and content performance[25]. Therefore, if native-language content is actively developed and the content is easier to use from the user's perspective, it may be used as an effective tool for communication competency and team efficacy, which were not proven to be effective in this study in addition to critical thinking skills. Virtual simulation has the advantage of being popular among students. It is also safe and time-efficient to experience realistic situations[26]. If the development of content that fully reflects this user experience and reality is activated, it is expected to be very useful for nursing education by reproducing clinical situations.

Given the above discussion, some of the limitations of this study include the potential impact of cultural differences and language barriers on the participants' communication and critical thinking engagement. It should also be considered that language barriers may affect the interpretation of virtual simulations and assessment tools.

Among the critical thinking dispositions in this study, the improvement of 'Systematicity' can be considered as an effect of the capstone design class. Capstone design class is a kind of project-based learning in which students work in teams to plan, design, and produce products to solve problems and produce results[27][28]. It has the advantage of enhancing practical skills[27][28]. In a study of nursing

students during the pandemic[7], the subjects scored particularly low on organizational skills among critical thinking skills. The study attributed this to the limitations of a non-face-to-face environment, which limits students' ability to engage in step-by-step logical reflection[7]. The capstone design class in this study was conducted face-to-face, and the researchers tried to give students a full experience of the systematic problem-solving process. Based on this, it is interpreted that systematicity improved as students experienced the process of running the class, as shown in the results of this study.

There was no significant improvement in team efficacy in this study. A limitation of the study was that only the team formation process was conducted. As there are many teamwork situations in nursing practice, continuous education on teamwork is important[29]. Simulation-based education, where virtual roles are experienced, provides rehearsal for various teamwork opportunities[29], so it is necessary to organize education that considers team efficacy. Furthermore, follow-up evaluation of the effectiveness of such training should be continued.

5. Conclusion

This study was conducted to explore the effects of a capstone design class utilizing virtual simulation content on nursing students' communication skills, critical thinking disposition, and team efficacy.

In terms of critical thinking tendencies, there were statistically significant improvements in "intellectual enthusiasm/curiosity" and "organizational skills." However, other variables did not show statistical significance. There were limitations to the lessons tried in this study. Difficulties such as teaming and limited access to foreign content may have prevented students from being fully immersed in applying the capstone design. However, these attempts can be valuable for research by exploring different learning strategies. In addition, the feasibility of exploring the possibility of integrating capstone design or virtual simulation content was reported. To develop students who can successfully adapt to the complex and rapidly changing healthcare environment, it is necessary to support a variety of attempts and success experiences. Therefore, nursing educators or institutions should integrate various communication strategies into their curriculum to help learners navigate cultural and linguistic diversity. In addition, regular assessments may be necessary to identify deficiencies in critical thinking and team effectiveness. Furthermore, scenarios could be enhanced to provide students with realistic, critical thinking-based problem-solving experiences that can be applied to complex situations. This includes the development of communication training content using generative AI. In addition, instructors need to be supported in designing lessons that evenly enhance critical thinking skills. Consideration should be given to strengthening team-based self-efficacy in course design. Finally, we recommend repeated studies on capstone design and education utilizing virtual content to provide students with evidence-based instruction.

This study highlights the potential of virtual simulation to enhance communication skills, critical thinking, and team efficacy in nursing education, especially in a post-pandemic context. This emphasizes the necessity of innovative teaching approaches in nursing education and indicates the efficacy of capstone design classes in enhancing students' practical competencies. Furthermore, the study emphasizes the significance of adjusting educational strategies to address modern challenges, such as incorporating technology and surmounting language barriers in diverse learning environments.

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