ORIGINAL RESEARCH

The impact of problem-based learning teaching interventions on nursing students' learning outcomes: An empirical study using a pre-and-post test design

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ABSTRACT

Objective: This study aims to explore the learning effectiveness and student experiences of nursing in-service students under the Problem-Based Learning (PBL) online teaching intervention.
Methods: A single-group pre-and-post test quasi-experimental design was employed, and standardized tests were used to assess learning performance before and after the simulated scenarios intervention, while paired sample *t*-tests were applied to analyze the differences.
Results: The results showed that the post-test scores (M = 85.35, SD = 9.13) were significantly higher than the pre-test scores (M = 74.58, SD = 6.97), $t(30) = 5.97$, $p < .001$, with an effect size of Cohen's d = 1.07. In PBL case-based learning, students indicated that simulated scenarios made the learning content easier to understand and effectively sparked their interest in learning.
Conclusions: Students held a positive attitude towards the online teaching courses designed using PBL, and the teaching intervention significantly enhanced learning outcomes, demonstrating its high application value. It is suggested that this approach could serve as a reference for future nursing curriculum planning and instructional design.

Key Words: Learning outcomes, Teaching intervention, Problem-based learning

1. INTRODUCTION

Web-based teaching has been developing for at least 20 years. Through the internet, images, text, videos, and other materials can be uploaded and stored on platforms, allowing learners to access relevant information and communicate from different locations. While it may not be widespread in Taiwan, it has been implemented internationally for many years.[1]

The courses offered by the Air University in the 1980s can be considered an early application of digital technology in education in Taiwan. They utilized audio-visual materials broadcasted through television to facilitate learning, allowing the public to study without attending in-person classes. In recent years, due to the promotion by schools and private organizations, online teaching has gradually been accepted by the public in Taiwan. This has been especially true during the past two years of the COVID-19 pandemic, where synchronous distance learning and live broadcasts were utilized. However, the effectiveness of these methods can be influenced by hardware equipment, user capabilities, and the nature of the courses.[2]

Internet-Based Education is one form of Distance Education and a type of digital learning.[3] According to our school's regulations, online teaching refers to instruction conducted

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interactively through communication networks, computer networks, video channels, and other transmission media, with at least half of the course hours (inclusive) delivered through online teaching. This includes both synchronous and asynchronous online teaching activities.

A university in Taiwan that implemented distance education found that most students recognized and supported the adoption of distance learning; however, improvements were needed in the variety of video platforms used by teachers, internet speed, and teaching methods. Most teachers believed they could manage distance teaching, but they still plan to primarily use in-person instruction in the future.[4]

During the COVID-19 pandemic, primary and secondary schools in India also conducted learning through distance education. However, it was found that there were significant differences in students' purposes and perspectives on learning, which were related to the type of school, location, and students' gender.[5] This is particularly relevant in the application of medical and nursing education, as the pandemic necessitated the use and implementation of distance teaching, including video conferencing software and social media platforms. When using these technologies, it is important to understand the platforms and their functionalities, as well as their limitations.[6]

However, online teaching is not meant to replace traditional instruction; rather, it provides an alternative avenue for students who cannot attend school in person. The quality of teaching remains the most important aspect of online education. Other international applications include the use of distance learning in the design of courses for pediatric dental trauma education, where students demonstrated excellent learning performance.[7] Online teaching differs from traditional face-to-face instruction, making it even more important to ensure its quality. To implement distance education effectively, both students and teachers must be on board. Schools should establish well-functioning learning platforms to verify the learning outcomes of distance education students, including evidence of all student achievements, such as assignments and learning hours.[8] Scholars have proposed two teaching methods for online learning. The first is resource-based learning, which involves planned instructional activities designed to cultivate students' abilities to identify problems, analyze data, express opinions, solve problems, and engage in self-directed learning. The second is demand-based learning, which breaks through the limitations of time and space through the internet, allowing students to determine their own learning time, location, and pace.[9] Researchers believe that teacher-student interaction is crucial in online teaching. Regardless of the teaching strategies or models used, teachers typically assist student learning through interaction. The learning model must create effective learning situations that allow learners to continuously engage with their environment. Office hours, where real-time interaction occurs between teachers and students, represent one such learning activity.

In online teaching, the methods of interaction employed by teachers vary depending on the different stages of learning. Problem-Based Learning (PBL) is a teaching approach centered around problems and focused on thinking, designed to enhance learners' self-directed learning and strengthen their problem-solving skills. This method combines characteristics of case studies and discovery learning, creating more appropriate learning objectives for learners than before. PBL originated in the 1950s at Case Western Reserve University in the United States and in the 1960s at McMaster University in Canada.[10] Problem-oriented learning has developed over the years, and many scholars have provided different definitions of PBL. Duch (1996)[11] describes it as a teaching method based on problems that uses real-world issues to cultivate learners' thinking and problem-solving abilities while helping them grasp important concepts within the curriculum. In addition to enhancing problem-solving abilities, some scholars have found that Problem-Based Learning (PBL) can stimulate students' learning motivation. There are significant differences in students' mastery of course progress and key points, improvements in their motivation for learning, thorough preparation before class, and active participation in group discussions.[12]

Furthermore, students' different learning styles are also related to the implementation of PBL. Some researchers suggest that before implementing the PBL teaching model, it is essential to address the shortcomings of students with different learning types. By understanding learners' varying preferences for learning styles, teaching policies, strategies, and even resources and materials can be timely adjusted to enable different students to achieve more effective learning outcomes within the PBL framework.[13] Over the years, PBL has not only been applied in medical education but has also gradually been integrated into other fields. For example, when PBL was incorporated into social care and service courses, it was found that this approach enhanced university students' understanding of the course implementation methods and increased their willingness to participate. Students gained a deeper understanding of service learning topics, and their self-reflective abilities and problem-solving skills were improved during the implementation of service learning activities.[14] In summary, based on the literature reviewed, Problem-Based Learning is a learning approach generated through students' problem-solving processes. It is a

student-centered learning method that focuses on real-world problems as the learning focal point and involves sharing and learning through discussions. This approach stimulates learners' thinking and enhances their self-directed learning motivation.

Online teaching may seem easy and convenient, but in reality, it is not just a matter of recording audio-visual materials and uploading them to a learning platform. There are many important key factors hidden within online teaching. If an effective online teaching model for nursing continuing education can be constructed, it will benefit more nursing students in their professional development, allowing them to achieve a balance between clinical work and further education, while also aiding in the retention of nursing staff. This study aims to convert the original face-to-face course into an online teaching course and guide students through PBL based on self-directed learning, with the goal of enhancing their learning interest and outcomes. Therefore, the purpose of this study is to explore the learning effectiveness and student experiences of the PBL model in online teaching courses.

2. Methods

This study employs a single-group pre-test and post-test quasi-experimental design, utilizing the PBL model, with the "Clinical Nursing Infection Control" course as the research context. The aim is to explore the learning process of students engaging in group case discussions within the framework of synchronous online distance education. Considering that students may vary in their self-management and effectiveness control abilities in the online teaching environment, teachers act as facilitators and supportive collaborators in this process, driving students' autonomous learning around the core problems. In addition to exploring answers through digital audio-visual materials or academic literature, students are required to present personal arguments supported by references. Ultimately, interactions and deepening of understanding occur through the discussion forum on the online learning platform and during teacher-student consultation times (Office Hours).

The research subjects were first-year students from the nursing department's continuing education program, totaling 31 participants. All participants held a nursing license and were employed in various healthcare institutions or related organizations, with ages ranging from 21 to 45 years and a balanced gender distribution. All students enrolled in the "Clinical Nursing Infection Control" course were included, and those who did not take the course were excluded. Data were collected from September 14, 2024, to January 15, 2025.

In terms of research tools, the "Clinical Infection Control Knowledge Test" was utilized. This test was personally developed and screened by researchers with over 15 years of experience in teaching clinical nursing infection control. The test focuses on five core areas most relevant to clinical practice: (1) the definition and related factors of infection control, (2) emerging infectious diseases in Taiwan, (3) infection control for invasive procedures related to healthcare, (4) patient safety, and (5) bundle care. After expert validity checks by two clinical infection control specialists (including an infectious disease physician and an infection control nurse), pre-tests and post-tests were administered to the research subjects to assess students' actual effectiveness in the clinical infection control course. Finally, the analysis of the pre-test and post-test data was conducted using SPSS for descriptive statistics and paired sample t-test analysis. Once the research application is approved by the IRB (IRB No.: 202400056A3), the study will proceed.

3. Results

A total of 31 students participated in this study, yielding a participation rate of 100%.The average score for the pre-test was 74.58 (SD = 6.97), while the average score for the post-test was 85.35 (SD = 9.13). The results of the paired sample t-test showed that $t(30) = 5.97$, $p < .001$, indicating that the post-test scores were significantly higher than the pre-test scores. The effect size, Cohen's d = 1.07, indicates a large effect. Students' total semester scores ranged from 80 to 99, with 29 students showing significant improvement in their post-test scores compared to their pre-test scores, with improvements ranging from 2 to 32 points. The range of pre-test scores was 64 to 88, while the range of post-test scores was 67 to 100, with the average post-test score being 85.4. Only three students had slightly lower post-test scores than their pre-test scores, with differences ranging from 1 to 3 points; overall, the average post-test score was significantly higher than the pre-test score. To examine the differences in learning outcomes from the instructional intervention, this study employed a paired sample *t*-test to analyze the pre-test and post-test scores(see Table 1). The results showed that the post-test score (M = 85.35, SD = 9.13) was significantly higher than the pre-test score (M = 74.58, SD = 6.97), $t(30) = 5.97$, $p < .001$, with an effect size of Cohen's d = 1.07, indicating a large effect. This suggests that the instructional intervention had a significant and highly positive impact on learning outcomes.

Feedback from PBL students regarding other aspects of learning includes: "Students do not mind difficulties in learning when it involves topics they are interested in," "These topics are all about current trending infectious diseases, which can spark interest," "I enjoy discussing ideas with others, but not

every session has to be a group discussion," "I prefer thinking about questions that have clear answers," and "Learning topics, problems, or exam questions should be as clear and achievable as possible."

Table 1. Results of the paired sample *t*-test for pre-test and post-test

Variable	Pre-test M (SD)	Post-test M (SD)	*t* value	*p* value	Cohen's d
Learning outcomes	74.58 (6.97)	85.35 (9.13)	5.97	< .001	1.07

4. Discussion

The results of this study indicate that after the PBL teaching intervention, students' learning outcomes significantly improved, with the effect size reaching a large level. This finding supports constructivist learning theory, demonstrating that innovative teaching methods can effectively promote learning transfer and deepen understanding. This study will discuss two aspects: first, the teachers' reflections on their teaching, and second, the students' feedback on their learning.

4.1 Teachers' reflections on teaching

First, it is essential to strengthen the authenticity of PBL case introductions. In curriculum design, continuously gather representative cases from clinical practice and appropriately simplify or adapt them, allowing students to think and discuss in a safe learning environment, thereby enhancing their clinical judgment and critical thinking skills. In class, students can be guided to organize their knowledge structure through PBL, helping them connect fragmented nursing knowledge and establish a clearer framework for nursing assessment and decision-making. Additionally, cases that balance knowledge and clinical application should be designed, reminding oneself that in curriculum design, it is important not only to teach theory but also to guide students to think about "how to apply it clinically," in order to prevent students from merely memorizing knowledge without practical application skills. At the same time, encourage student participation in reflection. During the case discussion and concept construction process, provide ample opportunities for students to speak and express themselves, and design guiding questions to allow students to further reflect on their thought processes.

4.2 Student learning feedback

Students generally believe that online teaching allows for autonomous scheduling of learning time and the ability to rewatch instructional content, which aids in understanding and absorption. However, some students mentioned that the need to complete multiple discussions and assignments might affect their focus on learning. Regarding PBL case learning, students indicated that the use of real cases makes it easier to understand the learning content and increases their interest and participation, although they still need time to adapt to this teaching method. Feedback from students about this course includes: "Learning with cases would be better!" "I can learn anytime!" "I can control my learning time!" "The content on infection control can be learned through online teaching!" "The operation of the learning platform is not difficult." It is worth noting that students' attitudes toward prolonged learning are not consistent, with 37.5% expressing neutrality or disagreement, indicating that more than a third of students do not prefer long-duration learning. Therefore, in arranging learning time, digital materials should be kept to a duration of 5 to 10 minutes whenever possible.

4.3 Limitations

The small sample size (N = 31) from a single continuing education program may limit the generalizability of the findings to a broader nursing population, and we recommend that future research include larger, multicenter samples.

5. Conclusion

In the future, when designing courses, it is important to continuously gather representative cases from clinical practice and appropriately simplify or adapt them, allowing students to think and discuss in a safe learning environment, thereby enhancing their clinical judgment and critical thinking skills. Additionally, teachers should continuously improve their teaching methods. After using cases, they should regularly review students' learning outcomes and reflect on whether their teaching strategies need adjustment to avoid rigidity and maintain flexibility and innovation in teaching. The overall research results indicate that nursing students in practice hold a positive attitude toward online courses designed using the PBL approach. Therefore, it is recommended to use this as a reference for future nursing curriculum planning and instructional design. This study confirms that the PBL teaching intervention has a significant and highly positive impact on nursing students' learning outcomes. It is suggested that future studies could expand the sample size and include a control group design to further strengthen the evidence of the research.

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Authors Contributions

Dr. Chu-ling Chang was responsible for research design, data collection, analysis, and manuscript writing and revising.

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DATA SHARING STATEMENT

No additional data are available.

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