Exploration and practice of undergraduate teachingreform of Nuclear Medicine guided by OBE concept under the background of New Medicine

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Abstract

Objective: Traditional approaches to medical education have become inadequate, virtual simulation-based medical education has catalyzed transformative changes in medical education while still facing inherent limitations. This study explores the reform of undergraduate nuclear medicine education guided by the outcome-based education (OBE) concept in the context of New Medicine. **Subjects and Methods:** Two hundred twenty three clinical medicine students participated in this teaching reform study in 2023. Focusing on student-centered learning and guided by teaching outcomes, the study aimed to refine educational objectives and optimize the use of virtual simulation. It explored a blended online and offline teaching model tailored to the needs of nuclear medicine undergraduates. Following the implementation, students completed a questionnaire andthrough a multi-dimensional evaluation approach to assess their learning outcomes. **Results:** The average comprehensive score for the 223 students was 80.4±6.2. Only 133 of all the students completed the questionnaire, 87.2% (112/133) believed that the blended online and offline teaching approach in nuclear medicine enhanced their understanding and mastery of the learning material. Additionally, virtual simulation teaching makes students improve their learning fun and learning efficiency, and 96.2% (128/133) students felt that virtual simulation teaching effectively bridged the gap between theory and clinical practice and improved their overall learning outcomes. However, operation complexity was identified as a concern by 19.5% (26/133) of the student cohort, particularly in multi-step procedural simulations. Furthermore, only 14.3% (19/133) of the students are highly willing to spend more time engaged in virtual simulation-based teaching and 96.2% (128/133) of the students agreed that it should complement traditional clinical practice instruction instead of being used alone. **Conclusion:** This teaching reform in nuclear medicine, guided by the OBE concept within the framework of New Medicine, especially the application of virtual simulation teaching, enables students to acquire a strong foundation in medical theory and practical skills. Given that the new teaching methodology also has certain shortcomings, it is imperative to further integrate it with clinical practice and continuously improve and optimize the approach.

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Introduction

The twentieth century saw significant changes in the education of health professionals, driven by technological advancements [1]. New Medicine emphasizes a comprehensive approach to health throughout the life cycle, aligning with contemporary scientific and technological revolutions. The integration of artificial intelligence (AI) into medical education has the potential to revolutionize the way students learn about biomedical sciences [2]. Nuclear Medicine serves as a crucial bridge in clinical education, particularly for tumor diagnosis and treatment [3]. However, its complex imaging processes pose risks such as radiation hazard during clinical practice. Simulation-based learning (SBL) allows students to engage in realistic scenarios without patient harm, making it an ideal method for enhancing nuclear medicine education [4]. Despite the rapid progress in SBL research, the application of virtual simulation in nuclear medicine remains underdeveloped.

Outcome-based education (OBE) prioritizes student learning outcomes over instructional processes. This approach requires a backward design of the curriculum, ensuring alignment with the goals of New Medicine and the capabilities of students [5]. The COVID-19 pandemic has further highlighted the effectiveness of hybrid teaching models, integrating face-to-face and online learning [6]. This study aims to define clinical teaching requirements for nuclear medicine under the New Medicine framework, enhancing the SBL platform and developing a mixed teaching model to improve educational quality and produce skilled medicalprofessionals.

Subjects and Methods

Participants

This study included 223 undergraduate clinical medicine students from four classes in the first and second halves of 2023. There are no teaching ethical problems in this study and the Medical Ethics Committee of Guangxi Medical University Cancer Hospital has approved the protocol (Approval Number:LW2025004).

Teaching design and reform implementation inventory

1) Sort out and improve the curriculum objectives, and set clear and progressive hierarchical teaching objectives (Figure 1).

This teaching reform was guided by the concept of OBE and resets the overall teaching objectives based on the development requirements of new medicine and students' ability. This process requires investigation and demonstration of teachers, school administrators, students and employers, and modification and optimization on the basis of traditional curriculum objectives. After establishing the overall goal of the course, we set up clear and step-by-step small goals according to the overall goal of the course, and realize the corresponding relationship between the teaching effect and the teaching goal in the teaching design.

2) Rich curriculum ideological and political teaching resources.

Ideological education requires students to understand their mission and responsibility, and have good medical ethics. On the one hand, as the engineers of the human soul, teachers bear the great responsibility of teaching and cultivation, and should carry out all aspects of network learning, classroom teaching and after-class talk education. On the other hand, the teaching content should be refined and transformed, and the cross-era medical humanistic materials (such as medical history, etc.) should be integrated into the teaching of nuclear medicine. Thirdly, we should carry out various forms of clinical practice, volunteer service and other activities to expand the methods and ways of curriculum ideological and political construction.

3) Reform teaching methods and organizational forms, optimize teaching means and resources.

Combined with the network learning platform of Chinese universities massive open online course (MOOC) and superstar, we carried out a mixed teaching mode that class teaches and group discussion team-based learning (TBL), teacher teaching and student participation, concentrated learning and independent learning, and online teaching and offline teaching.

4) Actively promote simulation based learning (SBL).

Simulation based learningrepresents a man-made illustration of a true world to attain instructional motives through experiential learning. The main principle behind simulation learning is to utilize simulation aids to mimic real clinical scenarios. With the "east wind" of new medicine, we actively promoted and optimized the virtual simulation projects of positron emission tomography/computed tomography (PET/CT) tumor imaging and iodine-131 (^{131}I) treatment of differentiated thyroid cancer" in Nuclear Medicine (Figures 2, 3), intuitively imparts abstract functional imaging knowledge of nuclear medicine to students and carry out virtual clinical practice.

Teaching procedures

The curriculum implementation process is mainly divided into four parts: online learning, classroom learning, clinical practice and after-class reflection (Figure 4).

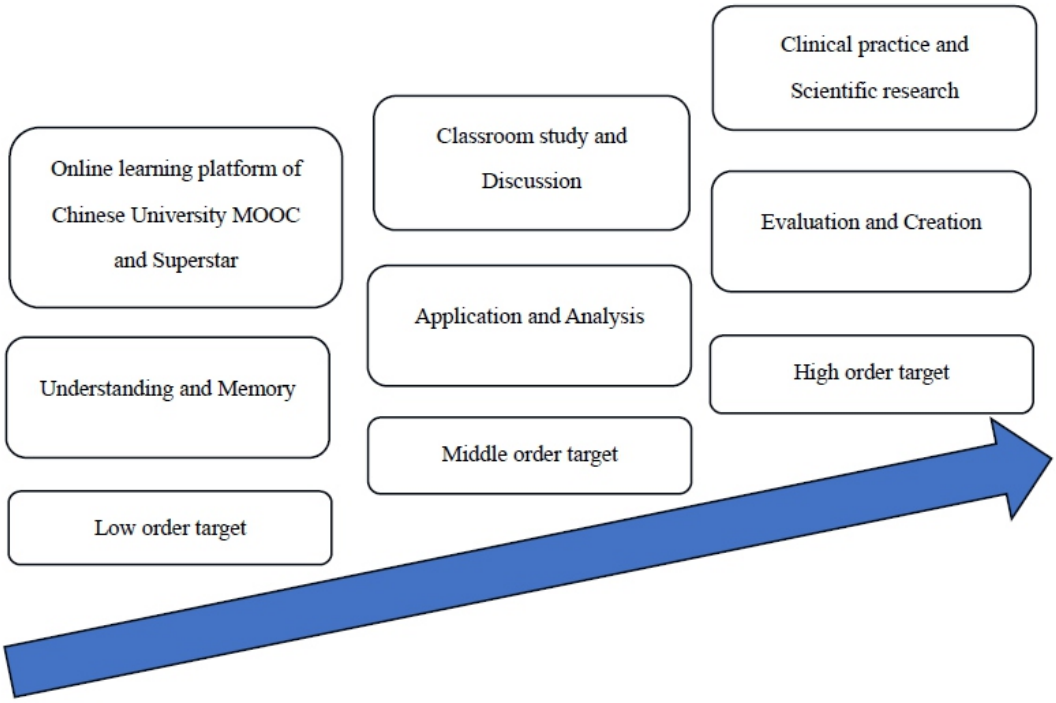

Figure 1. Progressive hierarchical teaching objectives.

Figure 2. Screenshot of the Virtual Simulation Project (PET/CT Tumor Imaging), illustrating students performing virtual operation of the PET/CT equipment for patient examination.

Figure 3. Screenshot of the Virtual Simulation Project (^{131}I treatment of differentiated thyroid cancer), illustrating students performing virtual rounds and guiding patients to take radioactive ^{131}I medication.

Evaluation of teaching effect

Using the platform of network learning and virtual simulation teaching, classroom test, final examination and questionnaire survey to set up a multi-dimensional evaluation and assessment system to evaluate the teaching effect and teaching quality (Figure 5). The questionnaire survey was designed by the teaching team. All questionnaires were distributed through an online questionnaire survey platform named SoJump at the end of the early stage of the course, which mainly investigated the effectiveness of the teaching reform and the SBL.

Statistical analysis

Data were analyzed using the statistical software SPSS (version 24.0 (Armonk, NY: IBM Corp.) and Microsoft Excel 2021.

Ethical considerations

This study was approved by the Guangxi Medical University Cancer Hospital Ethical Review Committee (approval number: Lw2025004). We explained that there would be no disadvantage even if the survey subjects refused to participate in the survey and that even if they consented, the disclosed data would not contain any personally identifiable information. Additionally, we confirmed that no personally identifiable information was included in the free text section of the questionnaire.

Results

Comprehensive performance

The evaluation of student performance was based on a multi-dimensional evaluation and assessment system, comprising a final examination (60%) and a process evaluation (40%). Among the 223 students, scores ranged from a low of 60.3 to a high of 93.5, with an average score of 80.4±6.2. Detailed score distribution is presented in Table 1.

Table 1. *Overall score distribution of 223 students.*

Grade distribution	Number of students	Proportion
60 ~ 70	11	4.9%
70 ~ 80	93	41.7%
80 ~ 90	108	48.4%
≥90	11	4.9%

Questionnaire survey

A total of 133 questionnaires were collected to assess students' perceptions of the teaching methods. The results indicated that 87.2% (112/133) believed that the blended online and offline teaching approach in nuclear medicine enhanced their understanding and mastery of the learning material. Additionally, virtual simulation teaching makes students improve their learning fun and learning efficiency, and 96.2%(128/133) students felt that virtual simulation te-

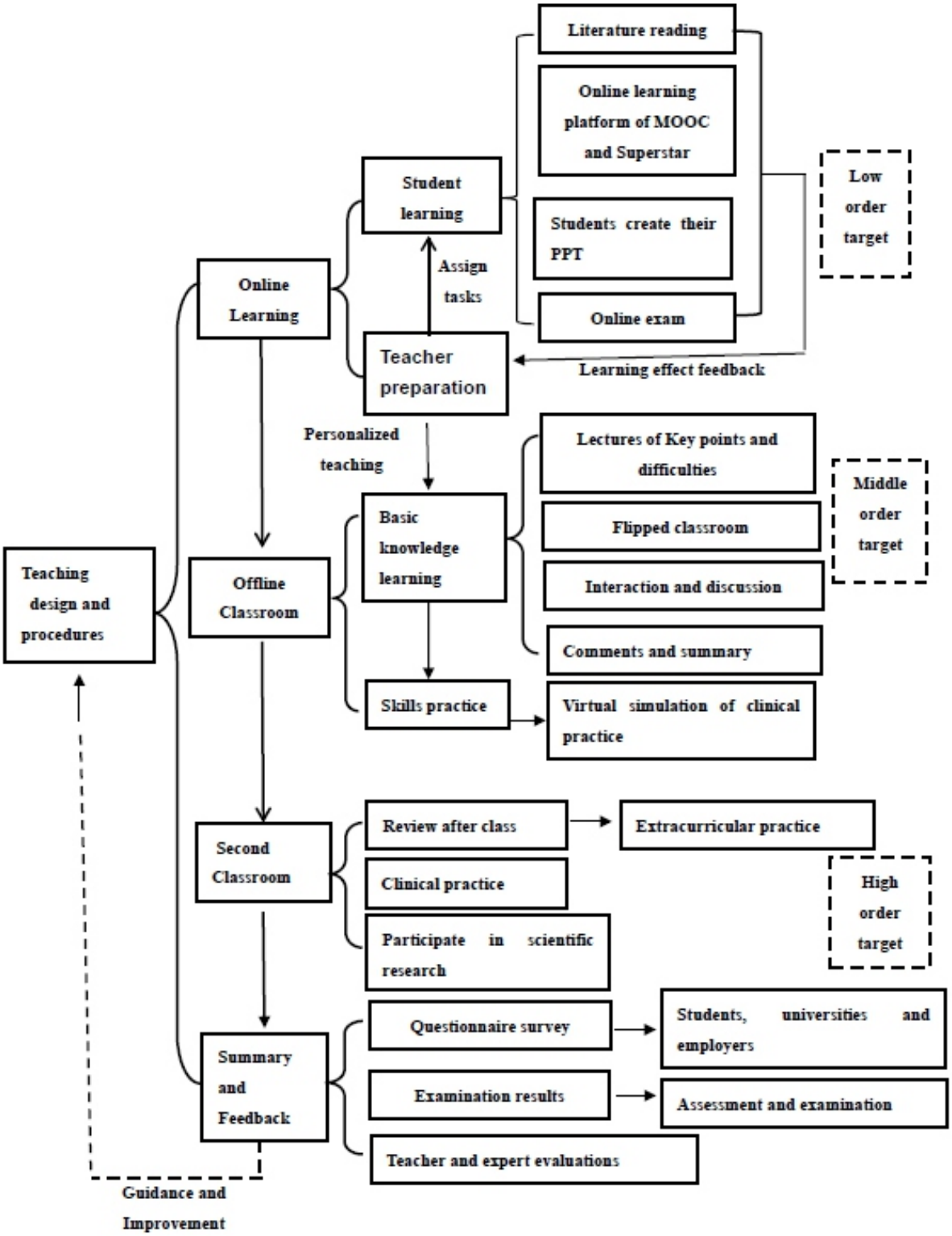

Figure 4. Teaching design.

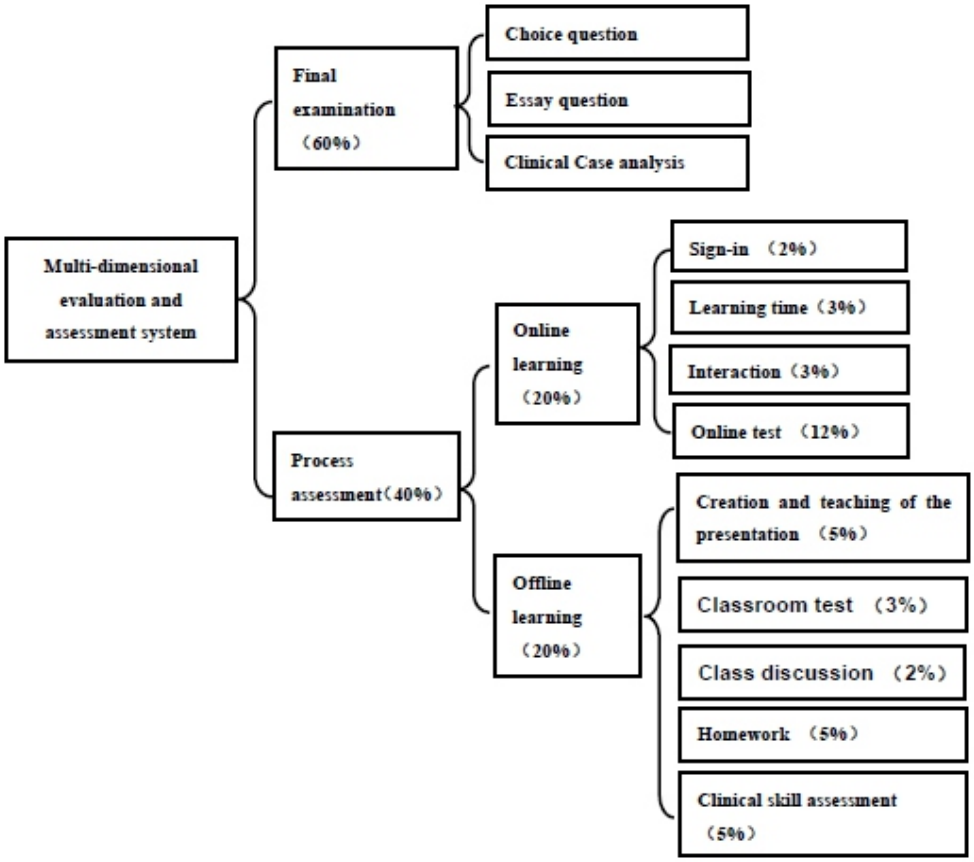

Figure 5. A multi-dimensional evaluation and assessment system.

aching effectively bridged the gap between theory and clinical practice and improved their overall learning outcomes. However, Operation complexity was identified as a concern by 19.5% (26/133) of the student cohort, particularly in multi-step procedural simulations. Furthermore, only 14.3% (19/133) of the students are highly willing to spend more time engaged in virtual simulation-based teaching and 96.2% (128/133) of the students agreed that it should complement traditional clinical practice instruction instead of being used alone.

Discussion

Traditionally, medical education has relied heavily on didactic lectures during the preclinical phase, serving as the primary means of information transfer from instructors to students. However, this model has faced significant challenges [7], prompting the need for modern learning techniques. New Medicine, in response to rapid technological advancements, calls for an update in teaching concepts and objectives to align with the evolving landscape of data-driven diagnostics and treatments. Our reform, guided by the OBE framework, aims to reset educational goals to meet the requirements of New Medicine while considering students' abilities. We have integrated humanistic education into the curriculum, enhancing clinical cases and incorporating virtual simulation and extracurricular practices. This approach not only fosters theoretical understanding but also deepens students' grasp of nuclear medicine technology through practical training. Our virtual simulation course in nuclear medicine is pioneering in the country, providing valuable insights and guidance for future educational practices.

In recent years, our teaching team has adopted various innovative methods, such as participatory teaching, problem-based learning (PBL), and case-based learning (CBL). These strategies have transformed the conventional lecture format and positively impacted student performance across basic medical sciences [8]. By leveraging platforms like MOOC and Superstar, we implemented a mixed teaching model that balances large-group instruction with student participation and independent learning. Students engage in discussions and presentations, promoting deeper internalization of knowledge, as they navigate both online content and in-person interactions. A survey results revealed that the oncampus practical training using simulators deepened students' understanding of the content they had encountered in classroom lectures, which provide oncampus practical training to students using simulators that enhance understanding of nuclear medicine technology [9]. By using a simulator to process nuclear medicine radionuclide clinical practice, students can repeatedly engage in operation processing and avoid radiation. Our course of virtual simulation in nuclear medicine is the first in the country, and the experience and shortcomings are summarized in practice, which provides ef-

fective guidance and reference for the informationization teaching practice of nuclear medicine. Despite these advancements, challenges remain, particularly regarding students' time allocation for studying nuclear medicine, which is often overshadowed by more recognized disciplines like internal medicine and surgery. The general lack of understanding of nuclear medicine among students and the public further complicates this issue.

In medical education, there are different evaluation tools to gauge the implementation of OBE, for instance, course reports appraisals, self-study evaluations, program annual reports, student surveys, and external and internal reviews [10]. Previously, our evaluation of learning relied solely on examination scores, which do not fully capture students' clinical abilities. To address this, we have diversified our assessment tools, incorporating course reports, self-evaluations, student surveys, and both internal and external reviews. Research has indicated that online assessments can yield results comparable to traditional lectures [11]. With OBE as our guiding principle, we have enhanced our evaluation system to include a variety of metrics-final exams, process evaluations, and both online and offline assessments-facilitating a more comprehensive evaluation of students' practical skills and innovative capabilities. Overall, our multi-dimensional evaluation demonstrated excellent student performance, with most participants believing that the hybrid teaching model significantly improved their understanding and application of nuclear medicine concepts. Additionally, the use of SBL was recognized for its effectiveness in bridging theoretical knowledge with clinical practice.

Limitations of the study and future research implications

One key limitation of this study is the difficulty in controlling the actual learning conditions of students during online instruction. Students may engage in passive learning, and online assessments could be compromised by collaborative efforts among classmates, leading to an inaccurate understanding of individual student progress. Additionally, the process evaluation is inherently subjective, which can affect the reliability of the results. Furthermore, we identified that the content of the virtual simulation resources does not always align perfectly with clinical applications. To enhance the undergraduate teaching reform in nuclear medicine, we plan to incorporate scientific knowledge graphs in future research. This approach will help us better understand students' and societal needs dynamically. We will also establish clear teaching objectives and refine our teaching plans, ensuring that the content of the virtual simulation practice platform is continuously updated and optimized for greater relevance to clinical practice.

In conclusion, this study, guided by the principles of OBE and incorporating SBL, investigates a mixed teaching model that effectively combines online and offline elements tailored to the needs of nuclear medicine. The multi-dimensional evaluation demonstrated outstanding student performance, and the questionnaire results indicated that the majority of students found the hybrid teaching approach beneficial for enhancing their understanding and mastery of the subject. Additionally, SBL proved effective in linking theoretical concepts to clinical practice. This teaching reform equips students with essential theoretical knowledge and practical skills, fostering a strong foundation in medical humanities, a spirit of scientific inquiry, and clinical competency, thereby aligning with national objectives for advancing New Medicine and intelligent education.

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The authors declare that they have no conflicts of interest.

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