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Innovative Assessment Strategies in Radiological Physics Education: A Mixed-Methods Study

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Abstract

Radiological Physics and Radiation Protection is a discipline focused on the generation, properties, measurement, and interactions of ionizing radiation (e.g., X-rays, γ-rays) with matter. Course assessment serves as a fundamental approach to evaluate the quality of talent development. This study analyzes the limitations of the traditional assessment model for the Radiological Physics and Radiation Protection course, introduces the Russian examination framework, and proposes an innovative oral examination model integrated into the teaching process. A pilot implementation was conducted with 22nd-grade Medical Imaging Technology students at Chengdu Neusoft University. Results demonstrate that this reform enhanced students' knowledge mastery, stimulated learning engagement, and fostered innovative thinking. The novel assessment model has achieved preliminary success, with plans for ongoing refinement and exploration.

Keywords

Radiological Physics and Radiation Protection; assessment model; examination reform; pedagogical reform.

1. Introduction

The Radiological Physics and Radiation Protection course is a critical foundational discipline for Medical Imaging Technology students, encompassing essential knowledge in nuclear physics, X-ray technology, radiotherapy, and radiation protection. Mastery of this course not only cultivates students' competencies in radiation safety for diagnostic and therapeutic procedures but also establishes a foundational understanding of nuclear physics for advanced studies in nuclear medicine and radiotherapy techniques. [1] However, based on prior teaching observations, the heterogeneous academic backgrounds of Medical Imaging Technology students—particularly insufficient preparation in high school physics and chemistry—combined with heavy concurrent course loads in the same academic year, create challenges in comprehensively assessing knowledge acquisition through traditional single-examination models. [2] Aligned with the OBE (Outcome-Based Education) framework, both radiological physics and radiation protection are pivotal for bridging subsequent professional knowledge (e.g., clinical applications) and workplace requirements (e.g., radiation safety protocols). This necessitates a thorough command of the subject, prompting the development of targeted assessment strategies to address these pedagogical gaps. [3]

2. The Problems Associated with The Original Examination Model

2.1. The monotonous examination format impedes progress

The current domestic examination model typically employs standardized tests to assess students' learning outcomes. Regardless of whether the examination format is open-book,

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closed-book, or semi-open-book, this approach remains monotonous and rigid. Such examinations predominantly evaluate students' ability to reproduce knowledge, thereby fostering common practices such as "copying notes in class, studying notes after class, memorizing notes before exams, and forgetting everything after exams," as well as last-minute cramming. Furthermore, relying solely on a single examination makes it difficult to fairly and objectively evaluate students' mastery of the course material. It also fails to effectively reflect teachers' instructional effectiveness, thereby hindering the implementation of teaching adjustments that could better promote student development in subsequent academic cycles. [4]

2.2. Current examination models tend to focus on individual knowledge points while neglecting comprehensive ability assessment

Traditional examination methods tend to focus on the assessment of individual knowledge points, with a limited scope of coverage. This rigid approach lacks flexibility, leading to monotonous learning experiences for students. Students often gain only fragmented knowledge of individual concepts rather than developing a systematic understanding by connecting these points. Furthermore, this approach discourages the development of students' proactiveness and creativity, thereby restricting the cultivation of open-minded thinking and innovative capabilities. [5]

2.3. Neglecting formative assessment and providing insufficient learning feedback

Traditional teaching models may lead to disengagement among some students during regular classes, as they focus solely on review sessions yet still achieve high scores. Over time, this can erode students' enthusiasm for classroom participation and encourage passive absorption of knowledge imparted by instructors. Additionally, teachers may rush through the curriculum to cover all textbook content, resulting in limited classroom interaction and an inability to effectively monitor student progress. [5]

3. Drawing on Russian University Examination Models

Based on the Russian higher education examination model, most final exams are conducted orally. Multiple sets of questions are sent to students before the exam, and students draw a set to prepare and answer. In addition to answering the drawn questions, teachers may ask additional questions based on the student's response, allowing students to fully express their views and opinions. This approach enables teachers to flexibly assess students' comprehensive application of knowledge, thoroughly understand their grasp of the material, and evaluate their problem-solving abilities. It also encourages students to take initiative and cultivates their analytical and problem-solving skills. [6] Therefore, aiming to enhance students' ability to apply knowledge, analyze and solve problems, strengthen their mastery of professional knowledge, and foster open-minded thinking and innovation, we integrate the TOPCARES training program with the Russian higher education examination model. Using the Dongsoft Smart Education Platform, we explore creating a comprehensive examination model that measures knowledge, ability, and quality. With students at the center, we aim to help them build a knowledge framework for their courses, making their understanding of knowledge more structured and enhancing their grasp of the knowledge system. By leveraging exams as a "guiding tool," we encourage students to learn actively, thoughtfully, and creatively, achieving harmony among teaching, learning, and assessment. During the teaching process, combining written and oral exams allows for a systematic evaluation of students' understanding, divergent thinking, innovation, and communication skills, fully showcasing their comprehension, logical thinking, and verbal expression abilities. [7, 8]

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4. Implementation of Examination Reform

4.1. Content of examination model reform

Drawing on Russia's examination model, teaching methods are adjusted based on written and oral exam performance, enabling exams to comprehensively reflect students' knowledge understanding, logical thinking, and verbal expression. The reform focuses on enhancing students' grasp of professional knowledge, fostering open-minded thinking, and encouraging the use of mind maps. Leveraging the Dongsoft Smart Education Platform, the reform combines written tests with innovative oral exams to systematically assess students' understanding, divergent thinking, innovation, and communication skills. This approach fully showcases students' comprehension, logical reasoning, and verbal expression abilities. Since purely theoretical courses rely entirely on understanding and memorization, unlike practical or engineering courses, which are more engaging and easier to remember, most courses in medical imaging technology are theoretical. Moreover, in the current employment environment, students need a high level of knowledge mastery and sufficient reserves to handle emergencies, necessitating the integration of various knowledge domains. [9, 10]

4.2. Specific implementation plan for examination model reform

Given the large student population, fully adopting Russia's combined written and oral examination model for final assessments is challenging. Instead, this format can be integrated into daily teaching, with oral exams conducted at the end of each major unit module, as shown in Figure 1. During implementation, instructors should introduce the new model to ensure students achieve the expected outcomes during oral exams and systematically connect the knowledge. The specific implementation plan includes the following three components:

(1) Question Quality: Oral exam questions should focus on the core knowledge points of the module, with moderate difficulty. The key goal of this exam reform is to encourage students to integrate knowledge points. Additionally, instructors should prepare divergent questions in advance for each topic to facilitate open-ended discussions.

(2) Oral Exam Monitoring: After the oral exam, promptly compile students' divergent questions as part of the teaching feedback process.

(3) Exam Summary: After the assessment, collect relevant evaluations and feedback from teachers and students to reflect on the reform's effectiveness and make appropriate adjustments based on the feedback. Following the exam, revisit the oral exam questions in class with additional divergent questions. This helps students gain a more intuitive understanding of the reform's changes and prepares them for future oral exams.

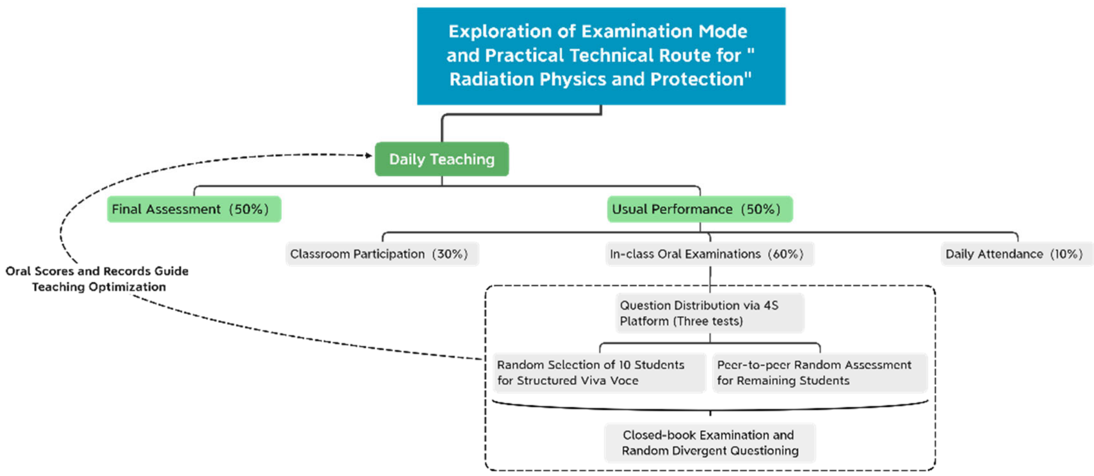

Figure 1. Examination Model Structure Diagram

5. Effectiveness of Examination Reform

The core of this reform lies in breaking the rigid framework of "single-exam determines performance" and promoting a shift towards a competency-oriented evaluation system. By introducing a diverse and dynamic assessment model, students transition from passive test-taking to active participation in the learning process, effectively enhancing their knowledge application and innovation skills. Additionally, formative assessment now accounts for over 50% of the evaluation, combined with real-time learning data feedback through digital platforms, enabling teachers to precisely adjust their teaching strategies. Through this examination reform, an innovative teaching reform approach that integrates the teaching process with examination reform has been proposed. This approach focuses on improving students' comprehensive quality and promoting the overall quality of talent cultivation.

After implementing the reformed examination model, teachers can promptly receive feedback, identify issues, and make appropriate adjustments to improve teaching effectiveness and help students better absorb knowledge. Moreover, innovations in course examinations have driven improvements in teaching methods, renewal of teaching content, and innovation in teaching models, significantly enhancing teaching quality and ensuring students gain substantive knowledge.

While the examination reform has achieved phased progress, ongoing feedback and exploration remain necessary. This exploration also indicates that innovative adjustments to assessment methods during teaching can lead to better educational outcomes.

6. Conclusion

Reform of the examination method for the "Radiation Physics and Protection" course for the 2022 cohort of medical imaging technology majors at Chengdu Neusoft Institute of Information has shown that this assessment approach can compensate for the traditional method's shortcomings to some extent. This is evident in increased student enthusiasm, engagement, and learning efficiency, as well as in better teacher understanding of student learning. Most notably, students' retention of knowledge has improved. For instance, during this year's "Nuclear Medicine" class for the 2022 cohort, most students could still recall relevant knowledge points when asked about basic nuclear physics knowledge previously taught in "Radiation Physics and Protection."

Incorporating oral exams for each major knowledge module into the teaching process emphasizes formative assessment. Unlike traditional exams, it doesn't rely solely on final exam scores to evaluate learning outcomes, making the assessment more objective and comprehensive.

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