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Research Progress on Computer-Based Case Simulation Based on Performance Assessment in Educational Evaluation

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Abstract:

Due to the transformation of medical mode and enhancement of people's awareness of self-protection, computer-based case simulations (CCS) have been developed and applied in medical education and evaluation. With the increasingly important function of the computer in examination evaluation, grading, and other aspects, performance assessment has become an emerging evaluation method adopted in the development and pilot application of CCS exams. This paper mainly clarifies the background information, construction of the evaluation plan, as well as the application prospect of CCS based on performance assessment in educational evaluation, and provides a basis for improving the reliability and validity of CCS evaluation.

Keywords:

Computer-based case simulation
Performance assessment
Medical education evaluation

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1. Introduction

Performance assessment is a method used to measure and evaluate students' ability to solve real problems using previously acquired knowledge through behavioral manifestations beyond objective testing in real-world scenarios [1]. Competency assessment has become an important component in the field of medicine. Considering the strong operational nature of medical courses, the application of performance assessment in medical education evaluation is appropriate [2]. Computer-based case simulation (CCS) exams, which are widely used in medical education evaluation, are primarily implemented based on performance assessment [3]. CCS involves a complex, unprompted, dynamic, and interactive simulation of the patient's diagnosis and treatment environment by a computer [4]. As a tool for performance evaluation, CCS aims to measure the participant's ability to manage patients through simulated time progression and the gradual unfolding of clinical case scenarios in a realistic environment. In 1999, the United States took the lead in applying CCS to the third stage of the United States Medical Licensing Examination (USMLE) [5].

In 2001, China Medical University undertook a project from the National Medical Examination Center to initiate research on the development and application of a domestic computer-based case simulation examination system [6]. This article analyzes the implementation background, evaluation scheme construction, and application prospects of CCS based on performance assessment in educational evaluation, aiming to provide a basis for improving the reliability and validity of computer-based case simulations.

2. Background of implementation

Performance assessment has a long historical origin, mainly focusing on qualitative evaluation in its early stages. With the emergence of quantitative evaluation, performance assessment fell into a low ebb. In the late 1960s, with the widespread popularity of psychological measurement evaluation paradigms, performance assessment once again appeared in people's field of vision. In the medical field, a new form of performance assessment emerged as computer-based case simulation (CCS) [7].

To cultivate innovative talents for the 21st century, basic education curriculum reforms are being carried out worldwide. With the continuous deepening of these reforms, the status of performance assessment is becoming increasingly prominent in the current evaluation reforms. The goal of performance assessment is to implement and test through authentic situational tasks, which are characterized by authenticity, contextuality, and complexity. Therefore, when completing learning tasks, students must demonstrate constructive responses, rather than merely selective reactions [8]. Performance assessment focuses on evaluating students' comprehensive abilities, as well as their internal dispositions such as logical thinking, attitudes, emotions, and values [9]. Unlike the traditional "point-to-point" teaching method and the evaluation of fragmented knowledge points, integrating performance assessment into CCS achieves a simultaneous transformation of curriculum design and evaluation design, while also driving students to engage in deep learning [10]. Some basic designs and principles of performance assessment originate from constructivist theory, especially constructivist learning theory. In the implementation process of performance assessment, students are deeply involved, assuming the role of learning subjects, and actively constructing answers or engaging in activities.

Constructivist learning theory posits that learning is not a passive reception of knowledge, but rather an active participation in the process of knowledge construction, encouraging learners to think critically. From a constructivist perspective, when learners encounter new information or experiences that do not fit their existing patterns, they must redesign existing schemes or construct new ones. Therefore, activating prior knowledge is crucial to the learning process [11]. Through simulating clinical scenarios, CCS provides a platform for medical students to reconstruct theoretical knowledge, which is conducive to promoting the cultivation of their clinical thinking. Simultaneously, it also facilitates the evaluation of medical students' knowledge levels and clinical skills. As an evaluation method, performance assessment plays a vital role in medical education evaluation.

3. Construction of evaluation scheme

The framework for CCS teaching design is partially based on Cook's e-Learning research model, which boasts potential advantages such as flexibility, controllability, and the ability to collect data for evaluation and feedback [12]. This framework utilizes four levels of teaching design to describe educational activities: The first level is teaching media, including textbooks, lectures, computer simulations, etc.; the second level is teaching format, consisting of computer simulations, simulated patients, simulated clinical immersions, and process simulations; the third level is teaching methods, encompassing self-directed learning and teacher-guided learning; and the fourth level is presentation format, which involves feedback, fidelity, simulator type, scenarios, and team composition. At each level, the choices made depend on the actual learning needs and objectives of the activity.

The design of a performance evaluation scheme typically consists of three components: determining evaluation objectives, setting performance tasks, and establishing evaluation criteria [13].

3.1. Determining evaluation objectives

The design and implementation of any evaluation scheme must first address "what are the evaluation types and purposes?" and "why is the evaluation being conducted?" [14]. From a theoretical perspective, the purpose of evaluation is for practical application and self-reflection; from a practical standpoint, the aim of student performance evaluation is to highlight each student's uniqueness, complexity, and authenticity, using evaluation to help every student recognize their own unique significance and self-worth [15]. In clinical teaching, the objective of performance evaluation is to promote and support learning through evaluation, stimulate students' learning motivation, enhance self-confidence and satisfaction, strengthen clinical decision-making abilities, and improve students' clinical competency by evaluating their practical skills and problem-solving abilities. In professional qualification assessments, performance evaluation aims to effectively examine candidates' practical abilities and problem-solving skills, providing a strong guarantee for improving the predictive validity of qualification assessments.

3.2. Setting performance tasks

Performance evaluation is accomplished through observation and analysis of the evaluated individual's actual performance in completing tasks within specific contexts [9]. The essence of setting performance tasks is designing situations and activities based on evaluation objectives, a process of contextualizing evaluation goals. Educator Eisner pointed out that evaluation task setting should strive to meet eight principles, which are also applicable to performance task design [16]: (1) Tasks should truly reflect the problems and tasks encountered in the situation and must be able to assess what students know and can do; (2) They should demonstrate students' thinking, observation, and reasoning about problems; (3) They should embody the values of the community they represent; (4) They can be completed individually or in group collaboration; (5) Multiple performance tasks should be allowed for the same objective; (6) Performance task design should be curriculum-adaptive; (7) Performance evaluation is not simply about reflecting students' ability to partially perceive problems but rather their sensitivity to the structure of things or problems and their overall control ability when completing tasks; (8) Performance evaluation should emphasize students' subjectivity, be meaningful to them, involve them in problem-solving, and help them perform better during task completion. The scientific, clarity, and operability of performance task setting determine the effectiveness of evaluation implementation.

3.3. Establishing evaluation criteria

The establishment of evaluation criteria is the fundamental guarantee for the smooth implementation of evaluations. Performance evaluation refers to a set of standards used to measure students' performance and outcomes during the task completion process. It mainly includes typical learning behavior language descriptions and grade judgments [17]. Essentially, it involves a hierarchical description of the performance process that students should exhibit during evaluation activities or outcomes, based on specific performance evaluation objectives. These criteria must satisfy the following requirements: (1) Clearly providing specific and unambiguous performance standards, stated in concrete and measurable terms; (2) Feasibility, which means that students should be able to achieve the established standards, and the standards should be implementable and operable; (3) Credibility, referring to the consistency, stability, and reliability of test results based on the evaluation criteria. The development of good evaluation criteria not only requires guidelines for formulating and modifying scoring rules but also necessitates an optimal chronological order for various matters during the scoring rule design process. For evaluation, a useful set of scoring methods and guiding principles can serve not only to judge the effectiveness of design work but also to help students improve their self-evaluation abilities. In CCS exams, candidates complete cases, which generate an execution list. This list provides a comprehensive record of the candidate's performance, showcasing every execution behavior during simulated time [18]. For example, the scoring system of the USMLE is based on overall performance in three categories: clinical reasoning, diagnostic performance, and patient management. Although each category has different scores, the final cumulative score is weighted, with 50% for clinical reasoning, 40% for diagnostic performance, and 10% for patient management [19].

4. Application prospects

4.1. Teaching training and evaluation

Computer-simulated cases offer convenience in terms of time and location, and the virtual patients within these cases provide interactivity. Therefore, CCS has been widely applied in program development for individual cases, teaching and training, as well as evaluation. By actively engaging students' knowledge, expanding simulation experiences, and strengthening active learning processes, CCS bridges the gap between acquiring knowledge and gaining experiential knowledge, promoting the learning of specific diseases or skills [20]. For instance, in simulation laboratories, students often feel pressured and anxious when analyzing clinical situations while learning clinical dispositions within a limited time [21]. CCS can be used as a transitional preparation for students before they enter simulation experiments. Combining CCS with face-to-face simulation experiences can enhance students' learning potential by recalling textbooks and strengthening knowledge acquisition [22]. With the help of high-fidelity simulators, good scenarios can be constructed, and participants' clinical abilities can be reliably evaluated through multi-station assessment tasks.

4.2. Professional qualification recognition

CCS is gradually becoming an important means of professional qualification recognition. The Assessment Center Program (ACP), jointly initiated by the USMLE and the Federation of State Medical Boards (FSMB), utilizes CCS to assist state medical associations in evaluating the clinical abilities of physicians whose skills are being questioned. Researchers at the University of Texas have developed CCS to identify errors made by emergency medicine residents in patient management [18]. The nursing profession also emphasizes the use of CCS and virtual patients to evaluate practical abilities. Both qualitative research [22] and clinical studies [23-25] have shown that CCS contributes to the improvement of students' abilities at different levels: (1) clarifying the roles and models of nursing care; (2) providing personalized learning experiences; (3) compensating for the rarity of critical cases in classroom and clinical teaching; (4) learning the priority of clinical problem-solving and enhancing clinical reasoning abilities; (5) reducing anxiety levels and boosting confidence in clinical work. The National Council of State Boards of Nursing (NCSBN), which administers the NCLEX-RN examination, has studied and indicated that simulation can replace 50% of traditional clinical experience as long as the implementation plan meets specific design conditions [26].

5. Suggestions for implementing CCS education evaluation based on performance assessment in China

5.1. Emphasis on assessing real clinical practice abilities in professional competency evaluation

The current clinical qualification examinations for physicians and nurses in China still primarily focus on clinical knowledge when comprehensively assessing candidates' professional qualities, making it difficult to evaluate candidates' clinical behavior in real situations [27]. To comprehensively and effectively assess candidates' clinical practice abilities and select qualified talent for the medical industry, professional qualification certification bodies should deeply understand the value and significance of performance assessment. They should prioritize candidates' work performance and practical knowledge in real clinical situations, gradually introduce performance assessment into qualification certification, improve the predictive validity of the evaluation, and identify excellent applicants.

5.2. Strengthening training in performance assessment skills for teachers

There is a certain gap between virtual case design and real clinical doctor-patient interaction, and the predictive validity of the evaluation needs to be improved. Firstly, it is essential to ensure that the scenarios and tasks are challenging and authentic [28]. Authenticity is a fundamental characteristic of performance assessment goals, while challenge is a prerequisite for evaluating core competencies. Only by ensuring the authenticity of scenarios and tasks can evaluators have the opportunity to assess students' abilities to apply knowledge and solve problems in real situations, effectively extrapolating their performance in similar tasks. Only by ensuring the challenge of scenarios and tasks can students' potential be stimulated, inducing the occurrence of core competency

behaviors. Secondly, the connection between scenarios and tasks should be strengthened [29]. Scenarios and tasks are formal elements of performance assessment questions. Tasks are performed in a specific context, and the context provides necessary clues for task completion. The mutual reliance and support between scenarios and tasks make it possible for performance assessment to examine students' problem-solving abilities in specific situations. If scenarios and tasks are separated, there will be a disconnect between evaluation form and content, meaning the tasks are not truly embedded in the scenarios, and the validity of performance assessment will inevitably decrease. Only by improving the question review and enhancement mechanism, ensuring the validity, reliability, and fairness of performance assessment, can we truly leverage the positive effects of performance assessment and facilitate profound reforms in medical education teaching and evaluation practices in China.

5.3. Importance of research on the quality of CCS education evaluation

The common method for evaluating medical students is modular, with each module assessment yielding a score. Students can graduate after passing all module assessments, but this model has many drawbacks [30]. It is ineffective to judge a medical student's clinical qualification based solely on exam scores obtained through rote memorization. To better evaluate students' skill levels, research on computer-simulated case assessments based on performance evaluation has been conducted and applied [31]. The assessment method of computer-simulated cases can evaluate the subject's level of safe practice skills and abilities and distinguish different performance levels between novices and experts [32]. CCS simulation teaching strategies are widely used in medical education, but domestic research on the effectiveness of these learning strategies, especially from the student's perspective, focusing on student and patient outcomes, is still insufficient [22]. Additionally, there are hundreds of clinical operations to choose from in the CCS exam, and more than 20% of candidates have performed at least one dangerous operation. The dangerous operation tendencies vary in each clinical case, and dangerous operations in the exam can potentially reflect the subject's tendency to perform similar operations in actual clinical work [33]. Clinical healthcare workers, educators, simulation experts, and researchers should strive to develop computer simulation in a scientific direction. Understanding the cognitive state of simulation science is key to advancing simulation science and will enable future research related to improving simulation science [34].

6. Conclusion

In summary, performance assessment, as an emerging evaluation method, has been developed and piloted in computer-simulated case exams as computers play an increasingly important role in exam administration and scoring. Drawing on the research and application experience of performance assessment can help advance the development and research process of computer-simulated cases in China and enhance the reliability and validity of education evaluation.

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