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The Integration of Digital-Intelligent Innovation Models with the Teaching Reform and Practice of Health Assessment Courses

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Abstract: With the rapid advancement of digital technologies and artificial intelligence, the field of higher education is undergoing profound transformations. As a core course in medical education, the Health Assessment curriculum faces significant challenges, including lagging updates to teaching content, limited teaching methodologies, and inadequate practical components. Grounded in the concept of digital-intelligent innovation and leveraging the Superstar Learning Platform, this study has developed a tripartite teaching model for the Health Assessment course—comprising "Knowledge Graph + Virtual Simulation + BOPPPS". By integrating the comprehensive process management functionality of the Learning Platform, virtual simulation technologies, and a knowledge graph engine, this model enables dynamic optimization of teaching content, diversified transformation of teaching methods, and more precise instructional assessment. Following two semesters of classroom implementation, students in the experimental group demonstrated significantly superior performance compared to those in the control group across all metrics—including theoretical knowledge mastery, clinical skill application, and comprehensive assessment capabilities (p <0.05); furthermore, their teaching satisfaction rate increased to 92.3%. This study demonstrates that the digital-intelligent innovation approach can effectively enhance the teaching quality of the Health Assessment course and improve students' learning experience, offering a valuable reference framework for the reform of nursing education.

Keywords: Digital-intelligent innovation; Virtual simulation; BOPPPS

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1. Introduction

1.1. Research background

Health Assessment serves as a bridging course that connects basic medical sciences with clinical practice, aiming to cultivate students' core competencies in systematically collecting patient health data, identifying health problems, and formulating nursing diagnoses. However, traditional teaching approaches face three major challenges: first, the pace of updating instructional content lags significantly behind the rapid evolution of clinical practice; a 2021 survey revealed that the average update cycle for Health Assessment textbooks used in Chinese medical schools was as long as 4.7 years; second, teaching methods remain overly simplistic, predominantly relying on classroom lectures, which result in students passively absorbing knowledge without engaging in immersive learning experiences; third, there is a shortage of practical training resources—the average teacher-to-student ratio for nursing programs nationwide is 1:18.6, leaving limited opportunities for clinical practicum experiences [1]. In recent years, the Chinese government has vigorously promoted the digital transformation of education. The “Next-Generation Artificial Intelligence Development Plan” explicitly calls for “leveraging intelligent technologies to accelerate the reform of talent cultivation models”. Against this backdrop, exploring the deep integration of digital and intelligent technologies into the Health Assessment curriculum has become a key breakthrough for enhancing the quality of medical education [2].

1.2. Research significance

The theoretical significance of this study lies in enriching and developing the medical education and teaching theory framework for the digital and intelligent era, as well as exploring pathways for transforming the “learner-centered” teaching paradigm under the energization of technology [3]. At the practical level, by establishing a replicable and scalable digital-intelligent teaching model, this study provides solutions to longstanding challenges in the health assessment curriculum—such as the disconnect between theory and practice and the lack of personalized teaching approaches—holding significant practical relevance for cultivating high-caliber nursing professionals suited to the era of smart healthcare [4].

2. Literature review and research framework

2.1. Research progress in digital and intelligent education

Research on digital-intelligent education by scholars both domestically and internationally primarily focuses on three dimensions: first, the construction of intelligent learning environments—for example, the AI-assisted teaching system developed by Stanford University in the United States can provide 24-hour Q&A services; second, the application of learning analytics technologies—research conducted at the Open University in the UK has shown that interventions based on learning behavior data can increase course pass rates by 23%; third, the exploration of blended teaching models—Chinese scholars have proposed an integrated approach combining “MOOCs + flipped classroom + virtual simulation”. However, most existing studies concentrate on general education, while systematic research specifically targeting medical professional courses, particularly health assessment, remains relatively scarce [5].

2.2. Current status of health assessment teaching reform

The current pedagogical reform in health assessment education primarily focuses on three key areas: case-based learning (CBL), problem-based learning (PBL), and the application of standardized patients (SP). A meta-analysis encompassing 12 institutions demonstrated that the PBL approach can increase clinical thinking competency scores by 15.8%; however, it faces challenges such as high faculty training costs and significant implementation difficulties. The introduction of virtual simulation technology offers a new approach to addressing these challenges; nonetheless, its current applications remain limited to isolated skill-training sessions, lacking comprehensive, systematic instructional design [6]. The BOPPPS model, a teaching design framework that emphasizes student engagement and immediate feedback, has proven effective across various disciplines; however, its systematic application within health assessment curricula remains underutilized.

2.3. Construction of the research framework

This study builds upon constructivist learning theory and the BOPPPS instructional design model to develop a four-dimensional, synergistic digital-intelligent innovation teaching framework encompassing "Technology–Content–Method–Evaluation". The Technology layer utilizes the Superstar Learning Platform as its core platform, integrating a knowledge graph engine and a virtual simulation training system; the Content layer enables knowledge graphing, resource granularization, and intelligent content updating; the Method layer adopts the BOPPPS six-step approach as its central framework, incorporating adaptive learning, collaborative inquiry, and contextual simulation; the Evaluation layer leverages the statistical analysis capabilities of the Learning Platform and in-class quizzes to collect formative data and provide immediate feedback [7].

3. Construction of the digital-intelligent teaching system

3.1. Intelligent teaching platform architecture

This study utilizes the SuperStar Learning Platform (hereinafter referred to as the "Learning Platform") as a foundational teaching management platform, upon which two core modules have been independently developed: the Knowledge Graph Engine and the Virtual Simulation Training System. The overall architecture is as follows:

3.1.1. Xuexutong basic platform

Handles routine teaching management functions such as course resource publishing, notifications and announcements, attendance tracking, group assignments, assignment submission, online examinations, and discussion forum interactions. Xuexutong supports seamless integration between PC and mobile devices, enabling students to complete previewing, reviewing, and interactive activities anytime and anywhere via their mobile phones. Teachers can utilize its statistical analysis tools to monitor students' learning progress, assignment completion rates, and quiz accuracy distributions, thereby enabling preliminary monitoring of learning behaviors.

3.1.2. Knowledge graph engine

This engine decomposes health assessment knowledge points into 327 smallest units, constructs a relational network, and supports personalized learning path recommendations. The engine is embedded as a plugin within the Xuetong course page; students can simply click to access the knowledge graph view. Based on pre-test results, the system automatically generates a learning plan; the test results show that the average time required for students to master all knowledge points has been reduced from 68 days under the traditional teaching model to 41 days.

3.1.3. Virtual simulation training system

This system develops 16 virtual case scenarios covering all bodily systems and utilizes the Unity 3D engine to construct a high-fidelity 3D hospital environment. The system incorporates built-in physiological signal simulators capable of generating real-time parameters such as heart rate, blood pressure, and breath sounds, while supporting interactive operations like auscultation and palpation. The system integrates with the Xuetong platform via an API; upon completion of the virtual training session, the system automatically transmits the student's scores and time tak'en back to the Xuetong gradebook.

3.2. Reconstruction of teaching content

This course incorporates "Assessment of Common Symptoms and Clinical Reasoning Training" as an independent teaching module, comprising a total of 18 credit hours, which accounts for 28.1% of the total credit hours. This module focuses on the systematic assessment methods and clinical reasoning training for 10 common clinical symptoms, including fever, pain, dyspnea, edema, and jaundice. Based on Bloom's Taxonomy of Cognitive Objectives, the course content is restructured into four levels:

3.2.1. Memory and understanding module

Design 10 role-playing scripts, each corresponding to a common symptom, with each script lasting 8–10 minutes. Students will work in groups to assume roles such as nurses, patients, or family members, completing the medical history taking and preliminary assessment within these simulated scenarios. Each script incorporates interactive questioning segments, requiring students to make immediate judgments and provide explanations for their decisions.

3.2.2. Application analysis layer

Designs 42 typical case studies, equipped with mind maps and decision trees, and is published in the LearningTong Resources module.

3.2.3. Comprehensive assessment layer

This layer features 12 comprehensive practical training projects, requiring participants to complete the full health assessment process via the virtual simulation training system.

3.2.4. Innovation and expansion layer

Introduces the latest clinical guidelines and research advancements, updated monthly via the Xuetong platform. See **Table 1**.

Table 1. A comparison of the content between traditional teaching and data-driven intelligent teaching

Dimension	Traditional model	Digital and intelligent transformation model
Knowledge carrier	Paper-based textbooks (average of 300 pages)	Role-playing script + Digital teaching materials + VR scenarios
Update frequency	Revised every 4–5 years	Monthly online updates
Number of cases	Fixed at 20–25 items	Dynamically expanded to 86
Practical proportion	Theory: Practice = 6:4	Adjusted to 4:6
Degree of personalization	Unified Timeline	Adaptive Learning Pathway

3.3. Innovation of BOPPPS-Based teaching methods

The BOPPPS model divides a complete teaching activity into six stages: Introduction (Bridge-in), Objective, Pre-assessment, Participatory Learning, Post-assessment, and Summary. This study integrates the BOPPPS model deeply with a digital-intelligent platform to develop a "three-stage progressive" teaching strategy:

3.3.1. Pre-class phase (Bridge-in + Pre-assessment)

Teachers use the Xuetong platform to publish introductory videos or clinical case studies to spark students' interest; subsequently, they distribute a pre-assessment questionnaire, which is automatically graded by the system to generate a learning progress report. Based on the pre-assessment results, the knowledge graph engine then delivers personalized preview resources. The average time spent on preview by students increased from 12 minutes to 28 minutes, while the achievement rate for preview tasks rose from 43% to 81%.

3.3.2. Class session phase (Objective + Participatory Learning)

After presenting the learning objectives, the teacher organizes participatory learning activities: group discussions (based on LearningTong's group assignments), virtual simulation exercises, role-playing performances, quick-response quizzes, and voting sessions. The teacher flexibly adjusts the pacing based on real-time interactive data from the LearningTong backend system, resulting in a 35% increase in classroom engagement.

3.3.3. Post-assessment & Summary phase

Teachers can publish post-test questions via Xuetong, where the system automatically grades the multiple-choice questions. Finally, teachers record a summary video to consolidate key concepts and challenging points. Students can watch this video repeatedly and utilize the virtual simulation training system for additional practice; the average number of practice sessions per student increased from 2.3 to 6.8.

The BOPPPS model establishes a closed-loop feedback system consisting of "pre-test – participation – post-test"; the LearningTong statistical feature automatically aggregates data from each session, helping teachers continuously refine their teaching practices.

4. Empirical research and data analysis

4.1. Study subjects and methods

This study selected 186 students from four nursing classes of the Class of 2025 at a certain medical university as research subjects, who were randomly assigned to either the experimental group (n = 94) or the control group (n = 92). No statistically significant differences were observed between the two groups in terms of gender, age, admission scores, or other relevant factors ($p > 0.05$). The experimental group adopted a digital-intelligent innovation teaching model based on LearningTong and the BOPPPS framework, whereas the control group continued to use a traditional teaching model (classroom lectures + printed textbooks + basic multimedia resources); both groups utilized the same instructors, with each group receiving 64 credit hours of instruction.

4.1.1. The evaluation indicators include the following four items

(1) Module-based theoretical knowledge assessment

Conducted as a closed-book written examination, comprising single-choice questions (40 items, 1 point per item), multiple-choice questions (10 items, 2 points per item), short-answer questions (4 items, 5 points per item), and case study questions (2 items, 10 points per item), with a total maximum score of 100 points. The test questions cover all knowledge points within the module, and the difficulty coefficient, as assessed by experts, ranges from 0.65 to 0.75. Reliability analysis shows that Cronbach's α = 0.81.

(2) The clinical skills assessment (OSCE format, maximum score: 100 points) employs the Objective Structured Clinical Examination (OSCE), comprising six stations: medical history taking, vital signs measurement, cardiopulmonary auscultation, abdominal palpation, neurological examination, and comprehensive assessment report. Each station is timed at 10 minutes; scores are independently evaluated by two trained examiners, with the final score calculated as the average of their ratings. The scoring criteria follow the "Health Assessment OSCE Scoring Guidelines" established by this institution, with a total possible score of 100 points, and the weightings for each station being 20%, 15%, 15%, 15%, 15%, and 20%, respectively.

(3) The Learning Engagement Scale adopts an adapted version of the NSSE-China (National Survey on Student Learning Engagement) scale, which comprises three dimensions—behavioral engagement (8 items), cognitive engagement (7 items), and emotional engagement (6 items)—totaling 21 items. The scale uses a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree), with total scores ranging from 21 to 105. The Cronbach's α coefficient for the scale is 0.87, and confirmatory factor analysis demonstrated good fit (CFI = 0.93, RMSEA = 0.06). Example items include: "I spend time outside of class reviewing the key operational points of health assessment" (behavioral engagement); "I try to analyze patients' symptoms using different methods" (cognitive engagement); "I am highly interested in the health assessment course" (emotional engagement).

(4) Teaching satisfaction questionnaire

This self-developed questionnaire comprises four dimensions—course content, teaching methods, platform experience, and overall evaluation—and contains a total of 18 items. It employs a 5-point Likert scale (1 = Very Dissatisfied; 5 = Very Satisfied), with a total score range from 18 to 90 points. The questionnaire was reviewed by five nursing education experts; its content validity index (S-CVI) was 0.92, and Cronbach's α was 0.87. Additionally, two open-ended questions were included: "Which teaching component do you find most satisfactory?" and "What aspects do you believe need improvement?"

4.2. Results analysis

4.2.1. Academic performance comparison

Table 2. A comparison of the assessment scores between the two groups of students

Assessment items	Experimental group (n = 94)	Control group (n = 92)	*t*	*p*
Speculative knowledge	86.47 ± 7.82	78.93 ± 9.14	5.98	< 0.001
History-taking	88.21 ± 6.53	79.45 ± 8.76	7.62	< 0.001
Check-up	84.36 ± 8.17	75.22 ± 10.34	6.71	< 0.001
Comprehensive assessment	83.95 ± 9.04	72.68 ± 11.27	7.48	< 0.001
OSCE total points	85.74 ± 7.29	75.32 ± 9.63	8.19	< 0.001

All performance metrics in the experimental group were significantly higher than those in the control group ($p < 0.001$), with the largest disparity observed in the comprehensive assessment ability (11.27 points), indicating that the digital-intelligent approach holds a clear advantage in fostering higher-order thinking skills.

4.2.2. Learning engagement analysis

The mean total learning engagement score was 4.31 ± 0.52 in the experimental group versus 3.58 ± 0.67 in the control group ($t = 8.46$, $p < 0.001$). Specifically, all three dimensions—behavioral engagement (4.38 vs. 3.61), cognitive engagement (4.26 vs. 3.49), and emotional engagement (4.33 vs. 3.65)—showed significant improvement. Notably, the frequency of deep learning strategy use among students in the experimental group was 2.1 times higher than that in the control group. Further analysis revealed that the "Participatory Learning" component of the BOPPPS model contributed most significantly to enhancing cognitive engagement, while the immediate feedback feature of the Learning Platform significantly strengthened emotional engagement.

4.2.3. Teaching satisfaction survey

The overall teaching satisfaction score for the experimental group was 4.51 ± 0.39 (out of 5 points), compared with 3.69 ± 0.54 for the control group ($t = 11.02$, $p < 0.001$). The satisfaction rate in the experimental group reached 92.3%, which was significantly higher than the 71.8% observed in the control group ($\chi^2 = 13.57$, $p < 0.001$). The three most highly praised elements were, in order: the virtual simulation system (96.8% of respondents believed it enhanced learning interest; 90.2% believed it provided a convenient mobile learning experience; 87.6% believed it facilitated anytime review); the BOPPPS-based clear classroom structure; and the ability to grasp key concepts effectively. In open-ended questions, students provided positive feedback such as "Role simulation allowed me to truly experience the way nurses think" and "The pre-assessment helped me identify my weak areas".

4.3. Discussion

This study found that the successful implementation of the digital-intelligent innovation model hinges on three key transformations: a shift in teaching decision-making from "experience-driven" to "data-driven"; a shift in the learning experience from "one-size-fits-all" to "tailored instruction"; and a shift in quality assurance from "summative assessment" to "formative assessment throughout the entire process". Virtual simulation technology addresses the challenge of being unable to conduct real-world drills for high-risk or rare medical cases; the BOPPPS model ensures the systematic nature of the instructional design and adequate student participation; while the LearningTong platform lowers the technical barrier, enabling both teachers and students to get started quickly. However, the study also identified several challenges: virtual simulation systems occasionally experience lag during periods of high concurrency; the statistical analysis features of LearningTong are relatively basic and struggle to enable the creation of deep-level learning profiles; these areas all require continuous refinement in future practical implementations [8].

5. Conclusion and future directions

5.1. Research findings

This study constructed and validated the application effectiveness of the BOPPPS digital-intelligent innovation teaching model, based on the Xuetong platform and integrating knowledge graphs with virtual simulation technology, in the Health Assessment course; the findings indicate the following conclusions: the digital-intelligent teaching model can significantly enhance students' theoretical knowledge and clinical skills, particularly demonstrating outstanding results in cultivating comprehensive assessment capabilities;

the integration of the BOPPPS model with the digital-intelligent platform effectively stimulates student engagement, fosters deep learning, and establishes an effective learning closed-loop through pre-class pre-assessments and post-class post-assessments; furthermore, Xuetong, as a mature teaching management tool, lowers the technical implementation threshold, thereby enhancing the scalability of the digital-intelligent teaching reform.

5.2. Research limitations and future directions

This study has certain limitations: the sample was drawn from a single institution, so its external validity requires further validation; the intervention period lasted only two semesters, meaning the long-term effects need to be monitored over time; and the stability of the technical platform still needs optimization. Future research could explore the following directions: first, conduct multicenter randomized controlled trials to enhance sample representativeness; second, investigate the application of AI-generated content (AIGC) in case development and integrate it with the Learning Platform; third, establish a cross-institutional teaching data sharing mechanism to facilitate the collaborative creation and utilization of high-quality educational resources.

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