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Construction of a Digital Twin Model for Pharmaceutical Education Driven by Transformative Learning — Innovative Practice of Chronic Disease Management Based on the Integration of Short Video, AI, and VR

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Abstract: To address the pain points in pharmaceutical education, such as the shortage of practical teaching resources and inadequate training in complex medication scenarios, this study constructed a three-in-one practical teaching mode for pharmacy, including "short video – virtual simulation – intelligent navigation". Based on the theories of microlearning and transformative learning, the study innovatively adopted the strategy of "cognitive load optimization + stepped task-driven" approach. The study dismantled the management of five major chronic diseases, including hypertension and chronic hepatitis B, into modular short videos. Additionally, the study introduced cutting-edge topics such as the visualization of the "DFI-DGCF algorithm for medicinal and dietary contraindications." Through the WeChat public platform, the study established a closed-loop system of "learning – practice – evaluation – application", integrating AI personalized navigation (recommending learning paths based on learning behavior analysis), VR pharmacy training (simulating 23 types of high-risk scenarios), and blockchain technology for ability certification. Practical application showed that this mode improved students' accuracy in clinical decision-making. The study provided an empirical paradigm of theory-technology-ecology collaborative innovation for the digital transformation of pharmaceutical education. The "three-dimensional and nine-degree" evaluation system and UGC crowdsourcing mechanism constructed in this study offered replicable solutions for the high-quality development of medical education.

Keywords: Short video teaching; Transformative learning; Digital twin; Chronic hepatitis B management; DFI-DGCF algorithm; Digitization of pharmaceutical education

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1. Expansion of the theoretical foundation of the teaching model

1.1. Deepening the application of microlearning theory

Recent research has confirmed that microlearning has unique advantages in improving cognition of medication safety. This model adopts a "knowledge point splitting + instant feedback" strategy, breaking down complex medication knowledge (such as chronic hepatitis B drug resistance management) into 5–8 minute short videos, and embeds instant self-testing sessions. This design aligns with the "cognitive load optimization model" proposed by scholars such as Nurul Fitriah [1]. Reducing the amount of information inputted at a time increases students' knowledge retention rate by 37%. Drawing on the experience of Indian pharmaceutical education, the "micro-sitcom" format is introduced in the medicinal and dietary contraindications module to enhance memory anchors through role-playing [2].

1.2. Practical innovation in andragogy theory

Based on Knowles' theory, a "transformative learning" mechanism is introduced as follows [3]. Establish a learner portrait system to push case libraries based on clinical experience differences (e.g., new pharmacists focus on prescription review processes, while senior pharmacists focus on medication consultation strategies); Design stepped challenge tasks, such as setting up a level-based challenge mode in the chronic hepatitis B module, which includes "beginner level – standard treatment review → advanced level – dosage adjustment for renal insufficiency", aligning with the achievement-driven characteristics of adult learners [4].

1.3. Scene upgrade based on constructivist theory

Integrating clinical teaching experience from Peking University Health Science Center, a "double-loop learning model" is constructed: the inner loop simulates the HBV virus replication mechanism through 3D animation (using Blender modeling), while the outer loop sets up a virtual patient consultation dialogue system. Through repeated "observation-practice-correction", students' clinical decision-making accuracy has increased to 89%, 21 percentage points higher than traditional teaching methods [5–6].

2. Suggestions for curriculum system optimization

2.1. Dynamic update mechanism for specialized modules

Establish a "guideline monitoring-case iteration" dual channel: Align with the WHO 2023 Guidelines for the Management of Chronic Hepatitis B, add key points for monitoring renal and hepatic toxicity of tenofovir alafenamide (TAF), and update treatment indication standards for adolescents [7]. Develop a pharmacogenomics topic covering the latest drug-food interaction content such as warfarin-CYP2C9 genotype, allopurinol-HLA-B*5801, and integrate the Wenzhou University DFI-MS prediction model to enhance teaching foresight [8].

2.2. Expansion of technology integration paths

Constructing a "digital twin" teaching ecology: VR pharmacy training: Introduce the Oubeier virtual simulation system to simulate 23 high-risk scenarios such as special drug refrigeration management and antiviral drug dispensing verification; AI personalized navigation: Based on learning behavior analysis (video pause points, wrong answer clustering), intelligently recommend learning paths, such as automatically pushing the "NSAIDs combination risk" topic for those weak in prescription review; Blockchain

certification: Write prescription review training records into the consortium blockchain, supporting employers to trace ability growth trajectories; Content framework: Starting from five major chronic diseases, including hypertension, hyperglycemia, hyperlipidemia, hyperuricemia, and chronic hepatitis B virus infection, design course modules around five-dimensional abilities.

Four major chronic disease topics: Starting from hypertension, hyperglycemia, hyperlipidemia, and hyperuricemia, design courses around five-dimensional abilities. For example, prescription review: process demonstration, unreasonable prescription case analysis (such as combination use of NSAIDs and diuretics for hypertensive patients). Medication education: Design short videos on communication skills based on patient consultation data (such as purine diet guidance for patients with hyperuricemia).

Chronic Hepatitis B (CHB) Topic: Focus on prescription review, drug resistance monitoring, and patient compliance management of antiviral drugs (such as entecavir and tenofovir). Case design: Simulate medication adjustment scenarios for patients with chronic hepatitis B and renal insufficiency.

Prescription audit: process demonstration and common unreasonable prescription case analysis.

Medication education: Design short videos on communication skills and medication knowledge based on patient consultation data.

Technical Implementation: The practical operation scenes are recorded by a team of senior pharmacists and edited using tools such as Jianying and Premiere, supplemented with graphics and animations to enhance expressiveness. Each video is controlled to be 5–8 minutes long, highlighting key steps and common mistakes. For example, cases such as "dietary interference with prescription rationality" (e.g., high-fiber foods affecting the absorption of levothyroxine) and animations demonstrating the microscopic interaction between drugs and food components in the intestine (such as CYP3A4 enzyme inhibition) are added. Collaborating with the information center, a new AI case generator is added, automatically generating personalized cases based on the WHO 2023 guidelines, strengthening the cognition of antiviral treatment plan updates.

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2.3. Evaluation of teaching effectiveness

2.3.1. Specialized analysis

To evaluate the learning effectiveness of the chronic hepatitis B module, additional assessments such as the "Antiviral Drug Knowledge Test" and "Patient Consultation Simulation Assessment" are introduced. The results show that students' mastery rate of antiviral drug indications has increased from 65% to 85%, and their familiarity with the drug resistance management process has increased by 30%. The topic of drug-food interactions integrates the mechanism and clinical suggestions for analyzing common drug-food

contraindications (such as warfarin and vitamin K).

2.3.2. Real-life cases

Simulation of patient consultation scenarios (e.g., a patient with chronic hepatitis B inquiring about conflicts between antiviral drugs and a high-fat diet). Hypertension topic: Emphasize the effect of grapefruit juice on calcium channel blockers, supplemented with a short video on the "dietary contraindications list." Chronic hepatitis B topic: Add a chapter on "Antiviral Drugs and Diet Management" to analyze the relationship between drug absorption and liver function protection.

Qualitative feedback: Student interviews indicate that the "Drug Adverse Reaction Warning" and "Patient Communication Skills" modules in the short videos on chronic hepatitis B are the most practically valuable, helping them reduce the risk of medication errors in real scenarios.

Improvement of quality evaluation system; construct a "three dimensions and nine degrees" evaluation model: To evaluate the learning effectiveness of the chronic hepatitis B module, additional assessments such as the "Antiviral Drug Knowledge Test" and "Patient Consultation Simulation Assessment" are introduced. The results show that students' mastery rate of antiviral drug indications has increased from 65% to 85%, and their familiarity with the drug resistance management process has increased by 30%. The topic of drug-food interactions integrates the mechanism and clinical suggestions for analyzing common drug-food contraindications (such as warfarin and vitamin K).

3. Improvement of quality evaluation system

The "Three Dimensions and Nine Degrees" evaluation model was constructed in **Table 1**.

Table 1. "Three Dimensions and Nine Degrees" evaluation model

Dimension	Evaluation indicators	Data sources
Knowledge Construction	Conceptual mastery/clinical reasoning/guideline compliance	Online tests, case analysis reports
Skill Development	Prescription review speed/communication effectiveness/ resilience	AI conversation logs
Vocational Qualification	Ethical decision-making/interdisciplinary collaboration/ continuous learning	360-degree evaluations, learning archives

Drawing on the clinical pharmacy evaluation experience from Shandong University, a fuzzy comprehensive evaluation method is employed to process qualitative indicators, and the entropy weight method is used to determine the weight of each indicator, ensuring that the error rate of evaluation results is controlled within ±5% [9].

4. Innovation in social service extension

Public science communication matrix: Develop a "Drug-Food Risk Quick Check" mini-program that integrates the DFI-DGCF graph neural network algorithm. The public can input drugs to obtain a visual map of forbidden foods.

Grassroots empowerment plan: Conduct live teaching on standardized treatment for chronic hepatitis B via WeChat live broadcasts, covering 132 county-level hospitals in central and western regions.

Policy response mechanism: Translate the requirements of the National Health Commission's "Opinions on High-Quality Development of Pharmaceutical Services" into teaching standards. For example, add a "long-term prescription management" scenario drill to the medication instruction module.

5. Sustainable development strategy

Content co-creation ecology: Establish a user generated content (UGC) course development platform where clinical pharmacists can upload practical cases (subject to review by the PCNE classification system). Excellent cases will be awarded continuing education credit hours.

Cross-institutional collaboration Network: Join the National Pharmaceutical Professional Degree Online Education Alliance to share 57 quality course resources and establish a credit mutual recognition mechanism.

Diversified revenue model: Develop customized training products for pharmaceutical companies (such as post-market monitoring of innovative drugs), which will feed back into teaching resource updates, achieving an annual self-sustaining funding rate of ≥65%.

6. Conclusion

Through theoretical, practical, and ecological innovations, this study constructs a digital teaching paradigm that meets the transformation needs of pharmaceutical services. In the future, the authors will further explore the construction of a metaverse teaching space, realizing multi-agent collaborative training among "pharmacists, patients, and AI assistants" to provide talent support for the "Healthy China 2030" strategy.

Disclosure statement

The author declares no conflict of interest.

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