

Research on the Intelligent Evaluation System of Nursing Teaching Quality in Universities Driven by Multimodal Data

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ABSTRACT Against the background of educational digital transformation and the rapid expansion of smart teaching, traditional evaluation of nursing teaching quality in universities is limited by single data sources, subjective dependence, delayed feedback, and insufficient connection with clinical practice. Nursing teaching is highly practical, operational, scenariobased, and humanistic, so single indicators cannot fully reflect the teaching process, professional competence, practical skills, learning outcomes, humanistic literacy, and clinical adaptability. This study introduces multimodal data and artificial intelligence into nursing teaching evaluation and constructs an intelligent evaluation system integrating classroom teaching, skill operation, online learning, clinical internship, teacher-student interaction, and emotional feedback. A six-dimensional evaluation index system and a machine-learning-based model are designed using video, audio, text, behavior logs, numerical scores, and emotional data. Empirical testing across nursing programs shows that the system improves evaluation objectivity, reduces human scoring bias, and supports timely diagnostic feedback. The architecture is also relevant to wireless sensing, edge computing, and electromagnetic-compatible clinical simulation environments.

INDEX TERMS multimodal data, nursing teaching, intelligent evaluation, wireless sensing, edge computing

I. INTRODUCTION

A. RESEARCH BACKGROUND AND SIGNIFICANCE

WITH the deepening implementation of the Healthy China strategy, the demand for high-quality, specialized, and versatile nursing talents in China continues to expand. As the core link of nursing talent cultivation, the teaching quality of nursing education in universities directly affects the ability level of nursing teams and the quality of medical and health services. Currently, nursing education has shifted from traditional classroom teaching to a new model that combines online and offline teaching, theoretical and practical integration, and on campus clinical collaboration. The teaching process generates a vast volume of heterogeneous data, including classroom videos, voice interactions, and behavioral logs. This multimodal environment necessitates sophisticated data processing techniques to extract meaningful insights into teaching quality[1-2]. However, there are still significant shortcomings in the quality evaluation of traditional nursing teaching:

(1) The evaluation data is single and relies heavily on questionnaire scoring, supervised lectures, and exam scores, making it difficult to cover key dimensions such as practical operation, emotional interaction, and clinical adaptation;

(2) The evaluation method is subjective, heavily influenced by expert experience and personal preferences, and

lacks objectivity;

(3) The evaluation results are lagging behind, mostly being one-time evaluations at the end of the period, which cannot achieve process monitoring and real-time improvement;

(4) The evaluation dimension is one-sided, emphasizing theory over practice, knowledge over skills, results over process, and disconnected from clinical nursing needs;

(5) Lack of intelligent means makes it difficult to process large-scale, multi type, high-dimensional teaching data, and achieve accurate diagnosis and personalized guidance. In the context of digital transformation in education, technologies such as multimodal data fusion, machine learning, intelligent analysis, and affective computing provide a new path to solving the above problems. Utilizing multimodal data to comprehensively depict the overall picture of teaching and achieving objective, refined, and dynamic evaluation of teaching quality through intelligent algorithms has become an important direction for nursing teaching reform in universities in the new era[3].

Theoretical significance: To construct a multimodal data-driven intelligent evaluation theoretical framework for nursing teaching quality, expand the theoretical system of intel-

lignant education evaluation, enrich the research paradigm of nursing education, establish a theoretical basis for the integration of multimodal data and nursing teaching evaluation, and provide new theoretical references for medical and practical professional teaching evaluation. Practical significance: To achieve objective, procedural, precise, and real-time evaluation of nursing teaching quality, reduce subjective bias, and enhance the credibility of evaluation; Real time discovery of teaching shortcomings and weak links, supporting teachers to quickly improve teaching; Provide scientific basis for teaching management, professional title evaluation, resource allocation, and professional certification; Comprehensively improving the quality of nursing talent training, better adapting to the needs of clinical medical and health services, has important promotional value[4-5].

B. CURRENT RESEARCH STATUS AT HOME AND ABROAD

1) Current Status of Research on Teaching Quality Evaluation

A relatively complete indicator system for teaching evaluation in domestic and foreign universities has been formed, but it is mainly based on universal evaluation. There is insufficient evaluation of the practical, operational, humanistic, and clinical characteristics of nursing profession, and the application of process and developmental evaluation is not widespread enough[6].

2) Application research of multimodal data in the field of education

Multimodal data is widely used in learning analysis, emotion recognition, behavior analysis, intelligent recommendation, and other fields. However, its systematic application in teaching quality evaluation, practical skill evaluation, and clinical adaptation evaluation is relatively limited, especially in the field of nursing education where research is relatively weak[7].

3) Application of Intelligent Evaluation and Machine Learning in Education

Intelligent evaluation can achieve automatic scoring, predictive analysis, and diagnostic warning, but most research focuses on theoretical courses, and there are few intelligent evaluation models for complex scenarios such as nursing skills operation, humanistic communication, and clinical thinking, and a complete system has not yet been formed[8].

4) Current Status of Nursing Teaching Evaluation Research

Nursing teaching evaluation often adopts traditional scales, supervisory evaluation, peer evaluation, and student evaluation, which have problems such as strong subjectivity, limited dimensions, and feedback lag. There is a lack of intelligent and full process evaluation methods driven by multimodal data[9].

5) Summary of Research Shortcomings

(1) The data source for nursing teaching evaluation is single, and multimodal teaching data is not fully utilized;

(2) The evaluation system fails to fully reflect the practical, humanistic, and clinical characteristics of nursing profession;

(3) Lack of intelligent algorithm support, insufficient objectivity, accuracy, and timeliness in evaluation;

(4) A closed-loop system of “collection analysis evaluation feedback improvement” has not been formed;

(5) Insufficient integration with clinical practice needs makes it difficult to support the cultivation of high-quality nursing talents[10].

C. RESEARCH CONTENT AND TECHNICAL ROUTE

1) Research Content

(1) Requirements for quality evaluation of nursing teaching in universities and analysis of multimodal data sources;

(2) Construction and preprocessing technology of multimodal data system for nursing teaching;

(3) Multimodal data-driven six dimensional evaluation index system for nursing teaching quality;

(4) Intelligent evaluation model based on multimodal feature fusion and machine learning;

(5) Design and Implementation of an Intelligent Evaluation Platform for Nursing Teaching Quality;

(6) Empirical analysis and effectiveness verification of nursing majors in multiple universities;

(7) System optimization strategy and promotion application plan[11].

2) Technical roadmap

Following the technical route of “requirement analysis data construction indicator design model development platform development empirical verification optimization promotion”, based on multimodal data, intelligent algorithms as the core, and nursing teaching laws as the basis, a complete intelligent evaluation system is constructed[12].

D. PAPER STRUCTURE

The full text consists of seven chapters: Chapter 1 Introduction; Chapter 2: Relevant Theoretical and Technical Foundations; Chapter 3 Construction of Multimodal Data System for Nursing Teaching; Chapter 4: Multimodal Driven Intelligent Evaluation Index System for Nursing Teaching Quality; Chapter 5: Intelligent Evaluation Model and Algorithm Design; Chapter 6: Empirical Analysis and Application Effectiveness; Chapter 7 Conclusion and Prospect.

II. RELATED THEORETICAL AND TECHNICAL FOUNDATIONS

A. CHARACTERISTICS AND QUALITY EVALUATION CONNOTATION OF NURSING TEACHING

Nursing teaching has the characteristics of high integration of theory and practice, standardized skill operation, strong

humanistic communication, and high clinical scenario. The evaluation of teaching quality must cover the entire process of theoretical teaching, skill operation, clinical thinking, communication expression, humanistic care, professional ethics, internship effectiveness, etc[13].

B. BASIC THEORY OF MULTIMODAL DATA

Multimodal data refers to different forms of data such as text, images, audio, video, action sequences, behavior logs, numerical scores, physiological feedback, emotional states, etc. It has heterogeneous, complementary, massive, and dynamic characteristics, and can comprehensively, stereoscopically, and meticulously describe complex teaching activities[14-15]. Intelligent evaluation is driven by data and centered around algorithms, achieving objectivity, automation, precision, and dynamic evaluation, replacing or assisting traditional manual evaluation, and improving evaluation efficiency, fairness, and guidance. See Table 1 for details[16].

TABLE 1. Multimodal Data Types in Nursing Teaching

Modal Type	Data Form	Application Scenario
Classroom Teaching	Video, audio, text, interaction logs	Lecture evaluation
Practical Skill	Operation video, action sequence	Skill assessment
Online Learning	Learning records, homework, scores	Autonomous learning
Clinical Practice	Internship logs, teacher evaluation	Clinical ability
Emotional Feedback	Expression, voice, satisfaction	Learning experience

C. MACHINE LEARNING AND FEATURE FUSION TECHNOLOGY

Machine learning can automatically extract features, mine patterns, and construct predictive models from multimodal data, achieving comprehensive evaluation and graded diagnosis of teaching effectiveness, teaching ability, and learning outcomes[17].

D. NURSING EDUCATION STANDARDS AND CLINICAL PRACTICE REQUIREMENTS

Nursing teaching must comply with the national nursing professional teaching quality standards, nurse practice standards, and clinical nursing job competency requirements, and the evaluation system must be highly adapted to clinical job competencies[18]. The multimodal data used in this article includes:

- (1) Text data: lesson plans, courseware, assignments, reports, comments, feedback, test papers;
- (2) Image data: screenshots of operational actions, classroom scenes, demonstration actions, internship records;
- (3) Audio data: classroom lectures, teacher-student conversations, communication training, ward rounds voice;
- (4) Video data: classroom recordings, skill operation videos, practical training videos, internship videos;
- (5) Behavioral data: learning duration, access records, operation steps, interaction frequency;

(6) Numerical data: grades, ratings, duration, frequency, accuracy rate;

(7) Emotional data: facial expressions, tone, attitude, satisfaction, and focus. This includes data cleaning, format standardization, redundancy removal, missing value filling, outlier removal, feature extraction, feature standardization, spatiotemporal alignment, etc., providing a high-quality data foundation for intelligent evaluation[19].

III. CONSTRUCTION OF MULTIMODAL DATA SYSTEM FOR NURSING TEACHING IN UNIVERSITIES

A. OVERALL FRAMEWORK OF MULTIMODAL DATA IN NURSING TEACHING

Construct a multimodal data system of six types, comprehensively covering the entire process of nursing teaching, and achieving the teaching process that can be recorded, quantified, analyzed, and evaluated.

- (1) Classroom teaching modal data;
- (2) Practical skills modal data;
- (3) Online learning modal data;
- (4) Clinical internship modal data;
- (5) Teacher-student interaction modal data;
- (6) Emotional feedback modal data.

B. CLASSROOM TEACHING MODAL DATA

This includes theoretical teaching videos, teacher lecture audio, courseware text, classroom interaction records, question and answer records, attendance records, classroom focus, classroom discipline, etc., reflecting the teacher's theoretical teaching ability and classroom organization ability[20].

C. PRACTICAL SKILLS MODAL DATA

The core data for nursing teaching evaluation includes nursing operation videos, action sequences, step standardization, operation accuracy, aseptic concepts, item preparation, humanistic care actions, operation time, and error action records. This includes the duration of online course viewing, learning progress, test scores, completion of assignments, discussions and speeches, note taking, resource downloads, learning paths, etc., reflecting the effectiveness of self-directed learning. Including internship position records, participation in ward rounds, writing nursing documents, number of clinical operations, patient feedback, teacher evaluation, case analysis, emergency response performance, etc., directly connect with clinical abilities. Including Q&A records, guidance records, communication content, feedback, evaluation exchanges, group discussions, etc., reflecting the quality of teaching interaction and guidance effectiveness. Including student facial expressions, voice emotions, classroom participation, learning engagement, satisfaction ratings, psychological states, professional identity, etc., reflecting learning experience and humanistic literacy, please refer to Table 2 for details.

TABLE 2. Intelligent Evaluation Index System for Nursing Teaching

First-level Index	Second-level Index	Data Support
Teaching Process	Design, interaction, organization	Video, behavior
Professional Ability	Knowledge, explanation, logic	Text, scores
Practical Skill	Standard, accuracy, safety	Operation video
Learning Effect	Scores, mastery, progress	Scores, records
Humanistic Literacy	Communication, care, attitude	Audio, emotion
Clinical Adaptability	Thinking, practice, post ability	Internship data

The multimodal data of nursing teaching has the characteristics of strong professionalism, strong standardization, strong temporal sequence, strong correlation, and concentrated scenarios, which are suitable for fusion evaluation through intelligent algorithms. Design a multi-channel, non-invasive, and normalized data collection scheme that utilizes cameras, microphones, sensors, platform logs, evaluation systems, internship management systems, and other automated data collection tools to reduce additional burden. Establish data integrity and security control mechanisms to ensure compliance with medical ethics. For high-stakes clinical interactions, the system prioritizes simulated training environments or uses edge-computing for real-time de-identification (blurring faces and removing Patient Identifiable Information).

IV. MULTIMODAL DATA-DRIVEN INTELLIGENT EVALUATION INDEX SYSTEM FOR NURSING TEACHING QUALITY

A. PRINCIPLES FOR CONSTRUCTING INDICATOR SYSTEM

- (1) Professionalism: Highlighting the characteristics and clinical orientation of nursing disciplines;
- (2) Comprehensiveness: covering the entire process, dimensions, and scenarios;
- (3) Objectivity: Based on data to reduce subjective bias;
- (4) Process oriented: Emphasize dynamic monitoring and continuous improvement;
- (5) Operability: Indicators can be collected, calculated, and applied;
- (6) Developmental: supports diagnosis, feedback, warning, and improvement.

B. SIX DIMENSIONAL INTEGRATED EVALUATION INDEX SYSTEM

Constructing a multimodal intelligent evaluation system with 6 primary indicators, 22 secondary indicators, and 68 tertiary indicators is the first multimodal data-driven evaluation system for nursing teaching in China.

1) Dimensions of Teaching Process

Including instructional design, teaching methods, classroom organization, interactive effects, teaching standards, and digital resource application.

2) Professional Ability Dimensions

Including professional knowledge, knowledge explanation, grasp of knowledge points, handling of key and difficult points, knowledge updating degree, and academic level.

3) Dimensions of Practical Skills

Including operational standardization, accuracy of actions, completeness of processes, sterile concepts, proficiency in operations, and operational safety.

4) Dimensions of Learning Effectiveness

Including theoretical grades, skill grades, homework quality, self-learning, knowledge mastery, and ability improvement.

5) Dimensions of Humanistic Literacy

Including communication and expression, caring awareness, professional attitude, patience and responsibility, teamwork, and humanistic care.

6) Dimensions of Clinical Adaptability

Including clinical thinking, case analysis, emergency response, document writing, internship performance, and job suitability.

C. RELATIONSHIP BETWEEN INDEX CONNOTATION AND MULTIMODAL DATA CORRESPONDENCE

Each third level indicator corresponds to a clear multimodal data source, achieving observable, quantifiable, and verifiable indicators. For example, corresponding skill operation videos and action sequences for standardized operations; Corresponding speech and dialogue text for communication expression; Clinical thinking corresponds to case analysis and internship records. Classify the quality of nursing teaching into four levels: excellent, good, qualified, and in need of improvement, which are used for result output, diagnostic warning, and evaluation. Through multiple rounds of evaluations by nursing education experts, clinical nursing experts, teaching managers, and frontline teachers, the system is ensured to be scientific, comprehensive, applicable, and implementable.

V. DESIGN OF INTELLIGENT EVALUATION MODEL AND ALGORITHM FOR NURSING TEACHING QUALITY

A. OVERALL ARCHITECTURE OF INTELLIGENT EVALUATION

Construct a six layer intelligent evaluation model consisting of multimodal acquisition, feature extraction, feature fusion, machine learning evaluation, comprehensive scoring, and diagnostic feedback.

B. MULTIMODAL FEATURE EXTRACTION

Extract key features from video, audio, text, behavior, numerical values, and emotions separately:

- (1) Video features: action, posture, steps, scene, focus;
- (2) Audio features: tone, speed, clarity, interactivity;

(3) Text features: content, logic, standardization, professionalism;

(4) Behavioral characteristics: frequency, duration, sequence, accuracy;

(5) Emotional characteristics: emotional state, satisfaction, and engagement.

C. MULTIMODAL FEATURE FUSION STRATEGY

By combining feature layer fusion with decision layer fusion, the complementarity of different modal data is fully utilized to improve evaluation accuracy.

D. MACHINE LEARNING INTELLIGENT EVALUATION MODEL

Constructing an intelligent evaluation model suitable for nursing teaching. The input layer consists of a 128-dimensional multimodal feature vector extracted from video, audio, and logs. Specifically:

(1) Random Forest and Gradient Boosting Tree models are employed as regressors to calculate the weight and importance of each indicator;

(2) LSTM is utilized to process temporal sequence data from skill operation videos to identify procedural errors;

(3) The final output is a comprehensive continuous score (0–100) and a four-level classification result;

(4) Attention mechanism fusion model;

(5) Multi model integrated evaluation model. The input of the model is multimodal features, and the output includes comprehensive scores, scores for each dimension, level determination, and shortcoming diagnosis.

E. DYNAMIC EVALUATION AND PROCESS MONITORING

Support a hybrid evaluation architecture where instantaneous data (e.g., classroom videos and interaction logs) enables real-time monitoring and immediate feedback, while lagging indicators (e.g., final internship records and exam scores) are integrated into phased and summative evaluations. This multi-layered approach ensures both dynamic tracking of the learning process and a comprehensive analysis of long-term educational outcomes. The system automatically identifies weak indicators and generates personalized improvement suggestions, such as strengthening operational norms, enhancing interaction, strengthening humanistic communication, optimizing clinical thinking training, etc. The performance of the model was validated using indicators such as accuracy, consistency coefficient, effectiveness, discrimination, stability, and feedback efficiency, as shown in Table 3.

TABLE 3. Evaluation Grade Standard

Grade	Score Range	Performance Level
Excellent	90–100	High-quality teaching
Good	80–89	Qualified and effective
Fair	70–79	Basic satisfaction
Needs Improvement	<70	Need optimization

Present evaluation criteria through feature importance, contribution analysis, dimension score radar chart, etc., to improve transparency and recognition.

VI. EMPIRICAL ANALYSIS AND APPLICATION EFFECTS

A. EMPIRICAL OBJECT

Selecting nursing majors from 3 undergraduate medical colleges and 2 vocational colleges as empirical objects, covering 120 nursing teachers, 3200 nursing students, and 46 nursing courses, with a large amount of data and strong representativeness. This study was approved by the Ethics Committee of Anyang Vocational and Technical College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

B. DATA COLLECTION

Collect multimodal teaching data for a semester, including 1860 hours of video, 920 hours of audio, 3.6GB of text data, 1.26 million behavioral records, and 28000 evaluation records.

C. COMPARATIVE EXPERIMENTAL SETUP

The experimental group adopted a multimodal intelligent evaluation system, while the control group used traditional evaluation methods to compare indicators such as objectivity, comprehensiveness, consistency, timeliness, and satisfaction.

(1) The objectivity of evaluation has significantly improved. Based on a sample of 120 teachers and 3,200 students, human bias (measured by the variance in inter-rater reliability) was reduced by 65.4% ($p < 0.01$) compared to the traditional manual scoring baseline;

(2) The evaluation dimensions are more comprehensive, covering weak areas such as practice, humanities, and clinical practice;

(3) The evaluation results are more accurate; Spearman correlation analysis shows that the correlation between the system's scores and students' actual clinical performance increased from 0.45 to 0.64, a relative improvement of 42.2%, demonstrating high predictive validity;

(4) More timely feedback, achieving process based monitoring and real-time improvement;

(5) The satisfaction of teachers and students has significantly improved. The most significant improvements have been made in the dimensions of practical skills, humanistic literacy, and clinical adaptability, which have addressed the weak links in traditional evaluation.

D. MODEL PERFORMANCE VALIDATION

The accuracy of the integrated model evaluation is 89.7%, with a consistency coefficient higher than 0.85. The stability, discrimination, and effectiveness all meet the requirements of teaching evaluation.

(1) Provide precise direction for teachers' teaching improvement;

- (2) Provide guidance for personalized learning for students;
- (3) Provide scientific basis for teaching management;
- (4) Provide data support for nursing professional certification;
- (5) Promote the digital transformation of nursing education. Through typical courses, typical teachers, and typical student cases, demonstrate the practical effects of intelligent evaluation in identifying problems, making precise improvements, and enhancing quality, as shown in Table 4.

TABLE 4. Comparison of Evaluation Effects

Index	Traditional Method	Multimodal Intelligent System
Objectivity	Low	High
Comprehensive Degree	Partial	Comprehensive
Feedback Timeliness	Slow	Real-time
Consistency	0.58	0.86
User Satisfaction	68.2%	92.5%

The system deployment is simple, the operation is convenient, the automation level is high, and there is no additional burden. It is suitable for various universities that offer nursing majors and has broad promotion conditions.

VII. CONCLUSION AND PROSPECT

A. RESEARCH CONCLUSION

(1) A multimodal data system covering six categories of nursing teaching, including classroom, skills, online, internship, interaction, and emotion, has been constructed to achieve data-driven recording and expression of the entire teaching process.

(2) We have established the first multimodal data-driven six dimensional integrated intelligent evaluation system for nursing teaching quality in China, which fully meets the characteristics and clinical needs of the nursing profession.

(3) An intelligent evaluation model combining multimodal feature fusion and machine learning has been proposed, significantly improving the objectivity, accuracy, comprehensiveness, and timeliness of evaluation.

(4) We have developed an intelligent evaluation system that integrates data collection, analysis, evaluation, diagnosis, feedback, and improvement, forming a closed-loop management mechanism that can be directly applied in business.

(5) The empirical results indicate that this system can effectively improve the quality of nursing education, promote continuous improvement of teaching, and provide systematic solutions for the high-quality development of nursing education.

B. MAIN INNOVATION POINTS

(1) The systematic integration of a multimodal data framework tailored for university-level nursing education, providing a structured methodology for capturing the complexities of the teaching process through diverse data streams.

(2) Create a six dimensional integrated nursing teaching quality intelligent evaluation index system, highlighting the three core nursing characteristics of practice, humanities, and clinical practice.

(3) Propose a multimodal fusion and machine learning intelligent evaluation model to achieve objective, dynamic, and precise evaluation.

(4) Establish a closed-loop system of “evaluation diagnosis feedback improvement” to promote the continuous improvement of nursing teaching quality.

C. RESEARCH PROSPECTS

(1) Further integrate new technologies such as virtual reality (VR), motion capture, and physiological sensing to improve the accuracy of skill operation evaluation.

(2) Deepen the intelligent evaluation of clinical internship scenarios and achieve integrated evaluation of school hospital collaboration.

(3) Build a nursing teaching model to achieve higher levels of intelligent diagnosis and personalized guidance.

(4) Promote to medical majors such as midwifery, rehabilitation, medical laboratory, clinical medicine, etc., and form a universal intelligent evaluation scheme for medical education.

(5) Establish a national nursing teaching quality evaluation database to promote standardized, intelligent, and balanced development of evaluation.

AUTHOR CONTRIBUTIONS

Shanshan Zhao designed, collected and analyzed the data, and drafted the manuscript. Shanshan Zhao conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Shanshan Zhao participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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HUMAN RESEARCH SUBJECTS

This study was approved by the Ethics Committee of Anyang Vocational and Technical College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

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