ISSN 2663-8169 Vol. 7, Issue 9: 70-76, DOI: 10.25236/IJNDE.2025.070910

Design of a Big Data-driven Multi-dimensional Evaluation System for "Dual-qualified" Teachers

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Abstract: *To solve the one-sidedness and subjectivity in traditional teacher evaluations at vocational colleges, we're building a system based on multiple data sources. It highlights six key areas — teacher ethics, instruction, mentorship, growth, service, and innovation — and pulls data from student records, learning platforms, and smart classroom tools. We use the Analytic Hierarchy Process (AHP), along with big data tech, to assign proper weights and develop personal growth profiles. What makes it different is its five-layer structure that not only checks performance but also helps teachers reflect and improve continuously. Instead of just ending with a score, the system supports both teachers and managers: teachers can self-assess; managers gain insights for smarter decisions. The goal is to move from fixed assessments to supportive feedback, helping build a stronger, "dual-qualified" teaching team and raising the standard of vocational instruction.*

Keywords: *Big Data; Teacher Evaluation; Multi-dimensional Portrait; "Dual-Qualified" Teacher*

1. Introduction

In recent years, China's higher vocational education has placed increasing emphasis on transforming how teachers are assessed. Major policy updates — such as the National Vocational Education Reform Implementation Plan, the revised Vocational Education Law, and the "Double High-levels Plan" — all highlight one shared goal: building a high-quality, practice-oriented teaching force known as "dual-qualified" instructors.

Yet, many of the current evaluation practices haven't kept pace. They remain overly reliant on subjective judgments, research output, and annual reviews [1]. As a result, they miss the everyday impact of teaching and fail to measure the essential blend of academic and technical skills that define vocational educators [2]. The gap between traditional models and modern needs is growing.

A breakthrough is now possible — thanks to smart campuses. They generate vast amounts of process data: how teachers design lessons, interact in class, and engage with professional development. This data brings clarity, offering real-time behavioral insights rather than isolated snapshots. For the first time, we can create dynamic "portraits" of teaching quality based on ongoing performance.

We envision an evaluation system that no longer just labels teachers as "pass" or "improve," but actually guides their development — with personalized feedback and growth pathways. We believe that's the core aim: shifting from judgment to support. By making evaluation a growth tool, we create a system that empowers teachers and better fulfills vocational education's mission of shaping skilled, virtuous professionals.

Ultimately, this big data-driven model redefines teacher assessment, moving it from a formal requirement to a meaningful resource for sustainable educational development [3].

2. Construction of the Multi-dimensional Teacher Evaluation Indicator System Based on Big Data

2.1. Logic of the Evaluation Model

Constructing a scientific evaluation indicator system is the core and foundation of the entire evaluation process. Adhering to the principles of being scientific, multi-dimensional, developmental, operational, and tailored to the characteristics of higher vocational education [4], and combining the features of higher vocational education with the fundamental task of "fostering virtue through

ISSN 2663-8169 Vol. 7, Issue 9: 70-76, DOI: 10.25236/IJNDE.2025.070910

education," we have built an evaluation framework covering six major dimensions: teacher's ethics and moral education, instructional design and input, classroom teaching and interaction, student growth and development, personal professional growth, and technical skills and social service. These six dimensions collectively form a three-dimensional, dynamic, and comprehensive evaluation framework for higher vocational education teachers. The core of constructing a scientific and effective data-driven developmental evaluation system for teacher instruction [5] lies in the design of the evaluation model and its supporting system. This is not merely a technical challenge but a systematic project that deeply integrates educational philosophy with data science. This section will elaborate on the composition of the evaluation model.

The evaluation model serves as the "brain" of the entire system, responsible for transforming massive, raw, process-based data into insightful evaluation conclusions and developmental recommendations. The logic of its construction is based on the quantification and mapping of the indicator system. We need to break down the abstract concepts of the aforementioned six dimensions into specific, data-measurable observation points and establish their mapping relationships with backend data.

2.1.1. Teacher's Ethics and Moral Education

Quantifiable indicators include the coverage rate of ideological and political education elements in courses [6], scores in the "value guidance" dimension of student teaching evaluations, hours of participation in public welfare tutoring, and records of supervising student clubs or competitions. Data is sourced from teaching plans and course syllabi in the Student Information System (SIS), the student evaluation system, and activity records in the Student Affairs Management System.

2.1.2. Instructional Design and Input

Quantifiable indicators include the update frequency of teaching resources, the diversity index of resources, the quantity and complexity of online teaching activities , and the duration and frequency of access to the course preparation platform before the course begins. Data is sourced from the backend logs of the Learning Management System (LMS), the teaching resource repository management system, etc.

2.1.3. Classroom Teaching and Interaction

Quantifiable indicators include the average student head-up rate in smart classrooms, the frequency and duration of teacher-student voice interactions, the online attendance rate, the participation and accuracy rates in in-class instant quizzes, and the number of posts and replies in online discussion forums. Data is sourced from IoT devices in smart classrooms [7], interaction data from learning platforms, etc.

2.1.4. Student Growth and Development

Quantifiable indicators include the value-added scores of students in the taught classes, the pass rate and excellence rate of skill certificate examinations, the average scores and good/excellent rates of student assignments/projects, the quality of guidance on graduation projects/theses , and students' satisfaction and recommendation ratings for the teacher. Data is sourced from the SIS, certificate management system, assignment modules in the LMS, employment guidance system, etc.

2.1.5. Personal Professional Growth

Quantifiable indicators include hours of participation in training and professional development, the quantity and level of published teaching and research papers, the number and funding of hosted/participated-in research projects, teaching achievement awards, and records of academic/professional title/vocational qualification advancements. Data is sourced from the university's human resources system, research management system, financial system, etc.

2.1.6. Technical Skills and Social Service

Quantifiable indicators include the amount of funding received from horizontal projects, the number of technical service contracts, the number of patent applications and grants, the duration and valid proof of enterprise practice, and records of participation in the formulation of industry standards. Data is sourced from the research management system, financial system, university-enterprise cooperation management platform, etc.

In practice, the system brings together a wide range of information from across campus—everything from how students learn, to how teachers teach, and how research and resources are used.

ISSN 2663-8169 Vol. 7, Issue 9: 70-76, DOI: 10.25236/IJNDE.2025.070910

But here's the challenge: most of this data lives in separate worlds. The student records, learning platform, research system, library logs, and even the campus card all keep their own data, each with its own rules and formats.

To make this data work together, we first build what's called an "Education Data Lake" — think of it as a central hub where all the relevant data flows in from different systems. APIs or ETL tools help pull this data out and move it into the lake.

But just collecting it isn't enough. Before we can find meaning in the numbers, we need to clean things up. That means removing inconsistencies, dealing with missing information, and normalizing the formats so that everything plays well together. We also anonymize the data carefully to protect personal privacy. Only after these careful preparation steps does the data become truly useful — ready for analysis that can really support teaching and decision-making.

2.2. Multi-dimensional Teacher Portrait Modeling

After establishing the indicator system, the Analytic Hierarchy Process (AHP) [8] can be employed. This involves organizing internal and external education experts, industry experts, master teachers, and administrators to perform pairwise comparisons and scoring of the importance of each level of indicators. Through calculation and consistency checks, scientific weights for each indicator are derived. In setting the weights, the positioning of higher vocational education should be reflected by appropriately increasing the weights of dimensions such as "Classroom Teaching and Interaction," "Student Growth and Development," and "Technical Skills and Social Service" to correct the past evaluation bias of an overemphasis on "papers and projects alone."

To reflect the flexibility and guidance of the evaluation, weight allocation should not be a "one-size-fits-all" approach but should be dynamically adjustable.

- Basic Weights. The institution sets a foundational weight proportion for the six major dimensions based on its development strategy, reflecting the overall value orientation .
- Role-based Weights. The evaluation focus should differ for teachers of different types (e.g., professional course teachers, basic course teachers, practical training instructors) and different professional ranks. For example, the weight for "Personal Professional Growth" might be increased for young teachers, while for professors, more emphasis might be placed on the weight of "Technical Skills and Social Service." The system should allow administrators to configure weight templates for different roles.
- Developmental Weights. Teachers should be allowed to jointly determine personal development goals with their department at the beginning of the semester and adjust the weights of certain indicators accordingly, reflecting the incentive of "self-selected actions."

Based on the high-quality dataset from the effective integration of multi-source heterogeneous data on campus, the system constructs a dynamically updated "multi-dimensional development portrait" [9] for each teacher. This portrait is described using a tag system, which is divided into fact tags, rule-based tags, and model-based tags.

- Fact Tags. E.g., "Rank: Professor," "Course Taught: Mechanical Design."
- Rule-based Tags. Derived from indicator calculations, e.g., "Teaching Resource Update Frequency: High," "Classroom Questioning Type: Primarily Open-ended."
- Model-based Tags. Mined through machine learning algorithms, e.g., "Growth Potential: High," "Teaching Style: Inquiry-based."

The portrait, visualized through forms like a radar chart, intuitively presents a teacher's performance score in the six primary dimensions based on their weights. For instance, a nstructional Design and Input" but low in "Classroom Teaching and Interaction." This portrait itself does not make a good or bad judgment but serves as an objective "mirror" to help teachers clearly understand themselves.

2.3. Scientific Evaluation Algorithm Engine

The "brain" of the evaluation system is its underlying algorithm model. The algorithm engine is responsible for calculating and analyzing the quantified data to generate evaluation results.

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2.3.1. Comprehensive Evaluation Model

A weighted algorithm is used to calculate the teacher's evaluation value for each dimension and overall. This value can serve as a reference for comprehensive performance over a certain period, but its more important role is as a starting point for subsequent diagnostic analysis.

2.3.2. Diagnostic Model

Clustering algorithms such as K-Means are used to group teachers with similar portrait characteristics, automatically identifying different teacher profiles like "teaching-intensive," "research-leading," "balanced-development," and "high-potential newcomer." This provides a basis for the institution to implement classified guidance and targeted support.

2.3.3. Correlation and Attribution Model

Association rule mining algorithms like Apriori are used to discover strong correlation rules between "teaching behaviors" and "student outcomes." For example, discovering a pattern that "teachers with 'high detailed feedback on assignments' have a significantly higher rate of 'student resubmission of assignments' in their classes" provides all teachers with data-supported suggestions for teaching improvement.

2.3.4. Intelligent Recommendation Engine

This is the key to achieving "precise empowerment." When the system diagnoses that a teacher is weak in the "Classroom Interaction" dimension, the recommendation engine will make recommendations based on the following two scenarios:

- Content-based: Recommends pedagogical articles and training courses related to "classroom interaction skills."
- Collaborative Filtering: Identifies other (anonymous) teachers who perform well in this dimension and have similar portraits, and recommends teaching cases or open class videos shared by these outstanding teachers.

3. System Architecture and Functional Design

3.1. Overall System Architecture

A stable, efficient, and user-friendly information system is the guarantee for the model's implementation. The design of this system should follow the principles of layered decoupling, service orientation, and user-friendliness, and it is divided into a five-layer architecture.

3.1.1. Data Storage and Processing Layer

This layer serves as the "granary and kitchen" of the system. It uses data warehouse or data lake technology to store raw and cleansed data. ETL toolchains are used to clean, transform, and integrate data, ensuring its consistency and accuracy.

3.1.2. Data Collection Layer

This layer acts as the "senses" of the system. It aggregates data non-intrusively and in near real-time from heterogeneous data sources such as the SIS, LMS, campus card system, research management system, HR system, and smart classrooms through API interfaces, database views, and log file capturing.

3.1.3. Model Analysis Layer

This is the aforementioned "Evaluation Model and Algorithm Engine," serving as the "brain" of the system. It is deployed independently, calls data from the processing layer, runs various analysis algorithms, and generates intermediate results and evaluation conclusions.

3.1.4. Application Service Layer

This layer functions as the "torso" of the system. It encapsulates the complex computational results from the model analysis layer into a series of standard, callable API services, such as "Get Teacher Radar Chart Data Service," "Generate Diagnostic Report Service," and "Recommend Development Resources Service."

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3.1.5. User Presentation Layer

This layer represents the "face" of the system. It provides user-friendly web and mobile interactive interfaces for different roles, such as teachers, teaching administrators, and university leaders.

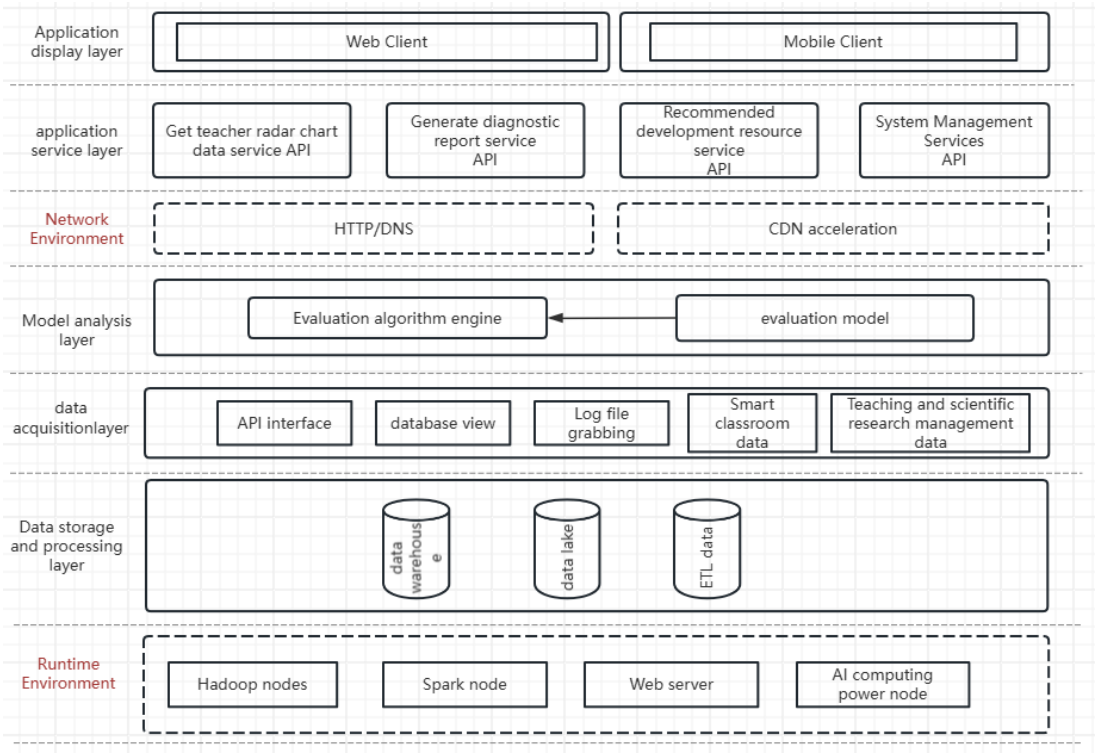

Figure 1: Teachers Multi-dimensional Evaluation System Architecture Chart

In addition to the five layers mentioned above, the system also has the necessary running environment and operational support, as shown in Figure 1.

3.2. Core Functional Module Design

In the design of the evaluation system for higher vocational teachers, we've created three functional modules to meet diverse needs. Let’s go through them one by one, from the perspective of a user who's trying to make sense of how this system works and how it could change daily practices.

3.2.1. Teacher Professional Development Center

This is where teachers get direct empowerment through data. When they log in, they’re greeted by a visual data dashboard—like a personalized trainer showing them how they're doing across six key areas of teaching performance. Radar charts, trend lines, and dynamic dashboards help them see where they're strong and where there's room to grow.

A system that, with just one click, generates a personalized “self-diagnosis report” for teachers. Not only does it break down your performance in numbers, but it also explains what those numbers really mean—something missing from the old model. Would you like to know how you compare to others? The “anonymous benchmarking” tool lets you compare yourself with peers teaching similar courses or at the same professional level. This helps you understand not only how you perform but where you stand in the wider picture.

The true strength of this center lies in the feedback loop it enables. After the analysis, the system doesn’t just stop—it actually recommends training resources or top teaching practices right to you. These might be an online course, a mentor’s feedback, or a real-life case study that matches your needs. Our goal is to make professional growth a natural and supported journey, rather than an occasional checkbox exercise.

3.2.2. Academic Command Center

Now picture this: you're a department head or a school manager. When you log in, the system

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provides you with a panoramic view of your faculty — akin to checking a health map. It shows how well different departments, majors, or teaching teams are doing overall, as well as patterns in strengths and challenges they face. We call this the "group portrait and analysis"—really useful when you're looking to lead with insight, not intuition.

But it goes further. The system automatically highlights teachers or teams who consistently perform well in certain areas—offering a strong data-backed basis for peer modeling and case sharing. On the flip side, it can also flag individuals showing signs of struggle, like a drop in engagement or inconsistent performance, so that administrators can step in before problems become severe.

These insights aren't just for looks—they shape resource decisions. Think of how many times we've guessed which group needed support. Now, with hard data, leaders can better plan workshops, staff training, and how teaching materials are allocated. This is how digital evaluation becomes a real driver of leadership—not just feedback for feedback's sake, but actionable tools for management.

3.2.3. Assessment Configuration Console

Behind the scenes, someone needs to govern the system—a bit like tuning the instrument before the music plays. This module gives administrators full control. If you need to adjust the evaluation criteria, the "Assessment Configuration Console" tool allows you to set or update the metrics aligned with the school's focus and teaching trends—ensuring that the system doesn't fall out of date.

Then there's the question of fairness. The "weight configuration" module helps fine-tune which evaluation categories count more or less for different teacher roles or review cycles. This flexibility is key—it avoids a one-size-fits-all approach and keeps the system relevant.

On the technical side, the "data interface management" is essential. Without smooth data flow across systems, the whole model can break down unnoticed. Admins can monitor input sources in real time, check for disruptions, and fix sync issues before they snowball into bigger problems.

Finally, but importantly, "permission management" ensures that only the right people are seeing the right data. From teaching staff to managers, access is sharply controlled—making sure that criteria, scores, and feedback remain both protected and actionable. It's a digital sandbox you can trust.

3.3. Data Security Design

Throughout the entire process of system design and implementation, data security and evaluation ethics must be given the highest priority. This is first reflected in the "strict protection of data privacy." The system will thoroughly anonymize all data involving personal privacy, especially during cross-individual benchmarking analysis, to ensure that no personal information can be identified, thereby resolutely safeguarding the individual rights of teachers. Second, a regular "algorithmic fairness review" mechanism must be established. This involves periodically auditing and validating the evaluation model and core algorithms to proactively eliminate potential discrimination that may arise from historical data biases, ensuring the objectivity and fairness of the evaluation process. More critically, the system must consistently "emphasize its developmental purpose" in all interface designs and interactive text, making it clear that its goal is to empower teachers' self-improvement and assist managers in providing targeted support, rather than for punitive judgment. Therefore, the connection between evaluation results and rigid metrics like performance appraisal must be handled with extreme caution, and a transparent and accessible appeal and review mechanism must be established.

Through the above model design and system construction, the aim is to create a teacher instructional development evaluation ecosystem that can objectively record, scientifically analyze, intelligently provide feedback, and precisely empower. This will genuinely make it a core engine driving the high-quality development of the faculty in higher vocational colleges.

4. Conclusion and Outlook

This paper addresses the issues of strong subjectivity, single-dimensionality, and delayed feedback in the current evaluation of higher vocational teachers by proposing the construction of a multi-dimensional scientific evaluation system based on big data. This system covers six major dimensions: teacher's morality, teaching, student nurturing, growth, and service. It relies on multi-source data to achieve dynamic monitoring and quantitative analysis of teachers' teaching behaviors. The Analytic Hierarchy Process (AHP) is used to determine indicator weights, and combined with data mining

ISSN 2663-8169 Vol. 7, Issue 9: 70-76, DOI: 10.25236/IJNDE.2025.070910

technology, it facilitates teacher portraiture and teaching diagnosis, enhancing the objectivity and developmental nature of the evaluation. The system architecture is divided into five layers, supporting self-diagnosis and management decision-making, and strengthening the process-oriented and scientific nature of the evaluation.

This research promotes the transformation of teacher evaluation from summative assessment to formative support, contributes to the construction of a "dual-qualified" faculty, and improves teaching quality. The next step will be to continuously optimize the system's level of intelligence, explore the integration of new technologies such as artificial intelligence and virtual reality to enhance the depth of data collection and the precision of evaluation, and build a human-centered teacher development support system to serve the needs of high-quality development in higher vocational education.

Acknowledgements

Funded by: The 2023 Special Research Project on Higher Education of the SHANDONG Association of Higher Education (Category: General Project for Higher Vocational Education), ‘Research on the Optimization of Development Paths for "Dual-Qualified" Teachers in Vocational Education in the Context of Big Data’ (Project No.: SDGJ2024E25).

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