Research on Data Application in Student Value added Evaluation

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Abstract: This paper focuses on a new value-added evaluation model under the background of educational evaluation reform, based on the collection and analysis of student learning process data in a smart teaching environment, and constructs a new application system for student value-added evaluation data. The paper first classifies and integrates process data and outcome data in the teaching platform, designs a method for standardizing heterogeneous data, and combines the proposed student behavior data standardization model to transform multi-source heterogeneous data into effective evidence for evaluation. This provides a new idea and practical model for promoting the scientific, informational, and intelligent development of educational evaluation data.

Keywords: Evidence based value-added evaluation; Unstructured data; Data standardization model

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1 introduction

1.1 Research background and significance

In October 2020, the Central Committee of the Communist Party of China and the State Council issued a guiding document for deepening the reform of education evaluation in the new era, titled "Overall Plan for Deepening the Reform of Education Evaluation in the New Era", which clarified the task book and roadmap for the reform of education evaluation in China in the new era. The "four evaluations" reflect respect for the laws of education and talent growth, emphasizing the dynamic, diagnostic, and diverse nature of evaluation, aiming to break the traditional and single evaluation model, and establish a more scientific, comprehensive, and in line with the requirements of the times education evaluation system. By reforming these evaluation methods, we can better promote the fairness and quality of education, and cultivate talents that meet the needs of social development. It is explicitly required to "fully utilize information technology to explore value-added evaluation", which is the first time that China has mentioned "value-added evaluation" in a central policy document.

1.2 Research Status

Student value-added evaluation refers to tracking students' academic performance, skills, literacy, etc. at different time points, using certain statistical analysis methods to analyze their changes, based on student development, weakening horizontal comparison, strengthening self vertical growth, providing positive feedback on student growth and progress, and playing an important role in motivating the development of underperforming students and promoting their healthy development. With the development of educational informatization, research on data-driven educational evaluation is becoming increasingly abundant. Wilson [1] used a systematic literature review method to collect and analyze 44 empirical studies on the evaluation of education big data, summarized commonly used data sources, analysis techniques, and evaluation models, and proposed the "Big Data Driven Evaluation Framework". Qian Mingxia et al. [2] explored the value implications of big data in undergraduate teaching quality evaluation, pointing out practical problems such as insufficient data literacy of evaluation subjects, lack of high-quality data support for evaluation criteria, algorithmic black box constraints on iterative optimization, and data ethics dilemmas. Zhang Zhuyu et al. [3] studied vocational colleges and constructed a three-dimensional knowledge gr

aph value-added model consisting of a knowledge base, a capability base, and mapping relationships. They proposed a process for data collection, personalized graph generation, and comprehensive evaluation. Fang Hongjun et al. [4] constructed a value-added evaluation system for college students' innovation and entrepreneurship abilities based on the Astin IEO theory model, which includes a three-level indicator system of individual student factors, school environmental factors, and innovation and entrepreneurship abilities. Evidence based education emphasizes data-driven approaches to developing and optimizing educational strategies based on empirical evidence. Pu Xuetao et al. [5] introduced the evidence-based concept into university governance, emphasizing the use of the best research evidence as the core and integrating subjective experience with stakeholder values

Through literature review, it can be found that although there has been some progress in value-added evaluation, data-driven evaluation, and evidence-based education research, there are still some shortcomings. Firstly, the content of value-added evaluation is relatively single, mostly focused on longitudinal comparison of academic performance, and lacks multidimensional evaluation of students' comprehensive qualities and abilities. Secondly, data-driven evaluation faces challenges such as data quality, data ethics, and algorithm transparency, and requires the establishment of a standardized data collection and processing system. Again, in evidence-based education research, the integration of theory and practice is not close enough, and there is a lack of evaluation model validation based on a large amount of empirical data. Therefore, this study intends to start from a data-driven perspective, with "value-added evaluation" as the core service object, to construct a value-added evaluation data application system that integrates data collection, data modeling, and data transformation. Through multi-source heterogeneous data collection and processing, a standardized model of behavioral data is constructed to achieve the transformation and evaluation of data into evidence, providing data support and theoretical basis for the subsequent construction of an evidence-based value-added evaluation system.

2. Research on Multi source Heterogeneous Process Data Types

2.1. Process data classification framework for teaching platforms

In the process of building a value-added evaluation data application system, the diversity of data sources and types is the key to ensuring the scientific and comprehensive nature of evaluation results. This study proposes a process data classification framework for teaching platforms based on the source and nature of the data, which divides the data into three categories: teaching platform process data, student behavior data, and unstructured data, as shown in Table 1.

Table 1 Process Data Classification Framework for Teaching Platforms

data type	specific content
Learning behavior data	Classroom interaction data: number of raises, number of answers to questions, participation in group discussions, etc.
	Resource access data: learning resource browsing duration, frequency of visits, download usage, etc.
	Online learning trajectory: distribution of login time, duration of stay, selection of learning path, etc.
	Social interaction data: frequency of discussions among students, depth of content, interactive network structure, etc.
Learning outcome data	Formative evaluation results: unit tests, stage assignments, experimental reports, etc.
	Summary evaluation results: final exams, comprehensive project scores, etc.
	Works and Achievements: Design works, research reports, innovative projects, etc. submitted by students.
	Ability performance data: problem-solving speed, innovative thinking performance, team collaboration efficiency, etc.
Learning attitude data	Self reflection report: qualitative data such as study logs and reflection notes.
	Questionnaire survey data: self-evaluation data such as learning interest, satisfaction, and engagement.
	Emotional state data: emotional states inferred through text analysis or behavioral patterns
	Learning motivation data: reasons for elective courses, setting learning goals, etc.

This classification framework provides a theoretical basis for the collection and processing of heterogeneous data. As Yang Siqi [6] pointed out in her research, the evaluation of teaching quality driven by big data needs to comprehensively consider multiple dimensions such as curriculum design, teaching experience, subject integration,

and teaching effectiveness, which is consistent with the data classification framework constructed in this study.

2.2. Unstructured data collection strategy

In addition to structured quantitative data, unstructured data (such as student discussion content, reflection reports, work descriptions, etc.) also contain rich value-added evaluation information. This paper proposes the following unstructured data collection strategies:

(1) Content analysis method: By analyzing the content of student discussion speeches, homework feedback, reflection logs, and other texts, keywords, themes, and emotional tendencies are extracted and transformed into quantifiable indicators.

(2) Observation and recording method: Teachers use structured observation forms to record students' behavior, emotional state, and cooperation in the classroom, forming comparable qualitative data.

(3) Portfolio evaluation method: Collect works or projects completed by students at different times, and evaluate the development and changes of their abilities and literacy through comparative analysis.

(4) Interview and Focus Group Method: Through semi-structured interviews and focus group discussions, gain a deeper understanding of students' perception and comprehension of their own learning changes.

These unstructured data collection strategies, combined with Johnson's GPT-4 based learning analysis tool [7], can automatically identify students' emotional states, learning preferences, and behavioral patterns, providing rich qualitative evidence for value-added evaluation.

3. Research on Standardized Modeling of Student Behavior Data

3.1. Processing methods for multi-source heterogeneous data

The multi-source heterogeneous data composed of process data in teaching platforms often have problems such as inconsistent formats, different dimensions, missing values, and outliers after collection, and require cleaning and conversion processing. This paper adopts the following technical methods:

3.1.1.Data cleaning aspect

To address the issue of missing values, mean/mode imputation, temporal interpolation, or multiple interpolation methods are used based on the data type; For outliers, box plot method, Z-score method or local density algorithm are used for identification and processing; Design a hash based fast deduplication algorithm for duplicate data.

3.1.2.In terms of data conversion

Standardize data from different sources, mainly including: normalization of numerical data (Min Max standardization or Z-Score standardization); Encoding conversion of categorical data (hot encoding or tag encoding); Feature extraction of time-series data (such as frequency features, trend features, etc.); Dimensionality of text data (such as TF-IDF, word embeddings, etc.).

Wilson pointed out in reference [1] that one of the main challenges facing the evaluation of educational big data is the heterogeneity and standardization of data. This paper achieves the unified representation of multi-source heterogeneous data through the above technical path, providing a standardized data foundation for subsequent value-added evaluation.

3.2. Construction of a standardized model for learning behavior data

Referring to the data-driven decision-making culture construction concept described by Thompson [8], and closely adhering to the purpose of "value-added evaluation of service education", combined with the proposed teaching platform process data classification framework, student behavior data value analysis, and multi-source heterogeneous data collection, processing, and evaluation research results, this paper proposes a three-layer architecture learning behavior data standardization model, which can effectively support teachers' visual understanding and timely intervention of students' learning trajectories.

The standardized model structure for learning behavior data is shown in Figure 1, which is divided into thre

e levels:

(1)Basic indicator layer: All indicators in this layer are derived from the analysis of raw behavioral data;

(2)Comprehensive feature layer: The indicators in this layer are obtained by extracting features from the bas ic indicator layer;

(3)Standard pattern layer: The indicators in this layer are obtained by classifying the patterns of the compre hensive feature layer;

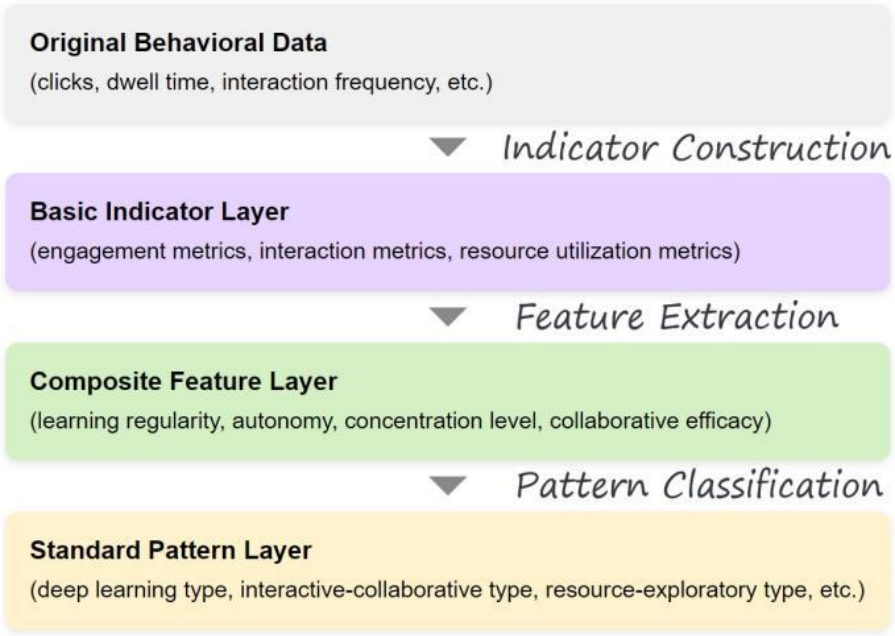

Figure 1: Three layer standardized model for learning behavior data

4. Research on the Conversion Path from Data to Evidence

4.1. Classification criteria for evidence levels in educational evaluation

The process data of the teaching platform is complex, and directly using it for educational value-added eval uation has poor results. It is necessary to screen and classify these multi-source heterogeneous data, and transfo rm the data into evaluation evidence that can be used for value-added evaluation. Therefore, this paper propose s a five level classification standard for educational evaluation, as shown in Table 3

Table 3 Five level classification criteria for educational evaluation evidence

Level of Evidence	Evidence type	Specific content and examples
First level evidence	Strictly compare the longitudinal tracking data of the design	Standardized evaluation results comparing pre - and post tests, learning effectiveness data with a control group, etc
Secondary evidence	Systematic collection of process performance data	Structured observation records, comprehensive analysis results of multi-source behavioral data, etc
Level Three Evidence	Learning output and outcome data	Assessment of homework quality, project portfolio, performance of abilities and tasks, etc
Level 4 evidence	Self reporting and Reflection Data	Learning logs, questionnaire surveys, self-evaluation and peer evaluation data, etc
Level 5 evidence	Situational observation and informal feedback	Classroom performance records, real-time feedback, unstructured discussions, etc

This level of evidence classification corresponds to the research of Chen Huanchun et al. [9] on evidence-bas ed education reform, avoiding the limitations of overemphasizing a single type of evidence and constructing a m ulti-dimensional complementary evaluation system.

4.2. Data Evidence Processing Flow

According to the five level classification criteria for evaluation evidence, this paper achieves a systematic transformation from "raw data" to "valid evidence" through the following four steps, providing a scientific process and basis for value-added evaluation.

The first step is to integrate and clean the original data using the multi-source heterogeneous data processing method proposed earlier;

The second step is to construct and calculate various indicators of the basic layer based on the proposed standardized data model for learning behavior;

Step three, based on the proposed standardized data model for learning behavior, utilize methods such as feature extraction and pattern recognition to construct and calculate comprehensive layer and standard pattern layer indicators;

Step four, based on the five level classification criteria for educational evaluation evidence, integrate educational evaluation evidence and conduct ratings. At the same time, the rating results can be dynamically fed back to step one to adjust and revise multi-source heterogeneous data processing methods. Repeat steps two to four until the rating results are optimal.

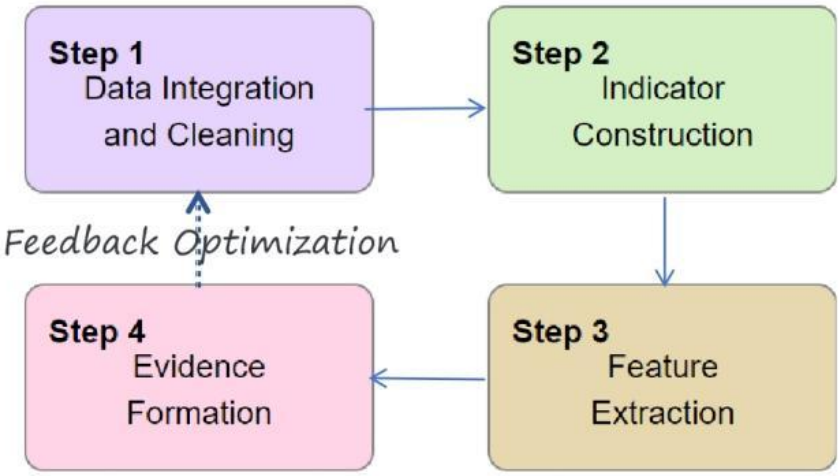

Figure 2 Four step conversion process from data to evidence

4.3. Reliability and validity verification of evidence

Martinez's research on the validity evidence of value-added models emphasizes the importance of content validity and consequence validity. In order to better ensure the rationality of data evidence processing results, this paper starts from two dimensions: reliability verification and validity verification, and adopts mechanisms of data cross validation and content validity evaluation (expert evaluation) to ensure the reliability and effectiveness of data evidence processing, avoiding the limitations of only focusing on predictive validity.

5. summarize

This paper focuses on a new value-added evaluation model under the background of educational evaluation reform, based on the collection and analysis of students' learning process data in a smart teaching environment, and constructs a new value-added evaluation data application system. This system starts from a data-driven perspective, with "value-added evaluation" as the core service object. Through multi-source heterogeneous data collection and processing, it constructs a standardized model for behavioral data, realizes the transformation and evaluation of data into evidence, and provides a solid data foundation for evidence-based value-added evaluation, which has certain theoretical and practical significance.

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