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Design of comprehensive evaluation model for pre-service teachers' Five-dimensional education based on machine learning

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***Abstract*—This paper explores China's Five-dimensional education policy, aiming at holistic student development. It analyzes its historical and theoretical underpinnings and proposes a method for constructing a comprehensive evaluation index system for pre-service teachers. We suggest using behavioral data from campus cards and online learning systems as independent variables, with data in the Five-dimensional education system as dependent variables. Six common machine learning models are employed to train and evaluate the data, identifying the optimal model. Our research aims to uncover the nonlinear relationship between behavior and Five-dimensional education levels, facilitating comprehensive student development interventions. This research provides a new train of thought for in-depth study on education evaluation.**

Keywords—five-dimensional education, machine learning, evaluate, pre-service teachers

I. INTRODUCTION

Cultivating what kind of people is the primary issue of education, the answer to this question is not the only one, different historical periods, different countries, different scholars for this issue are different opinions, but in general, there is a consensus, that is, the cultivation of people is to contribute to social development, different societies will have different talent needs. At all times, at home and abroad, there are many schools of thought and different theoretical viewpoints on education and running a school, but there is a consensus that education must train people needed for social development[1]. For China, socialist countries require education to train builders and successors of socialism, which is the direction and goal of our education requirements. At the same time, constructing the education policy with local characteristics is also a means to consolidate the foundation of national culture.

The cultivation of socialist builders and successors is inseparable and dialectically unified with the all-round development of morality, intelligence, physique, aesthetic and labor. The former is the political attribute of talent training, while the latter is the requirement of the quality structure of talent training [2]. Under the guidance of the goal of educating people, teaching needs to be reformed and reconstructed. However, the long-term misunderstanding of subject-centeredness and utilitarianism has led to an imbalance in the five aspects of education. The arrival of the intelligent era provides a new way for the transformation and reconstruction of the teaching paradigm, and also provides a new idea for the formation of localized STEM education(Science, Technology, Engineering, Mathematics). Some scholars have proposed that the implementation of the Five-dimensional education can be reformed from five aspects: education goal, characteristic curriculum, integrated resources, teaching mode and comprehensive evaluation [3]. Educational evaluation is the baton of educational reform. We should get rid of the "only score" evaluation method and develop a comprehensive evaluation plan for Five-dimensional education.

Education is the foundation of a hundred-year plan. The training quality of Pre-service teachers plays an important role in the quality of basic education. Training high-quality educational talents is an important way to achieve the goal of strengthening education. As a group of future teachers, Pre-service teachers should pursue "learning as a teacher and being a model", not only have the ability to cultivate all-round development of students, but also be preparatory teachers of Five-dimensional education at the same time and set an example. This research takes Pre-service teachers as the research object, establishes the comprehensive evaluation index of the Five-dimensional education of Pre-service teachers, designs a method of the evaluation model based on machine learning, and provides ideas for training Pre-service teachers with all-round development of morality, intelligence, physical fitness, aesthetic and labor.

II. RELATED WORK

The Five-dimensional education is an educational policy with Chinese cultural characteristics, which can be traced back to CAI Yuanpei's Opinions on New Education published in 1912: Military national education, materialism education, civic moral education, worldview education, and aesthetic education cannot be neglected in recent education[4]. Figure 1 shows the development process of the theory of the Five-dimensional education.

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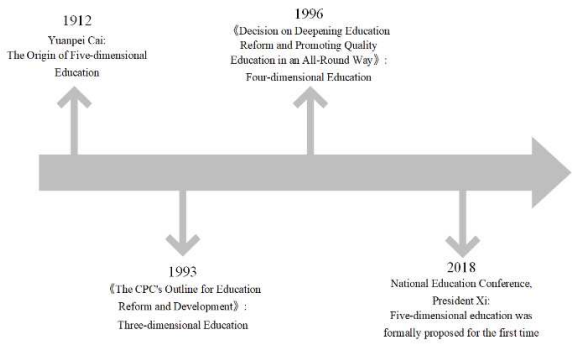


Fig. 1. Development process of the Five-dimensional education.

After the theory of the Five-dimensional education was put forward, relevant research began to explore and practice the theory around it. Zhong Bochang et al. believe that the imbalance of the Five-dimensional education and the lack of "localized STEM education" exist in the current education field, and the Five-dimensional education integration is a localized and cross-domain integration education paradigm that adapts to the characteristics of Chinese education [3]. Li Zhengtao et al. proposed the Five-dimensional education integration, that is, simultaneous development of Five-dimensional education and integrated education. The difficulties lie in the five aspects of daily life, mechanism, evaluation, subject and ecology, and proposed solutions to these difficulties [7]. In practice, primary and secondary schools across China are also actively exploring the practice of the Five-dimensional education. Lu Weizhong [8], vice president of Yangpu District College of Education in Shanghai, constructed an evaluation system of education effectiveness under the background of the Five-dimensional education integration, including first-level indicators from Five dimensions of moral education, intellectual education, physical education, aesthetic education and labor education, 20 second-level indicators and descriptions of key points. At the same time, taking "the value of labor" micro-course as an example, the evaluation index system is applied to teaching.

Educational evaluation is the "baton" and "heading mark" to improve the quality of education, which plays a very important role in the all-round development of students and the professional growth of teachers. Traditional evaluation is mainly based on result evaluation, and "result evaluation" is the most common educational evaluation method in primary and secondary schools, which mainly evaluates the final results of students' learning and teachers' classroom teaching results in the form of examinations for a learning stage, such as a unit, a semester or an academic year [9]. Although the traditional evaluation method can intuitively grasp the academic level of students, this single evaluation method is not conducive to the overall development of students. The comprehensive evaluation of the Five-dimensional education is a value orientation returning to humanism, which requires to abandon the single evaluation method of grade first, improve the evaluation system of students' morality and all-round development, put students' moral cultivation and all-round development in the first place, and put students' intellectual factors and non-intellectual factors in the same important position to promote students' all-round development.

In recent years, with the rise of big data and artificial intelligence technology, the application of intelligent technology to education and teaching is an important issue in the current education reform. The development of educational evaluation urgently needs new technology and new methods to break through and innovate. Devanshu et al. [10] reviewed the application of artificial intelligence in education and proposed that in terms of educational evaluation, data mining technology based on artificial intelligence can develop predictive models in the field of education, predict future student performance, predict learning outcomes, and identify at-risk students who may need additional support. Using ML algorithms to automate timely and personalized assessment of students saves educators time, ensures objective assessment, and speeds up feedback. Table 1 shows some representative research results of artificial intelligence, big data and other technologies in the field of educational evaluation.

In summary, the Five-dimensional education is a comprehensive education policy with local culture. In the process of implementing the Five-dimensional education, it is necessary to pay attention to the feedback and guidance of comprehensive evaluation on the education and teaching process. Based on technologies such as big data and artificial intelligence, the results of education evaluation can be fed back to students, teachers, and schools in a more objective, accurate, timely, and personalized manner, thereby providing data support for student development. This research takes Pre-service teachers as the research object, explores the comprehensive evaluation model of the Five-dimensional education for Pre-service teachers, and provides reference ideas for the training of pre-service teachers.

III. Research Framework

This research is aimed at Pre-service teachers, who are both teachers and students, to conduct a comprehensive evaluation of the Five-dimensional education. The main contents of the research are divided into three parts: Design a method to construct a five-dimension education evaluation index system for pre-service teachers; Collect pre-service teachers' campus life behavior data; Design a process for constructing a five-dimensional education model for pre-service teachers.

The construction of the comprehensive evaluation index system of the Five-dimensional education for Pre-service teachers is mainly divided into four steps: preliminary drawing of index, revision of index, reliability and validity test and weight determination. In the initial planning stage of the index, the literature research method is mainly adopted, the Delphi method is adopted in the index revision stage, and the reliability and validity are tested by factor analysis method. Finally, the analytic hierarchy Process (AHP) is used to determine the weight of the index.

After determining the index system, it is necessary to collect the behavioral data of Pre-service teachers. The collected data mainly includes learning data and life data. The learning data mainly comes from the process data of students'

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TABLE I. SUMMARY OF RECENT PAPERS ON ARTIFICIAL INTELLIGENCE IN EDUCATIONAL EVALUATION

Paper Title	*Authors*	*Year*	*Methodology*	*Focuses*
Modeling and application of online learning assessment based on learning analytics: Research on learner comprehensive evaluation reference model[11]	Qinhua Zheng, Yaohua Zheng, Hongtao Sun et al.	2016	Empirical Research	Personalized learning assessment, learning analytics
Development Trend of Undergraduate Academic Situation at Tsinghua University[12]	Xiaoxiao Yu, Ran Xu, Zequn Zhao	2023	Empirical Research	Cluster analysis, student development analysis
A feature weighted support vector machine and artificial neural network algorithm for academic course performance prediction[13]	Chenxi Huang, Junsheng Zhou et al.	2023	Empirical Research	Support vector machine, neural network, grade prediction model
Behavior-driven grade warning model based on three dimensional deep integration[14]	Junxi Zhuang et al.	2024	Empirical Research	Consumption behavior, activity behavior, and performance warning models

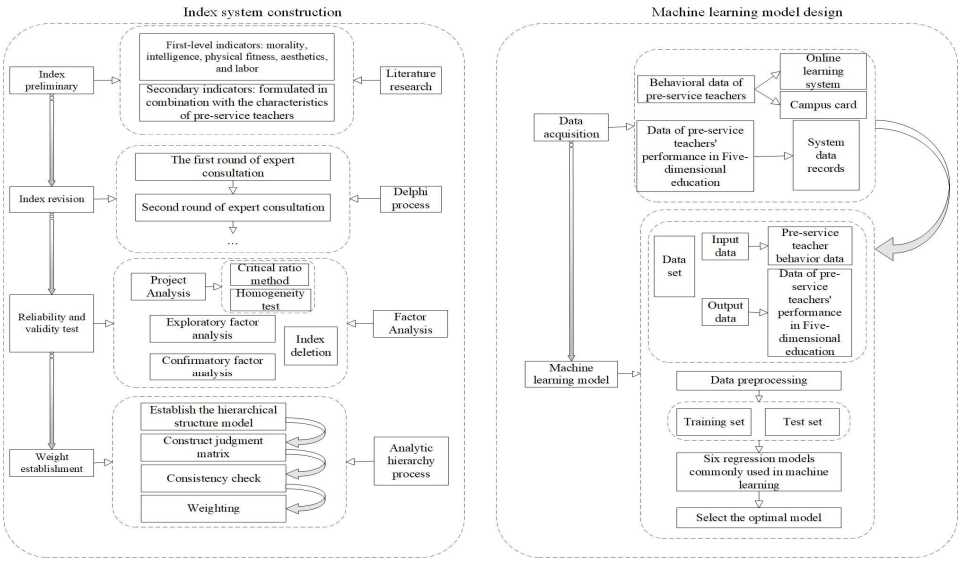


Fig. 2. Technology roadmap

online learning system. Life data comes from campus card data records, such as sports punch, food and beverage consumption.

The design of the comprehensive evaluation model of the Five-dimensional education for Pre-service teachers based on machine learning first needs to pre-process the collected behavioral data of Pre-service teachers and serve as the input data for model training. At the same time, the activity of Pre-service teachers in the Five-dimensional education system needs to convert into a score, which is used as the output data of model training. Several common machine learning models are trained on the data set, and the optimal model is selected as the final model of the comprehensive evaluation. The specific technical route is shown in Figure 2.

IV. INDEX SYSTEM CONSTRUCTION

The construction of the comprehensive evaluation index system is divided into four steps: preliminary preparation of index, revision of index, reliability and validity test and weight determination.

A. Index preliminary

To construct the index, it is necessary to determine the research question. Through literature research, according to China's Five-dimensional education policy documents, and referring to the relevant student evaluation standards at home and abroad, the characteristics and needs of the Five-dimensional education evaluation of Pre-service teachers are analyzed, the basic model of the evaluation index system is constructed, and the framework of the index system is initially formed. The index system is divided into primary index, secondary index and tertiary index. The first level index has been determined as the five dimensions of the Five-dimensional education, namely, moral, intellectual, physical, aesthetic and labor; The second index is based on the characteristics of Pre-service teachers, the content of the first index is expanded, and the third index is mainly the achievements of Pre-service teachers in morality, intelligence, physical education, aesthetic and labor, and converted into evaluation scores. In order to ensure the objective and accurate results of the comprehensive evaluation, evaluation indicators that can summarize the basic characteristics of each level of the evaluation content should be selected as much as possible during the initial establishment of the index system, so that there is room for selection in the final determination of the index system. Table 2 shows some of the preliminary indicators.

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TABLE II. SOME PRELIMINARY INDICATORS

Primary index	*Secondary index*	*Third index*
Moral	Ideological and political study and moral cultivation	Ideological and political theory scores, extra-curricular moral education credits
	Be honest and law-abiding	Extracurricular moral education credit
	Teachers' ethics and manners	Teacher education elective
	Social morality	Extracurricular moral education credit
Intellectual	Theoretical knowledge and basic skills	Theoretical course results, practical course results, discipline professional competition
	Scientific research ability	Academic activities, academic achievements
	Teaching innovation ability	Teaching skills competition
Physical	Basic skills of sports	Physical education course results, sports competitions
	Physical fitness	Physical test results, daily physical activity
	Sports culture	Watch sports and join sports clubs
Aesthetic	Aesthetic expression	Artistic performance
	Artistic sentiment	Watch an art performance
	Aesthetic experience ability	Works appreciation, art criticism
Labor	Labor basic knowledge and skills	Achievement in labor theory
	Labor habit	Individual labor activity
	Innovation consciousness	Innovation competition and innovation results

B. *Index revision*

The index will be revised after the initial plan is completed, and the revision of the index system mainly relies on Delphi method and factor analysis. First of all, the proposed comprehensive evaluation index system of the Five-dimensional education of Pre-service teachers will be revised through Delphi method, and the evaluation index system will be further improved according to the reasonable score of the indicators and specific modification opinions of the experts, so as to form a set of comprehensive evaluation index based on expert consensus. The Delphi procedure is shown in Figure 3.

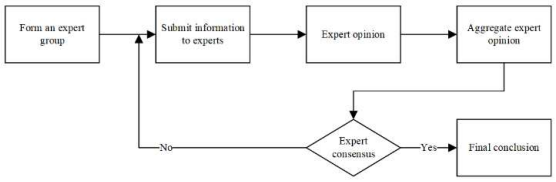


Fig. 3. Delphi process steps

C. *Factor analysis*

The reliability and validity of the comprehensive evaluation index system based on expert consensus will be analyzed by factor analysis. In this study, data were collected from the pre-service teachers' Five-dimensional education system to collect performance data in various aspects. After the data were pre-processed, exploratory factor analysis was conducted first to identify potential factors and discover potential links between evaluation indicators, so as to classify multiple relevant indicators into fewer factors. When performing factor analysis, it is necessary to select the appropriate factor extraction method, such as principal component analysis (PCA) or maximum likelihood method. The number of factors is then determined using methods such as Kaiser criteria (factors with eigenvalues greater than 1), Cattell's Scree Plot method, and so on. A factor rotation is then performed, such as using the maximum variance method (Varimax) or the oblique rotation method (Oblimin), to obtain a more easily interpreted factor structure. According to the results of factor analysis, a simplified model containing fewer factors is constructed, each factor represents a set of related evaluation indicators. Finally, confirmatory factor analysis (CFA) or cross-validation methods are used to verify the stability and reliability of the factor model[15]. The main steps of factor analysis are shown in Figure 4.

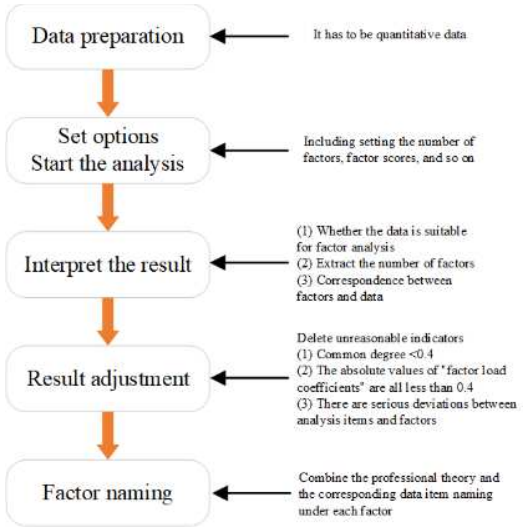


Fig. 4. Factor Analysis

D. *Index weight determination*

In order to ensure the rationality and scientificity of the evaluation system, it is necessary to further determine the assignment and weight coefficient of the evaluation index of the Five-dimensional education of Pre-service teachers. The process of calculating the weight of evaluation indicators is to determine the importance of indicators at all levels in all indicators. Generally, the more important the evaluation indicators are, the higher the weight value is. Currently, there are a variety of commonly used methods to determine index weights. Because AHP can not only determine weights and sort them, but also organically combine with other methods (such as fuzzy set theory, fuzzy logic, artificial neural network, etc.) in the future, it is a hierarchical and systematic analysis method that combines qualitative and quantitative methods and is highly logical, systematic and practical[16]. It is especially suitable for the establishment of multi-level and multi-index weight coefficients. Therefore, this study uses analytic hierarchy process (AHP) to determine the weight

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coefficient of the index system. The steps of the analytic hierarchy process are shown in Figure 5.

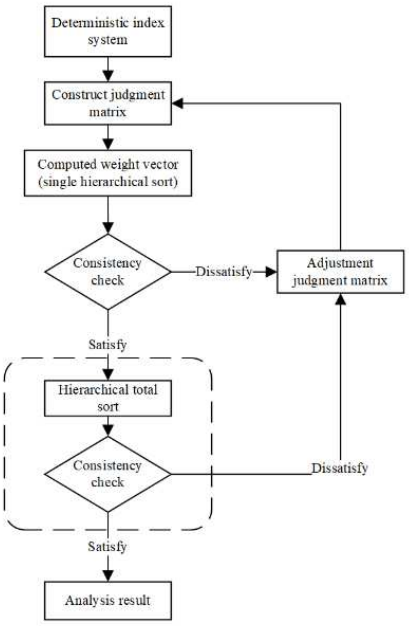


Fig. 5. AHP procedure

V. DATA COLLECTION

The machine learning model designed and constructed needs to collect two kinds of data, namely input data and output data, to form the data set for model training. The behavioral data of Pre-service teachers comes from campus e-card data and online learning system data, which covers all the data of Pre-service teachers' consumption, learning, sports and activities in school. Through the formal application process, data available for scientific research was obtained from the school data center. The daily living habits of Pre-service teachers can be reflected in the time of entering and leaving school, dining data in canteen, participating in various activities, entering and leaving library, borrowing books and punching in sports. The online learning system data can reflect the process data of normal college students' learning, such as the browsing times and time of learning materials, the time of homework submission, and the number of discussions with peers. These behavioral data may affect the development of Pre-service teachers' the Five-dimensional education, and these data are used as input data for model construction.

The data on the development level of Pre-service teachers' Five-dimensional education comes from the data of the Five-dimensional education system, which is a comprehensive evaluation system specially developed for the Five-dimensional education of Pre-service teachers, and systematically records the learning situation and achievements of Pre-service teachers in five aspects of moral education, intellectual education, physical education, aesthetic education and labor education. According to the evaluation index system established in the previous part, corresponding data are collected. As an output variable for model construction.

VI. MACHINE LEARNING MODEL DESIGN

A. Sample selection and pretreatment

Since the types of data collected are not uniform, it is necessary to preprocess the data before model training. After removing student samples with serious information loss and some outliers, the data were normalized and 75% were used as the training set and 25% as the test set to test the performance of the regression model after training.

B. Model training

In the past, linear models such as structural equation models were often used in relevant researches. Many phenomena in the real world are not linear, and nonlinear regression can describe these phenomena more accurately. Nonlinear regression can deal with the complex relationship between variables, and can fit the curve or non-linear relationship that linear regression cannot capture. Therefore, this study adopts machine learning model to construct nonlinear model. Six models of support vector machine, gradient lifting, logistic regression, decision tree, random forest and neural network were used for training to explore the relationship between the behavioral data of Pre-service teachers and the level of the Five-dimensional education. The model in Python Scikit-learn Package is used for implementation, and the model is screened by comparing the evaluation indicators of the model. The evaluation indexes of the model are shown in Table 3.

C. Result analysis

After selecting the optimal model according to the evaluation index of the model, the influence degree of all kinds of behavioral data obtained by the model on the overall level and the level of each dimension of Pre-service teachers' Five-dimensional education is sorted, and then the relationship chart is drawn to explore the nonlinear relationship, and the analysis and interpretation are carried out.

VII. CONCLUSION

As China's local integrated education policy, Five-dimensional education is a talent training strategy that integrates Chinese local culture. Pre-service teachers are the future group of teachers, and training good pre-service teachers is of great significance to China's talent training. The evaluation research of the Five-dimensional education is not only a test of the quality of education, but also a feedback, providing a basis for the improvement of educational activities. Traditional evaluation methods have problems such as strong subjectivity, single dimension and neglect of individual differences. In the era of big data and artificial intelligence, data-centered evaluation methods can provide comprehensive, objective, real-time and personalized feedback, bringing new methods for the reform of educational evaluation. The comprehensive evaluation method based on machine learning provides the detailed steps of evaluation index construction, data collection and model construction, which provides a feasible method for the implementation of the Five-dimensional education in China and a new technical means for the training of pre-service teachers.

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TABLE III. MODEL EVALUATION INDEX AND MEANING[17]

Index	*Implication*
EV（Explained Variation）	Refers to the proportion of variance that determines the interpretation of a variable, that is, the proportion of the variation explained in the regression model to the total variation. EV values range from 0 to 1, with the closer to 1 the better the model fit.
RMSE（Root Mean Squared Error）	Refers to the square root of the square of the mean error square, used to measure the average degree of error between the predicted results of the model and the actual results. The smaller the RMSE, the higher the prediction accuracy of the model.
MAE（Mean Absolute Error）	The average absolute error is used to measure the average absolute error between the predicted results of the model and the actual results. The smaller the MAE, the higher the prediction accuracy of the model.
MSE（Mean Squared Error）	The square of average error is used to measure the average degree of error between the predicted results of the model and the actual results. The smaller the MSE, the higher the prediction accuracy of the model.
R^2（Coefficient of Determination）	Coefficient of determination is used to measure the degree of fit between the predicted results of the model and the actual results. R^2 ranges from 0 to 1, with closer to 1 indicating a better model fit.

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