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Innovative Application of Cultural Heritage Education Resources Combined with Fuzzy Algorithm in Modern History Teaching

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This study utilizes a fuzzy algorithm to explore the innovative application of cultural heritage educational resources in modern history teaching, optimize the integration path of educational resources, improve teaching outcomes, and integrate traditional culture with modern education. With the acceleration of globalization, the protection and survival of cultural heritage have become an important subject of modern education. In modern history teaching, course content needs to incorporate rich cultural heritage resources as a key way to foster students' cultural identity and historical consciousness. This study uses a fuzzy algorithm for the integration and application of cultural heritage educational resources. It optimizes the allocation of teaching resources by intelligent means, and improves the quality of education. Firstly, it analyzes the characteristics of cultural heritage educational resources, points out their importance and uniqueness in modern history teaching, and addresses many challenges posed by the integration of cultural heritage educational resources, particularly in terms of providing diversified educational content and individualized teaching needs. Then, based on the fuzzy comprehensive evaluation model and the fuzzy clustering algorithm, an educational resource optimization model was constructed. Through methods such as data collection, questionnaire surveys, and interviews, the teaching data of educational institution A was obtained, and fuzzy algorithms were used to scientifically evaluate and optimize educational resources. The results show that the fuzzy algorithm can effectively deal with the uncertainty in the teaching process, provide personalized learning path recommendation, and effectively integrate cultural heritage resources and modern education technology through data analysis using the weighted average method. The results show that the application of the fuzzy algorithm in the integration of educational resources improves the accuracy of resource allocation and helps to create personalized learning paths. For model verification, the cross-validation method is adopted to determine the effectiveness and accuracy of the model, and confirm the feasibility of applying a fuzzy algorithm in the field of education. The study also found that the model has limitations in terms of data dependence and real-time update, and future research needs to optimize the adaptability and operability of the algorithm. By combining the fuzzy algorithm with cultural heritage education, this study provides a new approach to the optimization of educational resources, a feasible scheme for the integration of cultural heritage resources in modern history teaching, and promotes the innovative development of cultural heritage education.

Keywords: fuzzy algorithm; cultural heritage education; modern history teaching

1. INTRODUCTION

1.1 Background Information of the Research Field

Cultural heritage education is an important way to foster students' sense of cultural identity and historical responsibility, which is of great concern. With the acceleration of globalization, traditional culture is gradually disappearing, and the protection and transmission of cultural heritage has become an important topic in the field of global education. In China, cultural heritage is not only about the preservation of historical relics; it is also the link between national spirit and cultural identity. For young people, understanding and inheriting cultural heritage can enhance

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their national self-confidence and cultural consciousness. Modern history teaching is an important means of conveying inheriting history and culture, as it combines history with reality, and tradition with modernity. The effective integration of cultural heritage educational resources can enrich the teaching content and help to cultivate students' historical perspective and critical thinking.

At present, cultural heritage education in modern history courses is still in the preliminary stage, and faces several problems such as insufficient utilization of resources and single education mode. The diversity and richness of cultural heritage educational resources require modern history teaching to transcend the limitations of traditional teaching methods and pay attention to innovation and integration. How to use modern scientific and technological means to optimize and enhance the utilization of cultural heritage educational resources has become an urgent problem to be solved.

Fuzzy algorithms are mathematical tools used to deal with uncertainty and fuzzy information, and its potential in the optimization of educational resources has been gradually recognized and explored in recent years. A fuzzy algorithm can deal with complex educational data, solve the ambiguity and uncertainty in educational decision-making, and has a large application space in the allocation of educational resources and personalized recommendation. By building a fuzzy comprehensive evaluation model or fuzzy clustering algorithm, cultural heritage education resources can be accurately evaluated and screened, personalized teaching paths and learning content can be devised and the deep integration of cultural heritage education and modern history teaching can be achieved. It can enhance the adaptability of course content, optimize the learning experience of learners, and improve students' educational outcomes.

1.2 Research Status

1.2.1 Research on Educational Resources of Cultural Heritage

Cultural heritage education is a mature interdisciplinary course and practical field that connects heritage research, historical education, museum and site learning, as well as community engagement. In modern history teaching, it mobilizes tangible resources (ancient sites, cultural relics, archives) and intangible resources (language, rituals, handicrafts) as the main evidence to cultivate historical thinking, source criticism, cultural identity and civic awareness. With globalization and rapid urban changes intensifying the risks faced by heritage, this field has regained attention in both formal and informal Settings. Contemporary research explores how to plan, interpret and digitize heritage resources, design location-based and inquiry-driven activities, and combine conservation ethics with measurable learning outcomes and intergenerational sustainable communication.

On a global scale, important research achievements have been made on the application of educational resources in cultural heritage teaching. Axon et al. (2024) conducted an in-depth discussion on the sustainable management of cultural heritage in the coastal areas of the United States, revealed the impact of climate change on cultural heritage, and emphasized the important role of education in protecting cultural heritage. They point out that education is not only a means of safeguarding cultural heritage, but also a key factor in the adaptive and sustainable development of society [1]. It provides a new perspective on cultural heritage education and emphasizes the role of education in raising public awareness of cultural heritage conservation. From the perspective of energy sustainability, Cacciuttolo et al. (2024) discussed how to apply renewable energy to protect cultural heritage, indirectly pointing out the close connection between educational cultural heritage resources and environmental education [2]. It provides theoretical support for combining cultural heritage education with ecological protection and sustainable development in the future.

Mzembe et al. (2023) discussed the relationship between cultural heritage tourism and sustainable development, and emphasized the important role of education in the protection of cultural heritage, as well as the integration and optimization of teaching resources. The study found that cultural heritage education helps to enhance students' sense of identity with history and culture, and can also lead students to consider and have a deeper understanding of the multi-dimensional value of cultural heritage [3]. However, the incorporation of cultural heritage in school curricula still faces many challenges, and there is still a lack of effective solutions on how to improve the interactive and innovative education model.

The limitation of cultural heritage education when conducted via the traditional teaching mode is that it relies too much on text and images, and lacks interaction and innovation. Students have low interest in learning and poor participation, and therefore cannot achieve optimal learning outcomes. Wongkhuenkaew et al. (2023) proposed that the fuzzy clustering algorithm, as an effective data processing method, can play an important role in the allocation and personalized recommendation of educational resources, optimize the use of educational resources and improve learning outcomes [4]. It provides a theoretical basis for the digitalization and intellectualization of cultural heritage education resources and, to a certain extent, promotes the innovation and reform of cultural heritage education.

1.2.2 Research Progress of Fuzzy Algorithms

In recent years, the fuzzy algorithm has been widely used in the field of education as it is an effective facilitator of decision-making and optimization under uncertain conditions, and progress has been made in the research of educational resource allocation, evaluation and personalized recommendation. Through the operation of a fuzzy set, a fuzzy algorithm can make the originally ambiguous information of educational resources clear and achieve the optimal allocation of educational resources.

Zhu et al. (2023) studied the development of cultural heritage and souvenirs, and proposed that the evaluation and optimization of educational resources of cultural heritage by means of fuzzy logic could effectively apply educational resources of cultural heritage to history teaching [5]. The research shows that the fuzzy algorithm can evaluate the value of cultural heritage and provide a scientific basis for the optimization of educational resources. Wojcik et al. (2023)

applied a fuzzy expert system in the medical field in order to analyse patients' health data. Moreover, the fuzzy model proposed in this study also has implications for the application of fuzzy algorithms in education [6]. The potential of fuzzy algorithms in the field of education is not limited to resource assessment, but also includes decision support for teaching practices and the optimization of personalized education paths.

Ghahramani et al. (2020) studied community resilience in terms of cultural heritage protection and proposed that fuzzy algorithms could be used to assess the value of cultural heritage resources. Especially in regard to cultural heritage protection, when faced with many uncertainties, fuzzy algorithms can provide effective assessment and decision support [7]. The application scope of fuzzy algorithms in cultural heritage protection has been expanded, and the feasibility of applying fuzzy algorithms in cultural heritage education has been confirmed.

Liu et al. (2020) combined the VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje) method with a fuzzy environment to construct a comprehensive evaluation framework for low-carbon tourism destinations. In this framework, fuzzy mathematics was introduced to describe the uncertainty and vagueness of indicators, while the VIKOR method was applied to rank and optimize multiple criteria. Based on this integration, they proposed a fuzzy comprehensive evaluation approach. This method enables a scientific evaluation mechanism under conditions of multidimensionality, fuzziness, and trade-offs, thereby providing theoretical support for the integration and application of cultural heritage education resources [8]. It not only has practical value in the sustainability assessment of low-carbon tourism destinations but also offers a new pathway for the comprehensive evaluation of cultural heritage education, laying a theoretical foundation for the rational integration and allocation of resources.

In view of ways to integrate cultural heritage education resources in history education, several researchers have proposed specific fuzzy algorithm applications. Polishchuk et al. (2019) studied the application of risk assessment models in different environments and proposed that fuzzy algorithms could effectively assess the risks of cultural heritage resources and help educators rationally allocate resources when teaching [9]. Liao et al. (2018) proposed that fuzzy language preference relationship can be used to select and optimize educational plans, and this has important reference value for the integration of cultural heritage resources in history teaching [10]. It provides theoretical support for the application of fuzzy algorithms in cultural heritage education, and provides a practical basis for resource allocation, curriculum design and the optimization of teaching strategies.

1.2.3 Research Overview

On the whole, the research on the application of cultural heritage education in teaching, combined with the research of fuzzy algorithm to optimize educational resources, has achieved certain promising results, but it is still in the preliminary exploration stage. In the future, with the increasing application of fuzzy algorithms in the field of education, with the support of big data and artificial intelligence technology, teaching practices and the application of resources in cultural heritage education will be optimized and innovated, and more effective solutions will be provided to improve the quality of history teaching and the effect of the cultural heritage legacy.

1.3 Research Questions

1.3.1 Limitations of Cultural Heritage Educational Resources in Modern History Teaching

At present, the application of cultural heritage educational resources in modern history teaching has great limitations. Although cultural heritage has important educational value, the integration and application of relevant resources are still inadequate in actual classroom teaching. Most of the teaching relies on traditional teaching materials, and students' understanding of cultural heritage remains at the knowledge level, lacking in-depth explorations of cultural connotation, historical background and social significance. Traditional teaching methods have also failed to make effective use of multimedia and digital tools to display and impart cultural heritage knowledge, and the value of these resources has not been fully exploited. In modern history teaching, cultural heritage is closely related to specific historical events. How to apply these resources innovatively in modern history education to achieve better teaching results remains a problem to be tackled by further research [11–13].

1.3.2 How to Realize Innovative Application of Educational Resources Through Fuzzy Algorithms

Fuzzy algorithms provide a new method for the optimization of educational resources. Despite the complexity, uncertainty and fuzziness of educational resources, fuzzy algorithms can accurately classify, evaluate and optimize the allocation of educational resources related to cultural heritage. For example, the fuzzy comprehensive evaluation model can help evaluate the teaching effect of cultural heritage resources and make personalized recommendations according to students' learning needs and the objectives of the history curriculum. The fuzzy clustering algorithm can subdivide the student group and recommend the most suitable learning resources and paths for each sub-group. Therefore, this present research was conducted to determine how to effectively apply a fuzzy algorithm for the integration, optimization and personalized recommendation of cultural heritage resources.

1.4 Research Methods

1.4.1 Construction and Application of Fuzzy Algorithm Model

The core method of this research is the application of a fuzzy algorithm, specifically a fuzzy comprehensive evaluation model and fuzzy clustering algorithm. A fuzzy comprehensive evaluation model is constructed to comprehensively evaluate the educational resources of cultural heritage and optimize the allocation of resources according to the evaluation results. The fuzzy clustering algorithm is used to analyze students' learning characteristics and help to recommend personalized learning paths for each student. These algorithms can deal with uncertainty and fuzzy information, making the allocation of cultural heritage education resources more accurate and efficient.

1.4.2 Data Collection and Analysis Methods

The data for this study comprised feedback information from teachers and students on the use of cultural heritage educational resources, and was collected through questionnaires, interviews and classroom observation. The questionnaire survey contained items related to students' cognition of cultural heritage resources, learning interest and evaluation of teaching outcomes. The interviews were conducted with history teachers in order to obtain information on their actual use of cultural heritage resources and the challenges they encountered in their teaching practice [14, 15]. Classroom observation helped to analyze the actual effect of cultural heritage resources on teaching and learning. After the data was collected, it was cleaned and filtered to ensure its reliability and representativeness.

1.4.3 Experimental Design and Verification

In terms of experimental design, a comparative method was adopted to compare students' learning outcomes resulting from exposure to different teaching modes. The teacher allocated to the experimental group used the cultural heritage education resources optimized based on the fuzzy algorithm, while the teacher of the control group used the traditional teaching methods. The difference in the learning outcomes of the two groups of students was analyzed, and the actual effect of the fuzzy algorithm in the optimization of educational resources was determined. The experiment also focused on ascertaining students' interest and understanding of cultural heritage, and comprehensively assessed the value of applying the fuzzy algorithm in modern history teaching.

1.5 Significance and Impact of This Study

1.5.1 Theoretical Contribution

The theoretical contribution of this study is the construction of the application framework of a fuzzy algorithm in cultural heritage education. Traditional educational resource optimization methods mostly rely on statistics and data analysis, whereas the fuzzy algorithm can deal with fuzzy and uncertain data, so as to make the integration and optimization of cultural heritage resources more flexible and accurate. The construction of a fuzzy comprehensive evaluation model and fuzzy clustering algorithm provides a new theoretical framework for the optimization of cultural heritage educational resources, and provides a reference for the integration and optimization of resources in other educational domains. The research also promotes the combination of cultural heritage education and modern technological means, and expands the research field of cultural heritage education.

1.5.2 Practical Significance

The practical significance of this study is that it promotes the innovative integration of cultural heritage resources in modern history teaching. The application of a fuzzy algorithm to the optimal allocation of teaching resources can effectively prevent resource waste and address the inflexibility of traditional teaching methods, and help teachers to better design course content and teaching strategies according to the needs of students. For example, the fuzzy clustering algorithm is used to group students and recommend the most appropriate cultural heritage education resources for each student, making the teaching more personalized and targeted [16, 17]. The research results will help promote the digitization process of cultural heritage education, optimize the allocation and use of educational resources through big data and artificial intelligence technology, improve teaching efficiency and students' learning experience [18].

This study also provides new ideas for the digital transformation of education and fosters the development of the intelligent application of educational resources. The fuzzy algorithm framework that is constructed improves the quality of cultural heritage education, and also provides a feasible model and method for similar educational resource optimization research in the future. Therefore, this study has far-reaching implications for the development of cultural heritage education [19].

1.6 Related Concepts

1.6.1 Basic Concept and Application of Fuzzy Algorithm

The fuzzy algorithm is a mathematical method to deal with uncertainty and fuzzy information. Unlike the traditional calculation methods, the fuzzy algorithm introduces the concept of membership degree to express the fuzziness of things, and can deal with those problems that cannot be described by specific numerical values or boundaries. Based on fuzzy set theory, fuzzy algorithms quantify the degree of belonging of elements in different sets through membership functions, rather than providing a simple binary classification (yes/no).

In the field of education, fuzzy algorithms are often used in resource optimization, personalized learning path recommendations and so on. For the application of cultural heritage educational resources, the fuzzy algorithm can evaluate and optimize the allocation of resources according to different educational needs and resource characteristics. For example, the fuzzy comprehensive evaluation model can help classify and prioritize educational resources on cultural heritage, enabling educators to choose the most appropriate educational resources according to students' interests and learning goals. Membership function is the core concept of a fuzzy set, which is used to express the degree to which an element belongs to a certain set.For the fuzzy set A, the membership function is defined as the following formula (1):

$$\mu_A(x) = \frac{1}{1 + e^{-k(x-c)}} \tag{1}$$

where $\mu_A(x)$ represents the membership of the element x to the set A, K is a constant that determines the steepness of the function, and c is the central point of the membership function. When x is close to c, the value of the membership function is close to 1, and x means strongly belonging to the set A.

1.6.2 Characteristics of Cultural Heritage Educational Resources

Cultural heritage educational resources have unique characteristics, which are not only the accumulation of history and culture, but also the expression of national identity, social value and cultural identity. Cultural heritage resources are divided into two main categories: material cultural heritage and intangible cultural heritage. Material cultural heritage includes buildings, cultural relics, sites, etc. They are the concrete carriers of history and culture, with visibility and materiality. Intangible cultural heritage includes languages, art forms, traditional crafts, etc., which are often passed down through generations, with fluidity and cultural symbolism. Another characteristic of cultural heritage educational resources is their multi-dimensionality. Cultural heritage is not only the transmission tool of historical knowledge, but also involves the educational function of ethics, aesthetics, philosophy and so on. It provides a wealth of educational content that helps students understand and think about history and culture from multiple perspectives. Due to the regionalism and particularity of cultural heritage, educational resources are different in different regions and for different ethnic groups, and this diversity provides both challenges and opportunities for educators. In modern history teaching, cultural heritage, as a bridge connecting history and reality, has interdisciplinary teaching significance and is an important way to understand national history and social development.

1.6.3 Objectives and Methods of Modern History Teaching

The goal of modern history teaching is to help students obtain an in-depth understanding of key historical events, important people and social changes in modern history, and to cultivate students' historical thinking and critical analysis ability. The core objective is to enable students to master the basic knowledge and context of modern history, analyze realistic problems from a historical perspective, and understand the connection between historical processes and current society. Through the study of modern history, students can better understand the impact of historical events on the current world pattern and social culture, and develop a global perspective and cultural confidence.

Modern teaching practice should involve the teaching of historical facts while also encouraging students to think and explore. Generally, traditional teaching methods have been used to teach modern history. Teachers explain the background, process and results of historical events to help students build a framework of historical knowledge. With the emergence of new educational concepts, modern history teaching has gradually introduced more interactive and practical methods, such as project-based learning, case analysis and role playing. These approaches emphasize active student engagement and critical thinking, facilitating the formation of personal insights as students explore history. The application of information technology is also becoming more and more important in modern history teaching. With the help of multimedia, virtual reality and other means, teachers can present multi-dimensional perspectives of historical events and enhance students' perception and understanding of history.

2. MATERIALS AND METHODS

2.1 Data Collection and Sample Selection

2.1.1 Sample Source

The educational institution selected for this study is named A. A representative primary and secondary school in this region, with a history of 60 years. It currently has approximately 120 teachers and 1,800 students. This school boasts a profound historical and cultural heritage and a stable group of teachers and students, which can effectively reflect the current application of cultural heritage educational resources in teaching. Its teaching model integrates multiple elements of traditional education and modern educational technology, and has certain representativeness and high teaching quality. The curriculum not only covers basic disciplines but also emphasizes traditional culture and history education. It combines rich cultural heritage resources with modern history teaching, providing more comprehensive data support for this research.

Institution A has a long history and a comprehensive amount of cultural heritage education resources, such as cultural relics, local historical materials, intangible cultural heritage projects, etc. These resources are widely used in modern history teaching and have significant practical value. A The practical experience of educational institutions in this field provides suitable cases and data sources for this study, allowing the researcher to verify the result of using a fuzzy algorithm for the optimization of cultural heritage educational resources.

All educational institutions, as recognized by the government, provide data from formal teaching activities that are collected through official channels. All data are rigorously reviewed to ensure that they meet teaching and research standards and have a high degree of confidence. Institution A has a diverse composition of teachers and students, covering students of different age groups and cultural backgrounds, providing a wide range of perspectives and data support for research, and ensuring the representativeness and generalizability of research conclusions.

2.1.2 Data Collection Methods

A variety of data collection methods were used in this study to ensure the comprehensiveness and validity of the data.

Questionnaire: A detailed questionnaire was designed and distributed to teachers and students to obtain information on the use of cultural heritage resources in modern history teaching in terms of frequency, types, application and learning outcomes. The questionnaire included items related to the awareness of cultural heritage resources, the expectation of using a fuzzy algorithm in teaching, and the students' interest in traditional cultural education. The questionnaire was designed to ensure a comprehensive coverage of the application of cultural heritage resources in education and provide basic data support.

Interview: Based on the questionnaire survey, in-depth interviews were conducted with several teachers and students to further understand the specific problems and challenges they encountered in the teaching process, especially the extent to which cultural heritage resources were effectively integrated and applied in the classroom. Interviews can supplement questionnaire data, provide more in-depth qualitative data, and obtain valuable feedback on the exploration of fuzzy algorithm optimization path.

Classroom observation: The researcher participated in some modern history classes conducted by educational institution A in order to observe how cultural heritage resources were used in classroom teaching. Classroom observation focused mainly on how teachers explained historical events and cultural heritage, how they used multimedia, material materials and other resources to assist their teaching, and students' reactions to and interactions with teaching resources. Through classroom observation, the researchers obtained classroom-based data to help analyze the actual effect of using cultural heritage resources and the effectiveness of teaching methods.

Classification and coding of cultural heritage resources: For the data collection process, all cultural heritage resources were classified according to their form, content and teaching application, and a code was given to each resource. For example, resources such as material cultural heritage, intangible cultural heritage, historical documents and traditional crafts were assigned to different categories and given codes to facilitate subsequent data collation, analysis and model construction. The classification and coding clearly showed the practical application of cultural heritage resources in modern history teaching, and provided data support for the optimization path of the fuzzy algorithm.

2.1.3 Data Preprocessing

After the data collection, in order to ensure the quality of the data and the validity of the analysis, the research team conducted strict pre-processing of all the original data.

Data cleaning: First, the questionnaire and interview data were checked for completeness, and incomplete or obviously inaccurate data were eliminated. All questionnaire data should also be tested for consistency to ensure the accuracy and consistency of the data. For interview recordings and classroom observations, researchers transcribed and collated the original data, deleting irrelevant or invalid parts to ensure that the data used was relevant to the research question.

Screening methods: After the data was cleaned, the research team applied a screening method to remove outliers that deviated from the dataset. For example, some extreme values and feedback that were inconsistent with other data in the questionnaire were marked as abnormal data and excluded to prevent inaccuracies in the analysis results. The classroom observation data was compared with the interview records of teachers and students to confirm the actual application of cultural heritage resources in the classroom, and samples that could represent typical applications were selected for analysis.

Data standardization: In order to ensure the comparability of different types of data, the data was standardized. By transforming the units and dimensions of the data, it can be analyzed on the same scale. It is suitable for the calculation of a fuzzy algorithm to ensure that all kinds of input data can match the algorithm model, and finally obtain accurate evaluation and optimization results.

2.2 Model Construction

2.2.1 Model Selection

In this study, in order to optimize the application of cultural heritage educational resources in modern history teaching, two core fuzzy algorithm models were selected: the fuzzy comprehensive evaluation model and the fuzzy clustering algorithm.

Fuzzy comprehensive evaluation model: Through the comprehensive analysis of a number of evaluation indicators, based on fuzzy mathematics theory, this model deals with complex fuzzy information. In the optimal application of cultural heritage educational resources, the diversity and non-quantifiability of teaching resources make the fuzzy comprehensive evaluation model an ideal choice. The model can make comprehensive evaluation according to multi-dimensional teaching resources (such as literature, physical display, teacher explanation, etc.), and transform fuzzy variables into numerical values through membership function to support the integration and optimization of teaching resources. In the model, the membership value of each evaluation index represents the fitness and value of the resource in a specific teaching context, which helps teachers effectively select cultural heritage resources suitable for teaching objectives. The fuzzy comprehensive evaluation model is calculated as follows (2):

$$C = \sum_{i=1}^{n} w_1 \cdot A_i \tag{2}$$

C is the comprehensive evaluation result, representing the overall evaluation value after weighting all indicators. n is the total number of evaluation indicators. w_i refers to the weight of the i-th indicator, reflecting its relative importance in the comprehensive evaluation and satisfying $\sum_{i=1}^{n} w_i = 1$. A_i refers to the specific membership degree or score value of the third evaluation metric, which is usually within [0, 1].

Fuzzy clustering algorithm: This algorithm classifies and aggregates a large amount of data, integrates similar resources together, and facilitates the identification and utilization of the characteristics of different cultural heritage resources. In education resource management, fuzzy clustering algorithm can help to identify different application categories of resources and make classification optimization according to specific teaching needs. Through fuzzy clustering, we can better understand which cultural heritage resources are more advantageous in different teaching scenarios, and help educators to make targeted resource allocation. The key calculation of the fuzzy clustering algorithm is as follows (3):

Table 1 Model implementation process.

Step	Description	Key Technologies and Methods
Data Input	Collection and selection of relevant cultural heritage education data, including teaching materials, teacher feedback, and student evaluations.	Surveys, Classroom Observation, Interviews
Preprocessing & Cleaning	Denoising and standardizing raw data to ensure quality and consistency.	Data Cleaning, Standardization
Model Construction	Constructing fuzzy comprehensive evaluation and fuzzy clustering models based on the characteristics of cultural heritage resources.	Membership Function, Weighted Evaluation Model
Parameter Setting	Setting appropriate model parameters, such as fuzziness index, weights, and membership degree.	Expert Scoring Method, Historical Data Analysis
Calculation & Solution	Calculating and obtaining evaluation results and classification of cultural heritage resources.	Fuzzy Comprehensive Evaluation, Clustering Algorithm Calculation
Output of Results	Outputting optimized educational resource solutions based on model results, with classification and recommendations.	Resource Optimization Path, Personalized Recommendation
Evaluation & Validation	Performing cross-validation on model outputs to ensure accuracy and effectiveness of evaluations.	Model Evaluation, Effectiveness Verification

$$\mu_{ij} = \frac{1}{\sum_{k=1}^{m} \left(\frac{d_{ij}}{d_{ik}}\right)^{\frac{2}{m-1}}} \tag{3}$$

μ_{ij}: The membership degree of sample point x_i to j cluster, with values ranging from [0, 1], reflects the probability that the sample belongs to this cluster. the dataand the distance from the firstclass, for the fuzzy index, for the clustering number. By calculating the membership of each data point, the formula classifies different cultural heritage resources into appropriate categories, thus providing a basis for the subsequent integration and optimization of teaching resources.

2.2.2 Model Parameter Setting

In the application of fuzzy algorithm, the setting of model parameters has an important effect on the final calculation result. In order to ensure the accuracy and effectiveness of the model, reasonable parameters should be selected.

Membership calculation formula: Membership calculation is the core step of the fuzzy clustering algorithm. Membership represents the similarity of a data point to a cluster, ranging from 0 to 1, with higher values indicating a stronger correlation between the data point and the cluster.

Weight setting: In the fuzzy comprehensive evaluation model, each evaluation index of the model has a corresponding weight, and the setting of the weight directly affects the final evaluation result of each cultural heritage resource. In this study, according to the actual application of cultural heritage resources in modern history teaching, the weight was set by an expert scoring method and feedback in regard to history teaching practice. The relative importance of various kinds of cultural heritage resources in teaching was obtained through the evaluation of experts and the analysis of historical data, and appropriate weights were assigned to each index. An appropriate weight setting can ensure that the evaluation model has a better degree of differentiation and rationality.

Distance measurement method: In the fuzzy clustering algorithm, the distance measurement between data points is an important factor affecting the clustering effect. Common distance measurement methods include Euclidean distance, Manhattan distance and cosine similarity. In this study, Euclidean distance was used as a metric, because Euclidean distance can better reflect the similarity between different cultural heritage resources, which is suitable for the optimization of such teaching resources. By choosing the appropriate distance measurement method, we can ensure that the fuzzy clustering algorithm can effectively classify and optimize educational resources.

2.2.3 Model Implementation Path

The creation of the model involves the whole process from data collection to the final application result, including several key steps such as data input, model calculation and result output. In order to ensure the rational optimization and application of cultural heritage educational resources, this study built a joint framework comprising a fuzzy comprehensive evaluation model and a fuzzy clustering algorithm, achieving the systematic and effective application of the model. The model implementation process is shown in Table 1 below.

As shown in Table 1 above, by integrating multi-dimensional data input and algorithm calculation, the model implementation path achieves the comprehensive evaluation and clustering optimization of cultural heritage educational

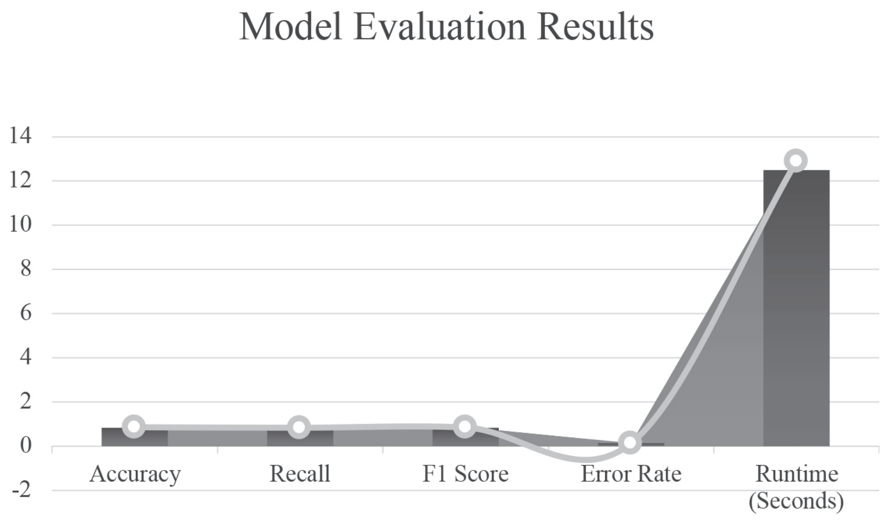

Figure 1 Model evaluation results.

resources, helps educators integrate and apply these resources more efficiently, and supports the innovative development of modern history teaching. Clear calculation steps and processes can ensure that the execution of each step is in line with the research objectives, and improves the utilization efficiency and educational effect of cultural heritage educational resources.

2.3 Data Analysis and Result Processing

2.3.1 Data Analysis Methods

In the data analysis stage, this study adopted a statistical analysis method to process and evaluate the collected data of cultural heritage educational resources to ensure the accuracy and reliability of the research results. The main analysis methods were: statistical indicators such as mean value, standard difference, and weighted average.

The mean value indicates the main trend of the data set. By calculating the mean value of various data, the effect of applying cultural heritage resources in modern history teaching can be understood. Standard deviation is used to measure the degree of dispersion of data, and can reveal the differences in the application of cultural heritage education resources under different teaching modes and resource allocation.

The weighted average method is used to determine the influence of different cultural heritage resources on teaching effectiveness. Because of the various levels of importance and weight of different resources, the direct calculation of weighted average can provide more accurate evaluation results. The weighted average method is calculated as follows (4):

$$\overline{X}_{weighted} = \frac{\sum_{i=1}^{n} w_i X_i}{\sum_{i=1}^{n} w_i} \tag{4}$$

where the $\overline{X}_{weighted}$ is the weighted average, w_i is the weight of all the resources, X_i for corresponding resource value, n for the number of resources. Through this method, the multi-dimensional attributes of cultural heritage resources can be comprehensively evaluated, and the contribution degree of different resources to the educational effect can be quantified. As the weighted average, w_i is the weight of all the resources, X_i for corresponding resource value, represents the number of resources. Through this method, the multi-dimensional attributes of cultural heritage resources can be comprehensively evaluated, and the degree to which different resources contribute to the educational effect can be quantified.

2.3.2 Model Validation and Effect Evaluation

In the validation and effect evaluation stage of the model, the cross-validation method is used to determine the accuracy of the constructed model. Cross-validation can effectively prevent the overfitting problem of the model on the sample data, and ensure the robustness and generalization ability of the model through multiple training and verification. In this study, the K-fold cross-validation method was adopted to divide the data set into K subsets, and each subset was taken as the verification set and the rest as the training set. The average performance of the model on different data sets was obtained through repeated training and testing.

Through this verification method, we can comprehensively evaluate the accuracy and stability of the model. The model in the study uses fuzzy algorithms for data processing and analysis. Cross-validation not only tests the applicability of the model under different conditions, but also shows the influence of various input parameters on the final results. For verification, several evaluation indexes such as precision, recall rate and F1 value were used to evaluate the prediction effect of the model from multiple angles. The evaluation results of models in different verification stages are shown in Figure 1 below. The evaluation indexes of each validation set show the stability and accuracy of the model. By means of evaluation indicators, the effectiveness of the model in the analysis of cultural heritage educational resources can be obtained, and data support can be provided for the subsequent optimization and application of the model.

Table 2 Integration mode of cultural heritage educational resources.

Resource Category	Integration Method	Technology	Application Scenario
Traditional Cultural Materials	Digital Storage	Document Scanning, Image Processing	Digital Library
Historical Sites	VR/AR Display	3D Modeling, Scene Reconstruction	Virtual Museum, Site Restoration
Traditional Festival Culture	Interactive Video	Video Editing, Interactive Interface	Online Learning Platform
Learning Feedback & Assessment	Intelligent Learning System	Data Analysis, AI Recommendation	Personalized Learning Path Recommendation

Table 3 Examples of recommended personalized learning paths.

Student ID	Learning Preference	Learning Level	Recommended Learning Resources	Recommended Learning Path
001	Ancient Civilization, Cultural History	Beginner	"Chinese Ancient Civilization" video, Historical Event Map	Study "Unification of China by Emperor Qin"
002	Modern History, Political History	Intermediate	"Rise of Modern China" text, Interactive Historical Map	Deepen study of "Opium War"
003	World History, Social History	Advanced	"World War II Review" documentary, Thematic Essay	Study "European Wars and Globalization"

2.4 Innovation Path and Application Suggestions

2.4.1 Integration Path of Cultural Heritage Education Resources

In the modern educational environment, the integration of cultural heritage educational resources needs to combine traditional teaching methods with the use of digital and intelligent technology. By means of digital technology, traditional cultural heritage materials, documents, audio and video are systematically organized and uploaded to the educational platform so that they can be made available to a wider group. The combination of modern educational technologies, such as virtual reality (VR), augmented reality (AR) and artificial intelligence (AI), can enhance the interactivity and immersive elements of cultural heritage education, allowing students to learn and experience cultural heritage through simulated historical scenarios. The specific path of cultural heritage education resource integration is shown in Table 2 below.

2.4.2 Optimization Path of Fuzzy Algorithm in History Teaching

The fuzzy algorithm processes uncertain educational data, provides personalized learning recommendations for students, and optimizes learning paths. The personalized learning needs of students in history classrooms are particularly evident, and indicate that students have differences in learning progress, depth of understanding, and learning style. The fuzzy algorithm can give personalized learning recommendations by analyzing students' learning behavior, performance data, interest preferences and other information. For example, the fuzzy algorithm can recommend appropriate learning materials according to students' mastery of a certain knowledge point, such as supplementary reading, video explanation, exercises, etc., so as to improve learning efficiency and learning outcomes. In this process, the fuzzy algorithm calculates the membership degree of different contents according to the students' learning progress, and provides the students with a learning path that conforms to their current state. An example of a personalized learning path recommendation based on the fuzzy algorithm is shown in Table 3 below.

2.4.3 Suggestions on Intelligent Application of Educational Resources

The intelligent application of educational resources, together with big data analysis and artificial intelligence, can improve the efficiency and popularization of cultural heritage education. Big data analysis can obtain insights into students' learning, needs and interests, and help teachers make more scientific teaching decisions. At the same time, artificial intelligence technology can automatically provide suitable learning content according to students' learning data, and carry out personalized education recommendations. For example, by building an intelligent learning system, education administrators can obtain students' learning status in real time, adjust the difficulty and learning path of course content, and optimize the allocation of educational resources. The data analysis and AI recommendation system not only support the personalization of classroom teaching; they can also improve the quality of teaching, so that cultural heritage resources can be widely applied and disseminated. The application of an intelligent educational resource recommendation system is shown in Table 4 below.

Table 4 Intelligent educational resource recommendation system.

Student ID	Learning Field	Learning Status	Recommended Content	Recommendation Method
001	Traditional Culture	Intermediate	"Introduction to Chinese Traditional Festivals" video	Video Viewing
002	Modern History	Advanced	"Opium War" thematic essay	Reading
003	World History	Beginner	"Introduction to World History" book	Book Reading
004	Cultural Heritage	Advanced	"Cultural Heritage Protection Methods" lecture	Online Lecture
005	Chinese History	Beginner	"Origins of Chinese Civilization" documentary	Documentary Viewing

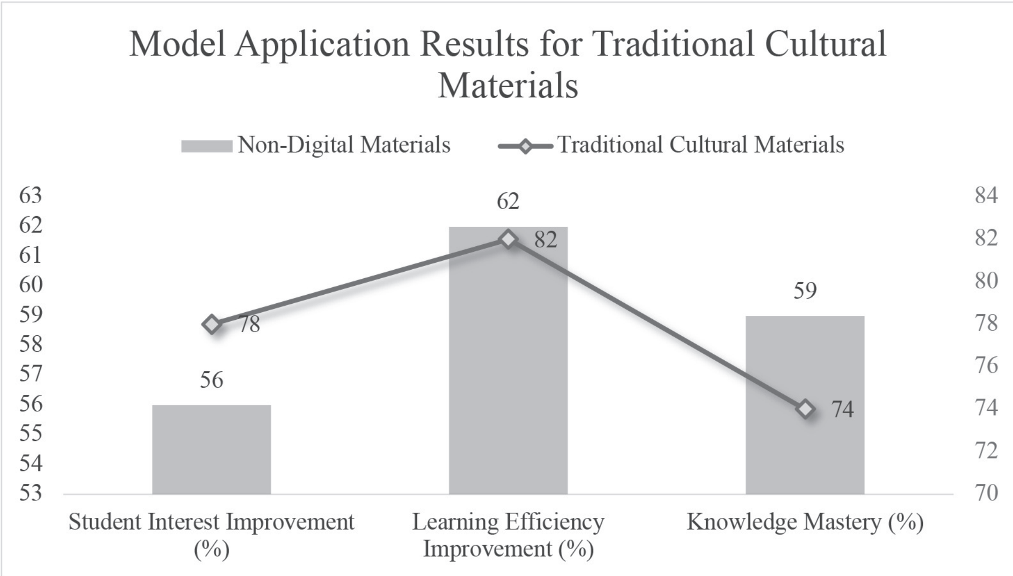

Figure 2 Model application results for traditional cultural data.

3. RESULTS AND DISCUSSION

3.1 Results

In this study, the fuzzy algorithm model was used to analyze the effects of applying different teaching resources and to explore the innovative application of cultural heritage educational resources in modern history teaching. The practical application of the model involves many different types of educational resources, including traditional cultural materials, historical sites, traditional festival culture, and learning feedback and assessment. The effectiveness and impact of various resources in different teaching environments is revealed by data analysis.

3.1.1 Application Effects of Traditional Cultural Materials

For the application of traditional cultural materials, the model evaluated the integration of digital cultural heritage resources, and analyzed the interaction of these resources in teaching and the improvement of students' learning interest. As shown in Figure 2 below, traditional cultural materials can effectively enhance students' interest in historical information, and improve their immersion and situational awareness of learning.

3.1.2 Application Effect of Historical Sites

The historical sites application enables interactive teaching through virtual reality (VR) and augmented reality (AR) technology. The results of model analysis show that virtual reality technology has a significant effect on the teaching of historical sites, which can improve students' spatial cognition ability and historical context understanding. Through 3D modeling and virtual display, students can more accurately perceive the changes and cultural background of historical sites, as shown in Figure 3 below.

3.1.3 Application Effect of Traditional Festival Culture

Traditional festival cultural resources are integrated into history teaching through interactive videos and online platforms. As shown in Figure 4 below, interactive videos can improve students' understanding of traditional festival culture and the combination of festival customs and historical background. The personalized recommendation system analyzes students' learning progress and preferences, provides suitable learning resources and tasks, and promotes the learning and understanding of festival culture.

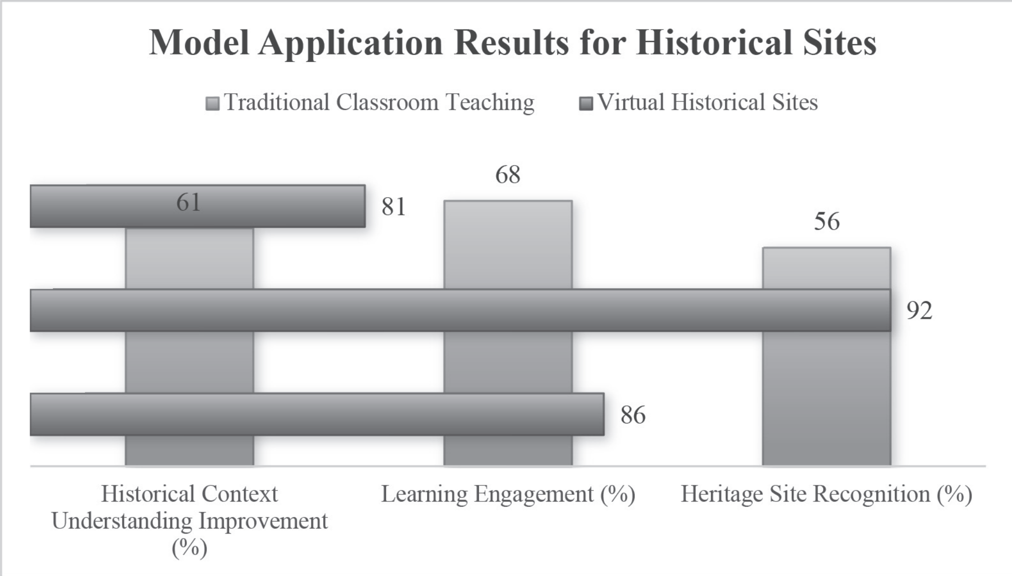

Figure 3 Model application results for historical sites.

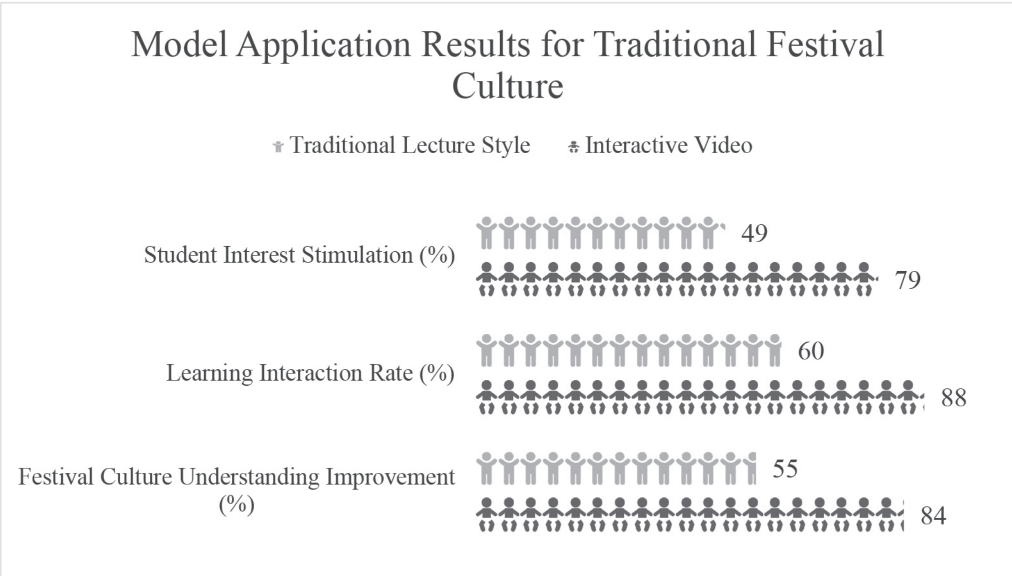

Figure 4 Application result of traditional festival culture model.

3.1.4 Application Effects of Learning Feedback and Evaluation

In terms of learning feedback and evaluation, the fuzzy algorithm provides personalized learning path recommendations for students through real-time monitoring of students' learning status, helping them find their own weaknesses in the learning process, and make targeted learning adjustments. As shown in Figure 5 below, the intelligent learning system can effectively improve students' academic performance and self-assessment ability, and students' active learning attitude is improved as they obtain continuous learning feedback.

The analysis above shows that there are obvious differences in the application effect of the model under different teaching resources. With the combination of digital education resources, virtual reality technology, interactive video and intelligent learning feedback system, students have shown significant improvement in the mastery of historical knowledge, learning efficiency and interest stimulation. Analyzing and adjusting the integration of these teaching resources will help to improve the effect and innovation of cultural heritage education in modern history teaching.

3.2 Discussion

3.2.1 Problem Summary

Using the fuzzy algorithm, this study conducted an in-depth analysis of the application of cultural heritage educational resources in modern history teaching. The research results provide useful ideas for the innovative integration of educational resources. However, despite the remarkable research results, the application of the current model still has limitations, and further analysis of its advantages and disadvantages is needed.

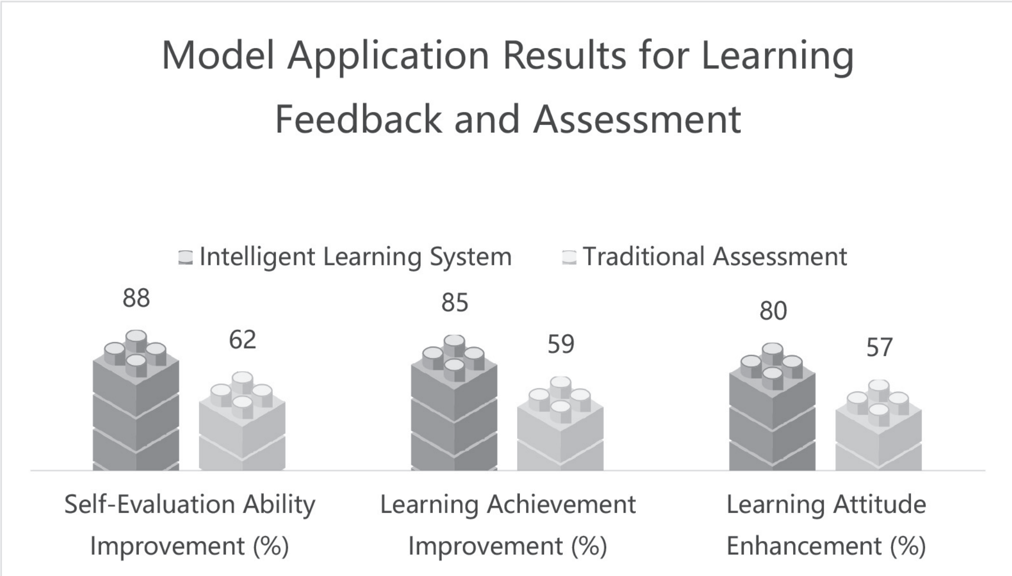

Figure 5 Results of model application for learning feedback and evaluation.

First of all, the biggest advantage of the current fuzzy algorithm model in the integration of educational resources is that it can deal with uncertainty and fuzziness, and it is outstanding in the field of cultural heritage resources, which has fuzzy information and strong subjectivity. Through the fuzzy comprehensive evaluation model and fuzzy clustering algorithm, different types of educational resources can be evaluated scientifically, providing data support for personalized learning path recommendation, and enhancing the pertinence and effectiveness of learning. The application of the fuzzy algorithm in educational feedback and evaluation can help to adjust teaching strategy in time and improve teaching quality.

However, the model also has several shortcomings that cannot be ignored. Fuzzy algorithms have strong dependence on data, and have high requirements for the accuracy and comprehensiveness of input data. If the data collection process is biased or incomplete, it will directly affect the evaluation results of the model. Fuzzy algorithms may oversimplify when dealing with complex problems. In the field of cultural heritage education, a single fuzzy model may have difficulty describing certain cultural elements accurately. The real-time and adaptability of the model is poor, and the accuracy can be improved through cross-validation. However, in the dynamic changing teaching environment, the model may not be updated immediately, which affects its flexible application in educational practice.

The fuzzy algorithm in terms of education optimization has several limitations: it does not fully consider the professional knowledge of teachers and the individual needs of students. This may result in a recommended path that does not fully cater for the individual learning needs of students. The application effect of fuzzy algorithm in large-scale teaching is not as good as expected in regard to resource allocation and teacher management. The fuzzy algorithm does not fully take into account several external variables (such as social and cultural background, family education status, etc.), so it might not fully reflect the diverse learning needs of students.

3.2.2 Research Suggestions

Based on the above problems, the following suggestions are offered in order to improve the application of the fuzzy algorithm.

Improving data quality and diversifying inputs: In order to improve the accuracy of the model, the comprehensiveness and accuracy of the data must be enhanced. Future research should consider including more diverse data inputs, such as students' psychological cognitive state and cultural background, to build a more comprehensive database. Human bias should be minimized during data collection, and more refined data cleaning and screening methods should be used to ensure data reliability.

Algorithm optimization and multi-model fusion: The traditional single fuzzy algorithm may not be able to fully cope with the complex teaching situation. Future research could try to integrate different intelligent algorithms, such as machine learning, deep learning, etc., to form a multi-model combination system, and improve the accuracy and practicality of the model through multi-angle and multi-dimensional analysis. In particular, in the personalized recommendation system, deep learning could be carried out in combination with students' interests, learning styles and grades to provide a learning path that is more aligned with individual needs.

Real-time and adaptive flexibility: In order to cope with dynamic changes in the teaching environment, it is necessary to enhance the real-time and adaptive model. This can be achieved by establishing a dynamic updating mechanism, such as a real-time feedback system that can adjust the output results of the model according to the learning progress of students and feedback data. Through periodic model training and adjustment, the model can always adapt to changes in the educational environment.

The role of teacher and the individual needs of students: Although the current model can provide students with a personalized learning path, it still lacks an in-depth analysis of the teacher's role. Future research could focus on incorporating teachers' feedback and interaction into the algorithm framework, so as to achieve more accurate teaching resource allocation and learning path recommendation by combining teachers' teaching experience and students' personality characteristics through fuzzy algorithms. Cultural heritage educational resources themselves also have strong cultural and emotional characteristics. How to make the algorithm better handle such content and make it more attractive and effective at the emotional and cultural levels is a problem that needs to be solved by future research.

Expanding the scope of application of the algorithm: At present, the fuzzy algorithm is still limited in the application of cultural heritage educational resources, especially in the integration of interdisciplinary education. Future research should consider the application of fuzzy algorithm to a wider range of disciplines and education fields, and explore the comprehensive application in history education, art education and other fields. Attention should be paid to the diversity of cultural heritage education resources and cross-cultural differences, and the fuzzy algorithm should be used to modify teaching practices in order to cater for students with different cultural backgrounds.

4. CONCLUSION

This study explored the innovative application of cultural heritage educational resources in modern history teaching by applying a fuzzy algorithm. The main aim of the study was to optimize the integration path of educational resources by means of fuzzy algorithms, provide personalized learning recommendations, and improve the effectiveness and teaching quality of cultural heritage education. The research results show that the fuzzy algorithm has significant application potential in the optimization of educational resources, can effectively solve the multiple uncertainties and fuzziness problems in education, and shows good adaptability and flexibility in the highly subjective and complex resources related to cultural heritage. A fuzzy comprehensive evaluation model and fuzzy clustering algorithm were adopted for the construction and application of the model. These models help us to scientifically evaluate educational resources, and also provide strong data support for personalized learning path recommendations. The results of the data analysis of the sample comprising educational institutions, combined with weighted average method and cross-validation method, the accuracy of the model has been confirmed. In addition, the model shows strong application value. The application results under different teaching resources show that through the intervention of a fuzzy algorithm, educational resources can be optimized and learning outcomes can be significantly improved.

Despite the positive results obtained by this study, there are still areas for improvement. Current models rely heavily on data and may be constrained by the accuracy and comprehensiveness of data collection in the educational context. Fuzzy algorithms have several shortcomings when dealing with complex and changeable teaching demands, and there is room for improvement in terms of dynamic adjustment and real-time update. Future research needs to improve the adaptability and real-time performance of such algorithms, and strengthen the integration of teacher feedback and students' needs in terms of educational practice and the appropriateness of personalized recommendations.

The application of fuzzy algorithms in the field of education still has great development potential, especially in the intelligent integration of cultural heritage educational resources and personalized learning path recommendation. With the development of big data technology and AI, fuzzy algorithms will play an increasingly important role in the allocation of educational resources, teaching quality assessment, personalized education and so on. In the special field of cultural heritage education, how to balance the combination of traditional cultural elements and modern teaching technology, and how to align the course content more closely with the diverse individual needs of students, is an important direction of research.

Further research should explore the comprehensive application of fuzzy algorithm in multidisciplinary education, including the intellectualization of educational resources, the integration of cross-cultural education, and the innovation of educational evaluation systems. Through multi-disciplinary collaborative research, the teaching quality of cultural heritage education can be improved, and new ideas and methods are provided for the integration of cultural heritage resources in modern history teaching.

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