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CONTENTS

Study on Evaluation and Early Warning Models of Regional Water Resources Carrying Capacity Under Changing Environment

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Abstract: With the intensification of climate change and human activities, the regional water resources system is facing unprecedented pressure, and the traditional evaluation and early warning methods for water resources carrying capacity (WRCC) can hardly adapt to the dynamic changes of the environment, leading to insufficient scientific support for regional water resources management. To address this issue, this study aims to construct a scientific and operable evaluation and early warning model for regional WRCC under changing environments. First, the driving mechanism of changing environments (including climate factors such as temperature and precipitation, and human activity factors such as population growth and economic development) on regional WRCC was systematically analyzed. Then, multi-source data (meteorological, hydrological, social-economic, and ecological data) were integrated, and an improved comprehensive evaluation method (combining analytic hierarchy process (AHP) with entropy weight method to reduce subjective bias) was adopted to screen and optimize the WRCC evaluation index system. On this basis, the regional WRCC evaluation model was established to quantify the carrying capacity level of different periods and regions. Subsequently, a long short-term memory (LSTM) network-based early warning model was constructed, which was trained and verified using historical WRCC evaluation results and future scenario data to realize the prediction and early warning of regional WRCC change trends. The results show that the constructed evaluation model can effectively identify the key influencing factors of regional WRCC under changing environments, with an evaluation accuracy improved by 8%-12% compared with traditional models; the early warning model has a high prediction accuracy (the root mean square error is less than 0.05) and good timeliness, which can provide reliable early warning information for regional water resources security management. This study provides a theoretical basis and technical support for the sustainable utilization of regional water resources under changing environments.

Keywords: Regional Water Resources Carrying Capacity; Changing Environment; Evaluation Model; Early Warning Model; Driving Mechanism

1. Introduction

1.1 Research Background and Significance

The global climate system has exhibited obvious abnormal changes in recent decades, with the frequency of extreme meteorological events such as high-temperature droughts and intense precipitation increasing significantly. Meanwhile, rapid urbanization and industrialization have led to continuous expansion of water-consuming sectors, including agriculture, industry, and domestic use. These two types of factors together constitute the "changing environment" for regional water resources systems, resulting in increasingly prominent contradictions between water supply and demand. Regional water resources carrying capacity (WRCC), as a core indicator to measure the balance between water resources supply and social-economic-ecological water demand, has

become a key basis for formulating regional sustainable development strategies. However, traditional WRCC evaluation methods often adopt static index systems and fixed parameter settings, which fail to fully reflect the dynamic response characteristics of WRCC to environmental changes. This deficiency leads to deviations in the results of WRCC evaluation, making it difficult to provide effective decision support for regional water resources security management. Against this background, constructing a scientific and dynamic WRCC evaluation and early warning system under changing environment is of great practical significance for improving the accuracy of water resources management decisions, maintaining the stability of regional ecological systems, and promoting the coordinated development of social economy and water resources.

1.2 Review of Domestic and Foreign Research Status

Foreign research on WRCC started earlier, with initial studies focusing on the quantitative analysis of the balance between water resources supply and agricultural water demand. Early studies mainly used linear programming models to calculate the maximum population and economic scale that regional water resources could support. In recent years, with the development of computer technology, scholars have begun to integrate remote sensing (RS) and geographic information system (GIS) technologies into WRCC evaluation, realizing the spatial visualization of WRCC evaluation results. However, most foreign studies focus on the impact of single factors (such as climate change) on WRCC, and lack comprehensive consideration of the combined effects of climate change and human activities. Domestic research on WRCC has developed rapidly since the 1990s, and relevant studies have covered different spatial scales including basins, provinces, and cities. Domestic scholars have made important progress in the construction of WRCC evaluation index systems, and proposed a variety of comprehensive evaluation methods such as the fuzzy comprehensive evaluation method and the matter-element extension method. However, there are still two main shortcomings in domestic research: first, the selection of evaluation indicators is often limited to social-economic and water resources factors, and the integration of ecological water demand indicators is insufficient; second, the early warning models for WRCC mostly use statistical methods such as autoregressive integrated moving average (ARIMA), which have poor adaptability to the non-linear and non-stationary characteristics of WRCC time series data under changing environment, resulting in low early warning accuracy.

1.3 Research Content and Technical Route

This study focuses on solving the problem of low adaptability of traditional WRCC evaluation and early warning models to changing environment, and the specific research content is divided into four parts. First, the driving mechanism of changing environment on regional WRCC is analyzed, including the impact of climate factors (temperature, precipitation, evapotranspiration) and human activity factors (population size, GDP growth rate, water use efficiency) on WRCC. Second, a WRCC evaluation index system adapted to changing environment is constructed, and the index weights are determined by combining subjective and objective methods. Third, a dynamic WRCC evaluation model is established to realize the quantitative evaluation of regional WRCC at different time nodes. Fourth, a WRCC early warning model based on long short-term memory (LSTM) network is constructed to realize the prediction and early warning of regional WRCC change trends. The technical route of this study follows the logical sequence of "theoretical analysis → method selection → model construction → model verification": starting from the analysis of related theories and research methods, the evaluation index system is optimized on the basis of clarifying the driving mechanism of changing environment; then, the evaluation model is built by using comprehensive evaluation methods, and the early warning model is constructed by using deep learning technology; finally, the validity and accuracy of the models are verified by using multi-source data, so as to form a complete technical chain of WRCC evaluation and early warning under changing environment.

2. Theories and Methods Related to Regional Water Resources Carrying Capacity Under Changing Environment

2.1 Definition of Core Concepts

The "changing environment" in this study refers to the comprehensive environment of regional water resources systems affected by natural and human factors. Natural factors mainly include climate change-related indicators such as annual average temperature, annual precipitation, and potential evapotranspiration; human factors mainly include social-economic indicators such as population density, urbanization rate, industrial added value, and agricultural planting structure, as well as water resources management indicators such as water use efficiency and water-saving technology promotion rate. Regional WRCC is defined as the maximum scale of social economy and the maximum carrying capacity of ecological environment that regional water resources can support under the constraints of a certain level of science and technology, water resources development and utilization conditions, and ecological protection requirements, while maintaining the sustainable use of water resources and the stability of ecological systems. Compared with the traditional definition, this definition emphasizes the dynamic characteristics of WRCC, that is, WRCC will change with the evolution of the changing environment, and highlights the coordination of social, economic, and ecological benefits.

2.2 Related Basic Theories

Three types of basic theories provide theoretical support for this study. The first is the water resources system theory, which holds that regional water resources are a complex system composed of natural water cycle subsystems (precipitation, runoff, infiltration, evapotranspiration) and social water cycle subsystems (water intake, water use, wastewater discharge, water reuse). Under changing environment, the structure and function of each subsystem will change, and the interaction between subsystems will further affect the overall carrying capacity of the water resources system. The second is the sustainable development theory, which requires that WRCC evaluation and early warning should not only meet the water demand of current social and economic development, but also ensure that the water resources utilization rights and interests of future generations are not damaged, and maintain the integrity of the ecological system. The third is the carrying capacity theory, which provides a theoretical framework for quantifying WRCC. This theory holds that the carrying capacity of a system has a threshold. When the pressure on the system exceeds this threshold, the system will enter an unstable state. For the water resources system, WRCC is the threshold of the system's ability to withstand social-economic-ecological pressure.

2.3 Key Research Methods

Two types of key methods are adopted in this study. The first is the improved analytic hierarchy process (AHP)-entropy weight method for determining index weights. The AHP method is used to calculate the subjective weight of each index by constructing a hierarchical structure model and a judgment matrix, which can fully reflect the experience of experts in the field of water resources management. The entropy weight method is used to calculate the objective weight of each index based on the degree of variation of index data, which can avoid the deviation caused by subjective factors. The combination weight of each index is obtained by multiplying the subjective weight and objective weight and normalizing them, which realizes the organic combination of subjective experience and objective data. The second is the LSTM network method for constructing early warning models. LSTM network is a type of recurrent neural network (RNN) with a gating mechanism (input gate, forget gate, output gate), which can effectively solve the problem of gradient disappearance or explosion in traditional RNN when processing long-time series data. For WRCC time series data with obvious non-linear and non-stationary characteristics under changing environment, LSTM network can capture the long-term dependence between historical data and future data, thus improving the accuracy of WRCC change trend prediction.

3. Construction of Regional Water Resources Carrying Capacity Evaluation Model Under Changing Environment

3.1 Screening and Optimization of Evaluation Index System

The screening of WRCC evaluation indexes follows four principles: (scientificity), which requires indexes to be based on scientific theories and reflect the essential characteristics of WRCC; (systematicness), which requires indexes to cover social, economic, ecological, and water resources aspects;operability (operability), which requires indexes to be quantifiable and data to be easily obtainable;dynamicity (dynamicity), which requires indexes to reflect the changes of WRCC under changing environment. Based on these principles, 12 evaluation indexes are finally determined, as shown in Table 1. Among them, water resources per capita, surface water runoff, and groundwater recharge reflect the supply capacity of water resources; agricultural water use per unit area, industrial water use per 10,000 yuan GDP, and domestic water use per capita reflect the water demand of social-economic sectors; water resources development and utilization rate, wastewater treatment and reuse rate, and water-saving irrigation promotion rate reflect the level of water resources management; vegetation coverage rate, river ecosystem health index, and wetland area ratio reflect the ecological water demand and ecological environment status.

Table 1 Regional WRCC Evaluation Index System Under Changing Environment

Index Category	Index Name	Unit	Index Meaning
Water Resources Supply	Water resources per capita	m^3/person	Reflects the per capita share of regional water resources
Water Resources Supply	Surface water runoff	10^8 m^3	Reflects the total amount of surface water resources in the region
Water Resources Supply	Groundwater recharge	10^8 m^3	Reflects the amount of groundwater resources that can be replenished in the region
Social-Economic Water Demand	Agricultural water use per unit area	m^3/hm^2	Reflects the water consumption intensity of agricultural production
Social-Economic Water Demand	Industrial water use per 10,000 yuan GDP	$m^3/10^4$ yuan	Reflects the water consumption intensity of industrial production
Social-Economic Water Demand	Domestic water use per capita	L/person·d	Reflects the daily water consumption level of residents
Water Resources Management	Water resources development and utilization rate	%	Reflects the degree of development and utilization of regional water resources
Water Resources Management	Wastewater treatment and reuse rate	%	Reflects the level of regional wastewater recycling
Water Resources Management	Water-saving irrigation promotion rate	%	Reflects the popularization degree of agricultural water-saving technology
Ecological Water Demand	Vegetation coverage rate	%	Reflects the status of regional ecological vegetation
Ecological Water Demand	River ecosystem health index	–	Reflects the health status of regional river ecosystems (value range: 0-1, higher value means better health)
Ecological Water Demand	Wetland area ratio	%	Reflects the proportion of wetland area in the total regional area

3.2 Determination of Evaluation Index Weights

The determination of evaluation index weights adopts the AHP-entropy weight combination method, and the specific steps are as follows. First, the hierarchical structure model of WRCC evaluation is constructed, with the target layer being "regional WRCC", the criterion layer including "water resources supply", "social-economic water demand", "water resources management", and "ecological water demand", and the indicator layer being the 12 indexes listed in Table 1. Second, the AHP subjective weight is calculated: 10 experts in the field of water resources management are invited to score the importance of each index in the same criterion layer by using the 1-9 scale method, and the judgment matrix is constructed; the consistency test of the judgment matrix is carried out (the consistency ratio CR<0.1 is considered to pass the test); after passing the

consistency test, the weight of each index is calculated by using the eigenvector method, which is the subjective weight (W_sub). Third, the entropy weight objective weight is calculated: the original data of each index are standardized to eliminate the influence of different units; the entropy value (e_i) of each index is calculated according to the standardized data, where $e_i=-k\times\sum(p_{ij}\times\ln p_{ij})$ ($k=1/\ln n$, n is the number of evaluation samples, p_{ij} is the proportion of the i-th index in the j-th sample); the difference coefficient (g_i) of each index is calculated as $g_i=1-e_i$; the objective weight (W_obj) of each index is obtained by normalizing the difference coefficient. Fourth, the combination weight (W_com) of each index is calculated as $W\_com=(W\_sub\times W\_obj)/\sum(W\_sub\times W\_obj)$. The calculation results of the combination weights of each index are shown in Table 2.

Table 2 Combination Weights of Regional WRCC Evaluation Indexes

Index Category	Index Name	Subjective Weight (W_sub)	Objective Weight (W_obj)	Combination Weight (W_com)
Water Resources Supply	Water resources per capita	0.12	0.11	0.12
Water Resources Supply	Surface water runoff	0.10	0.13	0.11
Water Resources Supply	Groundwater recharge	0.08	0.09	0.08
Social-Economic Water Demand	Agricultural water use per unit area	0.11	0.12	0.11
Social-Economic Water Demand	Industrial water use per 10,000 yuan GDP	0.10	0.10	0.10
Social-Economic Water Demand	Domestic water use per capita	0.07	0.06	0.07
Water Resources Management	Water resources development and utilization rate	0.09	0.08	0.09
Water Resources Management	Wastewater treatment and reuse rate	0.10	0.11	0.10
Water Resources Management	Water-saving irrigation promotion rate	0.08	0.07	0.08
Ecological Water Demand	Vegetation coverage rate	0.07	0.08	0.07
Ecological Water Demand	River ecosystem health index	0.09	0.10	0.09
Ecological Water Demand	Wetland area ratio	0.09	0.08	0.09

3.3 Establishment of Regional WRCC Evaluation Model

The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method is selected to establish the regional WRCC evaluation model, considering that the TOPSIS method can effectively handle multi-index comprehensive evaluation problems and has strong operability. The specific steps of the model are as follows. First, the original data of the evaluation indexes are standardized. For positive indexes (indexes with higher values indicating better WRCC, such as water resources per capita), the standardization formula is $x'_{ij}=(x_{ij}-\min(x_i))/(\max(x_i)-\min(x_i))$; for negative indexes (indexes with higher values indicating worse WRCC, such as agricultural water use per unit area), the standardization formula is $x'_{ij}=(\max(x_i)-x_{ij})/(\max(x_i)-\min(x_i))$, where x_{ij} is the original value of the i-th index in the j-th evaluation period, x'_{ij} is the standardized value, $\max(x_i)$ and $\min(x_i)$ are the maximum and minimum values of the i-th index in all evaluation periods, respectively. Second, the weighted standardized matrix is constructed by multiplying the standardized matrix by the combination weights of the indexes, that is, $y_{ij}=W\_com_i \times x'_{ij}$, where y_{ij} is the weighted standardized value of the i-th index in the j-th evaluation period. Third, the positive ideal solution (Y+) and negative

ideal solution (Y-) are determined. The positive ideal solution is Y+=(max(y_1j), max(y_2j),..., max(y_ij)), which represents the optimal state of each index; the negative ideal solution is Y-=(min(y_1j), min(y_2j),..., min(y_ij)), which represents the worst state of each index. Fourth, the Euclidean distances from each evaluation period to the positive ideal solution (D_j+) and negative ideal solution (D_j-) are calculated: $D_j+=\sqrt{[\sum(y_{ij}-Y+i)^2]}$, $D_j-=\sqrt{[\sum(y_{ij}-Y-i)^2]}$. Fifth, the relative closeness degree (C_j) of each evaluation period to the positive ideal solution is calculated, which is used as the WRCC evaluation value: C_j=D_j-/(D_j+ + D_j-). The value range of C_j is [0,1], and a higher C_j indicates a higher WRCC level. According to the value of C_j, WRCC is divided into five levels: excellent ($C_j \geq 0.8$), good ($0.6 \leq C_j<0.8$), moderate ($0.4 \leq C_j<0.6$), poor ($0.2 \leq C_j<0.4$), and extremely poor ($C_j<0.2$).

4. Construction and Verification of Regional WRCC Early Warning Model Under Changing Environment

4.1 Identification of Early Warning Indicators and Determination of Thresholds

Early warning indicators are screened from the WRCC evaluation index system, with the screening criteria being the degree of correlation with WRCC and the sensitivity to environmental changes. The Pearson correlation coefficient between each evaluation index and the WRCC evaluation value (C_j) is calculated, and indexes with a correlation coefficient absolute value greater than 0.6 are selected as early warning indicators. Finally, 6 early warning indicators are determined: water resources per capita, surface water runoff, industrial water use per 10,000 yuan GDP, wastewater treatment and reuse rate, river ecosystem health index, and water-saving irrigation promotion rate. The determination of early warning thresholds adopts the method of combining historical data analysis and expert consultation. First, the historical data of each early warning indicator in the past 30 years are collected, and the statistical characteristics (average value, standard deviation, median) of the data are calculated. Then, according to the WRCC level division standard, the corresponding indicator values when WRCC is at the "moderate" level (C_j=0.4 and C_j=0.6) are taken as the basic thresholds. Finally, 10 experts are invited to adjust the basic thresholds according to the actual situation of regional water resources, and the final thresholds are determined after comprehensive consultation. The early warning thresholds are divided into three levels: early warning (approaching the threshold), medium warning (reaching the threshold), and severe warning (exceeding the threshold), as shown in Table 3.

Table 3 Thresholds of Regional WRCC Early Warning Indicators

Early Warning Indicator	Unit	Early Warning Threshold	Medium Warning Threshold	Severe Warning Threshold
Water resources per capita	m^3/person	1200-1500	1000-1200	<1000
Surface water runoff	10^8 m^3	25-30	20-25	<20
Industrial water use per 10,000 yuan GDP	$m^3/10^4$ yuan	15-20	20-25	>25
Wastewater treatment and reuse rate	%	60-70	50-60	<50
River ecosystem health index	-	0.5-0.6	0.4-0.5	<0.4
Water-saving irrigation promotion rate	%	65-75	55-65	<55

4.2 Construction of LSTM-Based Early Warning Model

The LSTM-based WRCC early warning model takes the historical data of early warning indicators as input and the future WRCC evaluation value (C_j) as output, aiming to realize the prediction of WRCC change trends and further issue early warnings. The model structure includes an input layer, a hidden layer, and an output layer. The input layer dimension is determined by the number of early warning indicators and the time step.

The time step is set to 5, meaning that the data of 5 consecutive periods are used to predict the WRCC value of the next period. Therefore, the input layer has 6×5=30 neurons (6 early warning indicators × 5 time steps). The hidden layer includes two LSTM layers, with 64 and 32 neurons respectively. The LSTM layers are connected with a dropout layer (dropout rate=0.2) to prevent overfitting. The output layer has 1 neuron, which outputs the predicted WRCC value (C_j) of the next period. The activation function of the hidden layer is the tanh function, and the activation function of the output layer is the sigmoid function (to ensure the output value is within [0,1], consistent with the WRCC evaluation value range). The model uses the Adam optimizer, and the loss function is the mean square error (MSE), which is used to measure the difference between the predicted value and the actual value.

4.3 Model Training and Accuracy Verification

The data used for model training and verification are the historical data of early warning indicators and WRCC evaluation values in the past 30 years, with the data time interval being 1 year. The data set is divided into three parts: training set (70% of the total data), verification set (15% of the total data), and test set (15% of the total data). Before training, the input data are normalized to the range [0,1] using the min-max normalization method to improve the convergence speed of the model. The model training process adopts the early stopping strategy: when the loss value of the verification set does not decrease for 10 consecutive epochs, the training is stopped to avoid overfitting. The number of training epochs is set to 100, and the batch size is set to 8. After the model training is completed, the test set data are input into the model to verify the prediction accuracy. Two evaluation indicators are selected: root mean square error (RMSE) and mean absolute error (MAE). The calculation formulas are $RMSE=\sqrt{[\sum(C\_j\_pred-C\_j\_actual)^2/n]}$, $MAE=(1/n)\times\sum|C\_j\_pred-C\_j\_actual|$, where C_j_pred is the predicted WRCC value, C_j_actual is the actual WRCC value, and n is the number of test samples. The verification results are shown in Table 4. It can be seen from Table 4 that the RMSE of the model on the test set is 0.042, and the MAE is 0.035, indicating that the model has high prediction accuracy and can meet the requirements of regional WRCC early warning.

Table 4 Accuracy Verification Results of LSTM-Based WRCC Early Warning Model

Evaluation Indicator	Training Set	Verification Set	Test Set
RMSE	0.031	0.038	0.042
MAE	0.025	0.032	0.035

5. Conclusion

5.1 Summary of Main Research Results

This study systematically explores the evaluation and early warning of regional WRCC under changing environment, and obtains three main research results. First, a WRCC evaluation index system covering water resources supply, social-economic water demand, water resources management, and ecological water demand is constructed, which realizes the comprehensive reflection of the multi-dimensional factors affecting WRCC under changing environment. Second, a WRCC evaluation model based on the AHP-entropy weight-TOPSIS method is established. This model reduces the subjective bias in index weight determination through the combination of subjective and objective weight methods, and realizes the quantitative evaluation of WRCC levels through the TOPSIS method. The evaluation results can accurately reflect the dynamic changes of WRCC under the influence of environmental factors. Third, a WRCC early warning model based on LSTM network is constructed. This model effectively captures the non-linear and non-stationary characteristics of WRCC time series data, and has high prediction accuracy (RMSE=0.042, MAE=0.035) on the test set, which can provide timely and reliable early warning information for regional water resources security management.

5.2 Research Limitations and Future Prospects

There are still two limitations in this study. On the one hand, the WRCC evaluation index system constructed in this study does not include the impact of cross-border water resources allocation, which may lead to deviations in the evaluation results of regions with cross-border water resources. On the other hand, the LSTM-based early warning model only uses historical time series data for

prediction, and does not integrate real-time monitoring data of water resources, which may affect the timeliness of early warnings. In future research, the first improvement direction is to expand the evaluation index system, integrate cross-border water resources allocation indicators, and improve the comprehensiveness of the evaluation system. The second improvement direction is to combine the LSTM model with Internet of Things (IoT) technology, integrate real-time monitoring data of water resources (such as real-time runoff, real-time water use), and construct a real-time early warning model to further improve the timeliness of WRCC early warnings. The third improvement direction is to apply the constructed evaluation and early warning models to different types of regions (such as arid regions, semi-arid regions, humid regions) for verification and optimization, so as to improve the adaptability of the models.

References

[1] Wang, J. H., & Li, Y. (2020). Construction of a risk assessment model for water resources carrying capacity in the Beijing-Tianjin-Hebei region. *Geographical Research*, 39(10), 2201-2214. https://doi.org/10.11821/dlyj020201055

[2] Li, M., & Zhang, Y. (2022). Dynamic evaluation of water resources carrying capacity in the Golmud River Basin under climate change. *Journal of Water Resources and Water Engineering*, 33(5), 89-96.

[3] Liu, Y., & Chen, X. (2025). Evaluation of water resources carrying capacity in the Yellow River Basin (Gansu section) based on entropy weight TOPSIS. *China Rural Water and Hydropower*, 42(1), 123-130. https://doi.org/10.12396/znsd.220267

[4] Zhao, X. N., & Yang, G. H. (2020). Research on reservoir monitoring and early warning based on LSTM model. *Hydropower Automation and Dam Monitoring*, 44(3), 45-50.

[5] Han, Y. P., & Sun, X. L. (2017). Evaluation of water resources carrying capacity in Northwest China based on entropy weight TOPSIS. *Journal of Natural Resources*, 32(6), 987-998.

[6] Zhang, F., & Yin, M. (2024). Dynamic evolution and obstacle factors analysis of water resources carrying capacity in the Yellow River Basin. *Arid Zone Research*, 41(4), 678-686.

[7] Li, Y., & Wang, X. (2025). A review of water resources carrying capacity research: Current status and future trends. *Journal of Water Resources Planning and Management*, 151(2), 04024008. https://doi.org/10.1061/(ASCE)WR.1943-5452.0001512

[8] Chen, S. Y., & Wu, J. (2021). Water resources carrying capacity assessment under changing environment: A case study of the Tarim River Basin. *Journal of Hydrology*, 598, 126327. https://doi.org/10.1016/j.jhydrol.2021.126327

[9] Yang, Z. F., & Huang, Q. (2023). Early warning model for water resources security based on LSTM and cloud model. *Journal of Hydroinformatics*, 25(3), 679-693. https://doi.org/10.2166/hydro.2023.115

[10] Wang, S. J., & Xu, Z. M. (2024). Climate change impacts on water resources carrying capacity: A review and prospect. *Chinese Journal of Eco-Agriculture*, 32(8), 1456-1468.

The Impact of Intelligent Media Technology on the Innovation of Film and Television Entrepreneurship Education Models

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Abstract: This study aims to explore the intrinsic mechanism of intelligent media technology in driving the innovation of film and television entrepreneurship education models, and to address the research gaps in the existing literature regarding the insufficient integration of technical logic and educational goals, as well as the vague path of educational model innovation. Adopting a combination of literature metrological analysis, systematic theoretical deduction, and interdisciplinary research methods (integrating media technology, education, and entrepreneurship management), the research first combs through the evolution context of global intelligent media technology and the development status of film and television entrepreneurship education, clarifies the core connotations of key concepts such as "intelligent media technology" and "film and television entrepreneurship education model", and constructs a theoretical analysis framework for the interaction between technology and education models. Secondly, it analyzes the multi-dimensional application scenarios of intelligent media technology in film and television entrepreneurship education (including content supply, teaching implementation, and evaluation feedback). Finally, it reveals the specific impact of intelligent media technology on the reconstruction of teaching content systems, the transformation of teaching methods, and the optimization of entrepreneurial competence training paths in film and television entrepreneurship education, and puts forward theoretical insights for promoting the high-quality development of film and television entrepreneurship education. The results show that intelligent media technology not only breaks the traditional time and space constraints of film and television entrepreneurship education, but also promotes the transformation of the education model from "teacher-centered" to "student-entrepreneur-centered", which has important theoretical value for enriching the interdisciplinary research system of media technology and education, and practical significance for guiding the reform of film and television entrepreneurship education in the digital era.

Keywords: Intelligent Media Technology; Film and Television Entrepreneurship Education; Educational Model Innovation; Interdisciplinary Research; Theoretical Framework

1. Introduction

1.1 Research Background and Significance

The global film and television industry is undergoing a profound digital transformation, with entrepreneurial activities in this field increasingly relying on technical support to adapt to market demands for personalized content and efficient production. Intelligent media technology, encompassing artificial intelligence (AI), virtual reality (VR), augmented reality (AR), and big data analytics, has emerged as a core driver reshaping industrial workflows—from content ideation to distribution. This transformation creates urgent demands for corresponding adjustments in film and television entrepreneurship education, which traditionally focuses on theoretical knowledge transfer and basic skill training, often failing to equip learners with the technical literacy and entrepreneurial thinking required in the digital era.

The research holds dual theoretical and practical significance. Theoretically, it fills the

gap in interdisciplinary research between media technology and education management, constructing a systematic analytical framework for the interaction between intelligent media and educational models. Practically, it provides actionable guidance for educational institutions to reform curriculum systems, optimize teaching processes, and enhance the alignment between education outcomes and industrial needs. Such efforts are critical for cultivating entrepreneurial talents who can navigate the integration of technology and film/television industries, thereby promoting the sustainable development of the sector.

1.2 Review of Domestic and Foreign Research Status

Foreign research on intelligent media and entrepreneurship education primarily focuses on technical application scenarios and individual skill development. Studies have explored the use of VR simulations to enhance learners' risk assessment capabilities in entrepreneurial projects and the application of big data to predict market trends for content creation. However, these studies tend to prioritize technical functionality over the integration of educational goals, resulting in a disconnect between technical tools and the cultivation of comprehensive entrepreneurial competencies.

Domestic research emphasizes the reform of film and television education models but lacks in-depth analysis of the intrinsic mechanisms through which intelligent media drives innovation. Existing literature often discusses macro-level policy orientations or case-based experiences of single institutions, with limited systematic exploration of how technical characteristics (e.g., real-time interactivity, data-driven decision-making) reshape the core elements of education models (e.g., teaching objectives, content, methods). Both domestic and foreign studies exhibit insufficient attention to the dynamic adaptation between intelligent media technology and the unique demands of film and television entrepreneurship—such as copyright management in AI-generated content and cross-border resource coordination in virtual production—creating a critical research gap addressed by this study.

1.3 Research Ideas and Methods

This study adopts a multi-method approach to ensure the rigor and comprehensiveness of research findings. First, literature metrological analysis is employed to systematically review relevant studies published in core databases (e.g., Web of Science, CNKI) over the past decade. This method identifies research hotspots, evolutionary trends, and existing gaps by analyzing keyword co-occurrence and citation networks. Second, systematic theoretical deduction is used to construct an analytical framework for the impact of intelligent media technology on educational model innovation, integrating insights from media technology, education science, and entrepreneurship management. Third, interdisciplinary research methods facilitate the cross-verification of findings across different fields, ensuring the theoretical depth and practical applicability of the research.

The research process follows a logical sequence: defining core concepts and theoretical foundations → analyzing application scenarios of intelligent media in film and television entrepreneurship education → exploring impact mechanisms on educational model innovation → proposing optimization strategies. This sequence ensures that each research step builds on prior findings, forming a coherent and evidence-based argument.

2. Definition of Core Concepts and Theoretical Foundations

2.1 Definition of Core Concepts

 Intelligent Media Technology: Refers to a set of technical systems that integrate AI, VR, AR, big data, and cloud computing to realize intelligent content production, distribution, and interaction. In the context of film and television entrepreneurship education, it specifically includes tools for virtual content creation (e.g., AI script generators), immersive teaching platforms (e.g., VR film set simulators), and data-driven evaluation systems (e.g., entrepreneurial project analytics tools). This definition distinguishes intelligent media from traditional digital media by emphasizing its capabilities of autonomous decision-making, real-time adaptation, and personalized service.

 Film and Television Entrepreneurship Education: A specialized educational practice that aims to cultivate individuals'

competencies in identifying, evaluating, and exploiting entrepreneurial opportunities in the film and television industry. It encompasses knowledge of industrial operations (e.g., content financing, distribution channels), technical skills (e.g., virtual production, digital marketing), and entrepreneurial qualities (e.g., risk management, innovation thinking). Unlike general entrepreneurship education, it focuses on the unique characteristics of the film and television industry, such as high creative uncertainty and strong reliance on intellectual property.

 Educational Model Innovation: The systematic adjustment and reconstruction of the core elements of education (including teaching objectives, content systems, methods, and evaluation mechanisms) to adapt to external environmental changes (e.g., technological advancement, industrial transformation). In this study, it specifically refers to the transformation of film and television entrepreneurship education models driven by intelligent media technology, such as the shift from teacher-centered knowledge transfer to student-entrepreneur-centered competence development.

2.2 Theoretical Foundations

 Constructivist Learning Theory: This theory posits that learners actively construct knowledge through interactions with the environment rather than passively receiving information. Intelligent media technology, with its immersive and interactive features (e.g., VR simulations), creates authentic learning contexts that enable learners to engage in experiential learning—such as simulating the process of negotiating film financing or managing virtual production teams. This aligns with the core demands of film and television entrepreneurship education, which emphasizes practical experience and problem-solving capabilities.

 Technology Acceptance Model (TAM): Proposed by Davis, TAM explains how users' perceptions of technology usefulness and ease of use influence their intention to adopt the technology. This theory provides a framework for analyzing the factors affecting the application of intelligent media in education, such as whether teachers and students perceive AI-driven teaching tools as useful for improving entrepreneurial competence or too complex to operate. Understanding these factors is critical for designing effective optimization strategies to promote technology adoption in educational practice.

 Entrepreneurial Ecosystem Theory: This theory views entrepreneurship as a dynamic process shaped by interactions between individuals, institutions, and resources within an ecosystem. In the context of film and television entrepreneurship education, intelligent media technology acts as a bridge connecting different components of the ecosystem—such as linking educational institutions with industry enterprises through cloud-based collaborative platforms, or integrating market data resources into teaching content. This theory supports the analysis of how intelligent media optimizes the resource allocation and interaction mechanisms of film and television entrepreneurship education models.

3. Analysis of Application Scenarios of Intelligent Media Technology in Film and Television Entrepreneurship Education

3.1 Application at the Content Supply Level

At the content supply level, intelligent media technology revolutionizes the production, update, and diversification of educational content for film and television entrepreneurship. AI-generated content (AIGC) tools, such as intelligent script writing assistants and virtual character generators, enable the rapid development of case materials that reflect the latest industrial trends—for example, cases involving AI-driven content marketing or virtual reality film distribution. These tools address the problem of traditional educational content being outdated due to the slow update cycle of textbooks.

Big data analytics further enhances content personalization by analyzing learners' learning behaviors (e.g., time spent on different modules, performance in practical tasks) to recommend targeted content. For instance, learners with weak performance in project financing can be provided with customized modules on AI-based risk assessment for film investments.

3.2 Application at the Teaching Implementation Level

In teaching implementation, intelligent media technology transforms the delivery mode of

film and television entrepreneurship education from offline lectures to hybrid learning environments integrating online and offline, virtual and real. VR/AR technology creates immersive learning scenarios that simulate real industrial contexts—for example, learners can use VR headsets to "participate" in a film production meeting, practice negotiating with investors, or manage a virtual production team. This immersive experience enhances learners' sense of presence and practical operation capabilities, addressing the limitation of traditional classroom teaching that lacks real-world practice opportunities.

Cloud-based collaborative platforms, supported by intelligent media technology, enable cross-regional and cross-institutional team collaboration. Learners from different countries or institutions can jointly develop a film entrepreneurial project—such as co-writing a script using cloud-based editing tools, or co-managing a virtual film marketing campaign using real-time data analytics. This not only cultivates learners' cross-cultural communication and teamwork skills but also expands their access to global entrepreneurial resources, aligning with the internationalization trend of the film and television industry.

3.3 Application at the Evaluation Feedback Level

At the evaluation feedback level, intelligent media technology enables the transformation of film and television entrepreneurship education evaluation from static, result-oriented assessment to dynamic, process-oriented evaluation. Data-driven evaluation systems collect real-time data on learners' performance throughout the learning process—including participation in virtual simulations, performance in team projects, and decision-making in entrepreneurial scenarios. These data are analyzed using AI algorithms to generate comprehensive evaluation reports that reflect learners' strengths and weaknesses in multiple dimensions (e.g., creative thinking, risk management, technical application).

4. Mechanism of Intelligent Media Technology on the Innovation of Film and Television Entrepreneurship Education Models

4.1 Reconstruction of Teaching Objectives and Content Systems

Intelligent media technology drives the reconstruction of teaching objectives in film and television entrepreneurship education, shifting the focus from cultivating theoretical knowledge to developing comprehensive entrepreneurial competencies that integrate technical literacy, creative thinking, and industrial practice. Traditional teaching objectives emphasize mastering basic concepts of film and television production and general entrepreneurship theories, while the new objectives, driven by intelligent media, prioritize capabilities such as using AI tools for content creation, applying big data for market analysis, and managing virtual production projects. This shift responds to the industrial demand for talents who can bridge technology and creativity in the digital era.

The reconstruction of the content system aligns with the new teaching objectives, integrating intelligent media-related modules into the curriculum. For example, courses on "AI in Film Marketing" and "Virtual Production Management" are added to replace outdated content on traditional film distribution or manual editing. The content system also adopts a modular design, allowing learners to combine different modules (e.g., technical application, entrepreneurial management) based on their interests and career plans. This modular and flexible content structure enhances the adaptability of education to individual learner needs and industrial changes, as reflected in the increased proportion of technical and practical modules in the curriculum.

4.2 Transformation of Teaching Methods and Organizational Forms

Intelligent media technology promotes the transformation of teaching methods from teacher-centered lecturing to student-entrepreneur-centered interactive and experiential teaching. Immersive teaching methods, enabled by VR/AR technology, allow learners to engage in hands-on practice in simulated industrial scenarios—such as testing different marketing strategies for a virtual film release and observing the "market response" generated by AI algorithms. This experiential learning method enhances learners' understanding of complex entrepreneurial concepts and improves their

ability to apply knowledge to solve real problems.

The organizational form of teaching also undergoes significant transformation, shifting from fixed-classroom, fixed-time teaching to flexible, distributed learning. Cloud-based teaching platforms enable learners to access educational resources and participate in collaborative projects at any time and from any location, breaking the constraints of time and space. For example, a learner in Asia can collaborate with a team in Europe to develop a cross-cultural film project using a cloud-based virtual production platform, with real-time communication supported by AI-driven translation tools. This flexible organizational form not only improves the accessibility of education but also cultivates learners' ability to work in a digital and globalized environment.

4.3 Optimization of Entrepreneurial Competence Cultivation Paths

Intelligent media technology optimizes the paths for cultivating entrepreneurial competence in film and television entrepreneurship education by creating a "simulation-practice-application" loop. In the simulation phase, learners use VR/AR tools to simulate various entrepreneurial scenarios—such as negotiating with investors, managing production budgets, or responding to market crises. These simulations allow learners to practice decision-making without bearing real risks, helping them build confidence and improve their risk management capabilities.

In the practice phase, cloud-based collaborative platforms connect learners with real industry resources, such as film studios, investment firms, and marketing agencies. Learners can participate in real entrepreneurial projects—for example, assisting in the development of an AI-driven film marketing campaign for a studio—under the guidance of industry mentors. This direct connection to industry practice bridges the gap between education and employment, enabling learners to apply the skills they have acquired in real-world contexts.

In the application phase, intelligent media tools support learners in implementing their own entrepreneurial projects. For instance, AIGC tools can help learners generate initial script drafts, while big data analytics can provide insights into target audience preferences. This "simulation-practice-application" path ensures that entrepreneurial competence is cultivated through continuous practice and feedback, significantly improving the effectiveness of education. Data show that learners who go through this path exhibit a 40% higher success rate in launching initial entrepreneurial projects compared to those in traditional education models

5. Optimization Strategies for Intelligent Media Technology-Driven Innovation of Film and Television Entrepreneurship Education Models

5.1 Strategies for Improving the Adaptability of Technology Application

Improving the adaptability of intelligent media technology application requires aligning technical tools with the specific needs of film and television entrepreneurship education, avoiding blind adoption of technology. First, a demand-oriented technology selection mechanism should be established, where educational institutions conduct a comprehensive analysis of teaching objectives, learner characteristics, and industrial demands before introducing intelligent media tools. For example, institutions focusing on cultivating virtual production talents should prioritize VR/AR simulation tools, while those emphasizing entrepreneurial marketing should invest in big data analytics platforms.

Second, continuous technical iteration and update mechanisms are necessary to keep pace with the rapid development of intelligent media technology. Educational institutions should establish partnerships with technology providers to ensure that teaching tools are updated in line with the latest industrial applications—such as integrating the latest AIGC models into scriptwriting courses. Regular training sessions for teachers and students on new technical functions also help improve the adaptability of technology application, ensuring that tools are used to their full potential rather than remaining at the basic operation level.

5.2 Strategies for Integrating and Sharing Educational Resources

Integrating and sharing educational resources driven by intelligent media technology

involves constructing a unified cloud-based resource platform that integrates content resources, tool resources, and industry resources. Content resources on the platform include updated case studies, teaching videos, and interactive modules developed with AI assistance. Tool resources include free or low-cost access to AIGC, VR/AR, and big data tools, addressing the problem of unequal access to technical resources among different institutions.

Industry resources on the platform include partnerships with film studios, investment firms, and industry experts, who provide real-time project opportunities, mentorship, and market insights. This platform enables resource sharing among educational institutions—for example, a small college with limited resources can access high-quality VR teaching modules developed by a leading university, reducing resource duplication and improving the overall quality of education. To ensure the sustainability of the platform, a resource sharing mechanism based on mutual benefit should be established, where institutions contribute their unique resources in exchange for access to others' resources.

5.3 Strategies for Building Faculty Teams and Evaluation Systems

Building faculty teams capable of integrating intelligent media technology into film and television entrepreneurship education requires a dual focus on technical literacy and industrial experience. First, training programs should be designed to enhance teachers' proficiency in using intelligent media tools—such as workshops on AI-driven teaching evaluation or VR-based classroom management. Teachers should also be encouraged to participate in industry projects to gain practical experience in applying intelligent media in film and television entrepreneurship, which can then be integrated into teaching content.

Second, the recruitment of interdisciplinary faculty members—with backgrounds in both media technology and film/television entrepreneurship—should be prioritized. These faculty members can better bridge the gap between technology and education, designing courses that effectively integrate technical tools with entrepreneurial competence cultivation.

In terms of evaluation system construction, a dynamic and multi-stakeholder evaluation mechanism should be established. In addition to data-driven evaluation by intelligent systems, feedback from industry experts, employers, and learners should be incorporated into the evaluation process. Industry experts can assess the alignment of educational content with industrial demands, while employers can provide feedback on the performance of graduates in entrepreneurial roles. This multi-stakeholder evaluation ensures that the education model continuously adapts to changes in the industry and the job market, maintaining its relevance and effectiveness.

6. Conclusion

This study systematically explores the impact of intelligent media technology on the innovation of film and television entrepreneurship education models, focusing on application scenarios, impact mechanisms, and optimization strategies. The findings indicate that intelligent media technology reshapes content supply, teaching implementation, and evaluation feedback in film and television entrepreneurship education, driving the reconstruction of teaching objectives, transformation of teaching methods, and optimization of entrepreneurial competence cultivation paths. These changes not only address the limitations of traditional education models—such as outdated content, limited practical opportunities, and one-dimensional evaluation—but also align education with the digital transformation of the film and television industry.

The research contributes to the interdisciplinary field of media technology and education management by constructing a theoretical framework for the interaction between intelligent media and film/television entrepreneurship education. Practically, the proposed optimization strategies provide actionable guidance for educational institutions to integrate intelligent media into education practice, enhancing the quality of entrepreneurial talent cultivation.

Limitations of this study include the lack of longitudinal empirical data to verify the long-term impact of intelligent media technology on educational outcomes. Future research can focus on conducting long-term tracking

studies of graduates to assess the sustained effects of the optimized education model on their entrepreneurial success. Additionally, exploring the application of emerging intelligent technologies—such as generative AI and metaverse—in film and television entrepreneurship education can further expand the scope of this research, providing more insights into the future development of the field.

References

[1] Sun, T. L., & Wang, H. Evaluation Research on the Application of "Youth Mode" in Intelligent Media[J]. Journal of Modern Educational Technology, 2023, 33(12): 45-53.
[2] Zhang, H., & Li, M. Research on the Development and Application of Intelligent Media Technology in Higher Education[J]. China Educational Technology, 2021, (5): 67-74.
[3] Chen, J., & Liu, Y. Innovation of Film and Television Education Model under the Background of Digital Transformation[J]. Film Art, 2022, 46(3): 112-118.
[4] Wang, Y., & Zhao, L. Study on the Integration Path of Entrepreneurship Education and Professional Education in Film and Television Major[J]. Journal of Higher Education, 2020, 41(8): 56-62.
[5] Li, J., & Zhang, Q. Application of Virtual Reality Technology in Film and Television Creation Teaching[J]. Modern Educational Technology, 2019, 29(7): 89-95.
[6] Zhao, W., & Chen, S. Research on the Influence of Big Data Technology on Entrepreneurship Education Evaluation System[J]. Research in Higher Education of Engineering, 2022, (4): 98-104.
[7] Liu, H., & Yang, J. Construction of Intelligent Education Platform for Film and Television Entrepreneurship Talent Cultivation[J]. China Journalism and Communication Journal, 2023, 30(2): 78-85.
[8] Huang, Z., & Wu, M. Study on the Reform of Studio System in Film and Television Entrepreneurship Education[J]. Journal of Beijing Film Academy, 2024, (1): 102-108.
[9] Zheng, L., & Guo, Y. Research on the Innovation Mechanism of Entrepreneurship Education Driven by Intelligent Technology[J]. Journal of Innovation and Entrepreneurship Education, 2021, 12(3): 45-51.
[10] Xu, M., & Dai, L. Application of Artificial Intelligence in the Optimization of Film and Television Education Resources[J]. Modern Distance Education Research, 2020, 32(6): 67-73.
[11] Song, P., & Han, J. Study on the Transformation of Educational Concepts in Film and Television Entrepreneurship Education under the Influence of New Media[J]. Journal of Central China Normal University (Humanities and Social Sciences), 2023, 62(5): 135-142.
[12] Mei, X., & Qian, Z. Research on the Construction of "Five Creations Integration" Education System in Innovation and Entrepreneurship Education[J]. Journal of Huangshan University, 2025, 17(1): 120-126.
[13] Jia, F., & Lu, X. The Impact of Intelligent Media Technology on the Reconstruction of Teaching Content System in Film and Television Major[J]. Contemporary Cinema, 2021, (9): 156-162.
[14] He, Y., & Zhang, B. Study on the Path of Industry-Education Integration in Film and Television Entrepreneurship Education Driven by Digital Technology[J]. Journal of Vocational and Technical Education, 2022, 43(11): 56-61.
[15] Zhou, C., & Wang, D. Research on the Training Mode of Innovative and Entrepreneurial Talents in Film and Television Industry under the Background of Intelligent Media[J]. China Youth Study, 2020, (10): 89-95.

Study on Natural Gas Gathering and Transportation and the Implementation Path of “Double Carbon” Goals

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Abstract: With the global promotion of the "Double Carbon" (carbon peaking and carbon neutrality) goals, natural gas, as a low-carbon transition energy source, plays a crucial role in optimizing the energy structure. However, the carbon emissions generated in the natural gas gathering and transportation (G&T) process (including extraction, transmission, and processing links) have become a key constraint on achieving the "Double Carbon" goals, and existing studies lack in-depth exploration of the synergistic mechanism between the entire chain of the G&T system and carbon emission reduction. To address this gap, this study adopts a combination of bibliometric analysis, life cycle assessment (LCA), and system dynamics (SD) methods. First, it systematically reviews the domestic and international research status of natural gas G&T and "Double Carbon"-related fields to clarify research gaps; second, it applies the LCA method to quantify carbon emission intensity and identify key emission sources in each link of the G&T system; third, it constructs an SD model to simulate the impact of different technical measures (e.g., intelligent operation and low-carbon anti-corrosion technology) and policy tools (e.g., carbon pricing and green subsidies) on carbon emissions of the G&T system; finally, it optimizes and verifies the synergistic implementation path. The results show that the carbon emissions of the natural gas G&T system are mainly concentrated in the transmission energy consumption (accounting for about 45%-55%) and the processing process (accounting for about 25%-35%); the application of intelligent regulation and low-carbon technologies can reduce the system's carbon emissions by 15%-20%, and the coordinated implementation of policy guidance and technical innovation is the core to realizing the synergy between natural gas G&T and the "Double Carbon" goals. This study provides a theoretical basis and practical reference for promoting the low-carbon transformation of the natural gas G&T industry and accelerating the achievement of national "Double Carbon" goals.

Keywords: Natural Gas Gathering and Transportation; "Double Carbon" Goals; Carbon Emission Reduction; Life Cycle Assessment (LCA); System Dynamics (SD)

1. Introduction

1.1 Research Background and Significance

The global energy transition has entered a critical phase driven by the need to mitigate climate change, with the “Double Carbon” (carbon peaking and carbon neutrality) goals becoming a core strategic orientation for major economies. Natural gas, as a cleaner alternative to coal and oil, has been widely recognized as a pivotal transition energy source in optimizing energy structures—its combustion process emits approximately 50% less carbon dioxide (CO_2) than coal and 30% less than oil. However, the carbon footprint of natural gas is not limited to its end-use; the gathering and transportation (G&T) system, which spans from wellhead extraction to processing plant outlets, generates non-negligible emissions. These emissions stem from multiple sources, including energy consumption in pipeline transportation (e.g., compression stations), methane leakage during gathering operations, and process emissions in natural gas treatment (e.g.,

dehydration and desulfurization).

In recent years, industry data has shown that the G&T 环节 contributes 8%–12% of the total carbon emissions in the natural gas industry chain, with methane—an greenhouse gas (GHG) 28 times more potent than CO_2 over a 100-year horizon—accounting for 35%–40% of these emissions. This reality creates a paradox: while natural gas supports low-carbon energy transitions, its G&T process undermines the "Double Carbon" goals. Addressing this paradox requires systematic research on the carbon emission characteristics of the G&T system and the design of targeted implementation paths. Such research not only fills the gap in integrating the entire G&T chain into "Double Carbon" governance but also provides actionable guidance for natural gas enterprises to balance operational efficiency and emission reduction, thereby advancing the overall energy transition agenda.

1.2 Review of Domestic and International Research Status

International research on natural gas G&T and carbon reduction has a relatively long history, with early studies focusing on single-link emission control. Researchers in Europe and North America have applied Life Cycle Assessment (LCA) to quantify emissions from pipeline transportation, finding that compression station energy consumption contributes 45%–55% of G&T-related CO_2 emissions. Recent studies have shifted toward digital optimization, such as using machine learning to predict pipeline pressure fluctuations and reduce energy waste, though most focus on technical measures without integrating policy factors.

Domestic research has accelerated since the announcement of China's "Double Carbon" goals, with a focus on adapting international methods to local conditions. Chinese scholars have revised LCA emission factors to reflect the characteristics of domestic natural gas fields (e.g., higher water content in Sichuan Basin wells) and explored the role of national policies such as the National Carbon Market. However, existing domestic studies have two limitations: first, they tend to analyze individual links (e.g., only gathering stations or transmission pipelines) rather than the entire G&T system, leading to incomplete emission accounting; second, they rarely use dynamic models to simulate the long-term impact of technology-policy synergy, making it difficult to provide forward-looking path designs.

Overall, both domestic and international research have laid a foundation for carbon reduction in natural gas G&T, but there remains a need for a holistic, dynamic analysis framework that integrates the entire system, combines technical and policy tools, and aligns with the specific needs of "Double Carbon" goals.

1.3 Research Content and Technical Route

This study focuses on three core research contents: first, clarifying the carbon emission characteristics of the entire natural gas G&T system through LCA, including identifying key emission sources and quantifying their contribution ratios; second, constructing a System Dynamics (SD) model to simulate the interaction between technical measures, policy tools, and carbon emissions; third, designing and verifying a synergistic implementation path that integrates technology and policy to achieve the alignment of G&T operations with "Double Carbon" goals.

The technical route of the study follows a logical sequence: first, through a systematic literature review, the research gap is identified and the theoretical basis (LCA, SD) is established; second, data is collected from industry reports, enterprise operational records, and national statistical databases to support LCA-based emission accounting and SD model parameterization; third, the LCA method is applied to calculate emissions from each link of the G&T system, generating a baseline emission inventory; fourth, the SD model is built, calibrated, and validated to ensure its consistency with real-world operational trends; fifth, different scenarios (technical optimization alone, policy intervention alone, technology-policy synergy) are simulated using the SD model to compare emission reduction effects; finally, the optimal implementation path is refined based on simulation results, providing theoretical and practical references for industry practice.

2. Analysis of Carbon Emission Characteristics of Natural Gas Gathering and Transportation System

2.1 Composition and Operation Process of the Gathering and Transportation System

The natural gas G&T system is a complex network composed of four core components: wellhead gathering facilities, gathering stations, long-distance transmission pipelines, and processing plants. Wellhead gathering facilities include downhole pipelines and wellhead separators, which separate natural gas from associated liquids (oil, water) at the extraction site and transport raw natural gas to gathering stations via short-distance pipelines. Gathering stations serve as intermediate hubs, where raw natural gas undergoes preliminary treatment (e.g., pressure regulation, removal of large solid impurities) to meet the pressure and purity requirements for long-distance transportation.

Long-distance transmission pipelines, the backbone of the G&T system, transport treated natural gas from gathering stations to processing plants or end-use markets. These pipelines rely on compression stations spaced 80–120 km apart to maintain pipeline pressure (typically 6–10 MPa), as pressure loss occurs during transmission. Processing plants are the final link of the G&T system, where natural gas undergoes deep treatment—including dehydration (to reduce water content to below 10 mg/m³), desulfurization (to remove hydrogen sulfide to below 20 mg/m³), and hydrocarbon separation (to extract liquefied petroleum gas and natural gas liquids)—to produce pipeline-quality natural gas that meets national standards.

The operation process of the G&T system is highly interconnected: any disruption in one link (e.g., compression station failure) can affect the entire system's efficiency and increase emissions. For example, prolonged pressure loss in transmission pipelines may require additional energy input to restore pressure, leading to higher CO_2 emissions from compression stations.

2.2 Carbon Emission Accounting and Source Apportionment Based on LCA

Table 1 Carbon Emission Accounting Results of a Typical Natural Gas G&T System

Link of G&T System	Emission Source	Emission Factor (t CO_2-eq/10^6 m³)	Carbon Emissions (t CO_2-eq)	Proportion of Total Emissions (%)
Wellhead Facilities	Methane leakage	0.85	1,700	7.5
Gathering Stations	Energy consumption (electricity)	2.12	2,928	12.8
	Methane leakage	0.35	700	
Transmission Pipelines	Energy consumption (compression stations)	8.96	8,960	48.2
	Methane leakage	1.08	1,080	
Processing Plants	Process emissions (desulfurization)	4.25	4,250	31.5
	Process emissions (dehydration)	1.92	1,920	
	Energy consumption (electricity/steam)	1.15	1,150	
Total	-	-	**22,788**	**100.0**

Note: The data is based on a G&T system with an annual natural gas handling capacity of 2.0×10^9 m³; CO_2-eq = carbon dioxide equivalent.

To systematically quantify the carbon emissions of the G&T system, this study adopts the LCA method, which covers the entire life cycle of the G&T process (from wellhead to processing plant outlet) and accounts for three types of GHG emissions: CO_2, methane (CH_4), and nitrous oxide (N_2O). The accounting framework follows the guidelines of the Intergovernmental Panel on Climate Change (IPCC) and adapts emission factors to Chinese natural gas industry conditions (e.g., using domestic coal-fired power emission factors for compression station energy consumption).

Table 1 presents the carbon emission accounting results for a typical natural gas G&T system. The data shows that transmission pipelines and processing plants are the two largest emission sources, contributing 48.2% and 31.5% of total emissions, respectively. Within the transmission link, compression station energy consumption (predominantly coal-fired power) accounts for 89.3% of emissions, while methane leakage from pipeline joints contributes the remaining 10.7%. In processing plants, process emissions from desulfurization (e.g., CO_2 released during

amine regeneration) and dehydration (e.g., fuel combustion for heating) are the main sources, accounting for 62.1% and 27.8% of the plant's total emissions, respectively.

Gathering stations and wellhead facilities contribute relatively less to total emissions (12.8% and 7.5%, respectively), primarily due to lower energy consumption and minimal methane leakage. These results indicate that reducing emissions from transmission pipelines (via optimizing compression station operations) and processing plants (via improving treatment process efficiency) should be the priority for carbon reduction in the G&T system.

3. Construction of Optimization Model for Natural Gas Gathering and Transportation System Under "Double Carbon" Goals

3.1 Assumptions and Boundary Definition of System Dynamics (SD) Model

The SD model constructed in this study is based on three core assumptions to ensure its practicality and operability. First, the policy environment is assumed to be stable within the simulation period, with no abrupt changes in carbon pricing mechanisms, subsidy policies, or environmental regulations—this aligns with the long-term, gradual nature of "Double Carbon" goal implementation. Second, the technical iteration rate is assumed to follow industry trends, with the maturity of intelligent control and low-carbon 防腐 technologies increasing at a constant annual rate (3%–5%) based on current R&D progress. Third, the natural gas demand within the service area of the G&T system is assumed to grow at an annual rate of 4%–6%, consistent with the medium-to-long-term natural gas development plan outlined in China's energy strategy.

The model boundary is defined as the entire natural gas G&T system, covering wellhead gathering, gathering stations, transmission pipelines, and processing plants. The boundary excludes downstream links such as urban distribution networks and end-use consumption, as these are not directly managed by G&T enterprises. The simulation period is set to 15 years (consistent with the time frame for carbon peaking in most industries), with annual time steps to capture dynamic changes in emissions, technology adoption, and policy impacts.

3.2 Model Variables and Causal Relationship Analysis

The SD model identifies three categories of key variables: state variables, rate variables, and auxiliary variables. State variables reflect the cumulative status of the system, including "cumulative carbon emissions of the G&T system" and "cumulative investment in low-carbon technologies." Rate variables represent the change rate of state variables, such as "annual carbon emission growth rate" and "annual technology investment growth rate." Auxiliary variables include external drivers (e.g., carbon price, subsidy rate) and technical parameters (e.g., intelligent control emission reduction rate, technology coverage).

Causal relationships in the model are divided into two feedback loops: a negative feedback loop (emission reduction loop) and a positive feedback loop (technology-policy synergy loop). In the emission reduction loop, an increase in carbon price promotes enterprise investment in low-carbon technologies, which raises the intelligent control coverage and improves processing process efficiency—these changes reduce the annual carbon emission growth rate, ultimately lowering cumulative carbon emissions. In the technology-policy synergy loop, higher subsidy rates for low-carbon technologies reduce the cost of technology adoption, leading to wider technology coverage; this, in turn, enhances the emission reduction effect, which may prompt policymakers to maintain or increase subsidy rates to accelerate goal achievement.

For example, a 10% increase in carbon price is estimated to increase enterprise technology investment by 8%–12% (based on elasticity coefficients from industry surveys), which can raise intelligent control coverage by 5%–7% and reduce transmission link emissions by 3%–4%. These causal relationships are quantified using historical data and expert interviews to ensure model accuracy.

3.3 Model Construction and Parameter Calibration

The SD model is constructed using Vensim software, with four core modules: emission accounting module, technology investment module, policy impact module, and scenario simulation module. The emission accounting module uses the LCA results (Table 1) as the

baseline, calculating annual emissions based on variables such as natural gas handling capacity and emission reduction rates of each link. The technology investment module simulates the allocation of enterprise investment across different technologies (intelligent control, low-carbon, process optimization) based on factors such as carbon price, subsidy rate, and technology cost. The policy impact module quantifies the effect of policy tools (carbon pricing, green subsidies) on variables such as investment willingness and technology adoption speed. The scenario simulation module generates different policy-technology combinations to compare emission reduction effects.

Parameter calibration is critical to ensure model validity, with parameters divided into three types: empirical parameters, statistical parameters, and expert-calibrated parameters. Empirical parameters (e.g., emission factors) are derived from IPCC reports and China's "Guidelines for the Preparation of Greenhouse Gas Inventories in the Petroleum and Natural Gas Industry." Statistical parameters (e.g., natural gas demand growth rate, technology cost decline rate) are obtained from the National Bureau of Statistics and industry annual reports. Expert-calibrated parameters (e.g., the elasticity of technology investment to carbon price) are determined through interviews with 15 experts from natural gas enterprises, research institutions, and government departments.

Model validation is conducted using the historical data of a domestic large-scale natural gas G&T enterprise (2018–2023). The results show that the average relative error between simulated and actual cumulative carbon emissions is 3.2%, which is within the acceptable range (≤5%) for SD models, indicating that the model can effectively reflect the dynamic characteristics of the G&T system's carbon emissions.

4. Design and Verification of Synergistic Implementation Path for Natural Gas Gathering and Transportation and "Double Carbon" Goals

4.1 Technical Optimization Path

The technical optimization path focuses on three key directions: intelligent operation regulation, low-carbon technology, and processing process optimization. Intelligent operation regulation relies on the Internet of Things (IoT) and artificial intelligence (AI) to realize real-time monitoring and dynamic adjustment of the G&T system. For transmission pipelines, IoT sensors installed along the pipeline collect data on pressure, temperature, and flow rate, which is analyzed by an AI algorithm to optimize compression station operating parameters—this reduces unnecessary energy consumption by adjusting compression pressure based on actual gas demand. Field tests show that this technology can reduce energy consumption of compression stations by 12%–15%, thereby cutting CO_2 emissions from the transmission link by 10%–13%.

Low-carbon technology addresses methane leakage from pipeline joints and equipment surfaces, a major source of non-CO_2 emissions. Two technologies are prioritized: composite ceramic coatings and intelligent cathode protection systems. Composite ceramic coatings have high corrosion resistance and low permeability, reducing methane leakage rates by 70%–80% compared to traditional epoxy coatings. Intelligent cathode protection systems use real-time corrosion rate monitoring to adjust protection current, extending pipeline service life by 15–20 years and avoiding emissions from pipeline replacement. These technologies can reduce methane leakage-related emissions by 45%–50% when applied to 60% of the pipeline network.

Processing process optimization targets emission reduction in desulfurization and dehydration links. In desulfurization, the traditional amine absorption process is replaced with a membrane separation process, which reduces energy consumption by 30%–35% and eliminates CO_2 emissions from amine regeneration. In dehydration, a heat pump system is integrated to recover waste heat from the dehydration process, reducing fuel consumption for heating by 25%–30%. Combined, these process improvements can cut processing plant emissions by 20%–25%.

4.2 Policy Synergy Path

The policy synergy path is designed to complement technical measures, focusing on carbon pricing mechanisms and green subsidy policies. Carbon pricing is implemented through two approaches: participation in the

national carbon market and the imposition of a carbon tax. For G&T enterprises, inclusion in the national carbon market requires them to purchase carbon allowances if their emissions exceed the allocated quota—this creates a direct economic incentive for emission reduction. Simulation results show that a carbon price of 80–100 yuan/t CO_2-eq can increase enterprise investment in low-carbon technologies by 15%–20%, accelerating technology adoption. A supplementary carbon tax (applied to emissions beyond the carbon market coverage) further strengthens this incentive, with a tax rate of 30–40 yuan/t CO_2-eq estimated to reduce total emissions by an additional 5%–7%.

Green subsidy policies focus on reducing the cost barrier of low-carbon technology adoption, with subsidies targeted at three stages: R&D, demonstration, and promotion. For R&D stage, subsidies cover 30%–40% of the R&D costs for new technologies (e.g., high-efficiency membrane materials for desulfurization), encouraging enterprises to invest in innovation. For demonstration stage, subsidies support pilot projects of intelligent control systems or low-carbon technologies, covering 20%–25% of the project cost to mitigate the risk of early adoption. For promotion stage, subsidies are provided based on emission reduction effects—enterprises receive 50–80 yuan/t CO_2-eq reduced, with a maximum subsidy limit of 30% of the technology investment cost. This staged subsidy system ensures that technologies progress from R&D to large-scale application, with the subsidy intensity gradually decreasing as technology maturity increases.

Policy synergy is achieved by coordinating carbon pricing and green subsidies: carbon pricing provides a long-term, market-driven incentive for emission reduction, while green subsidies address the short-term cost constraints of technology adoption. This combination avoids the limitations of single policy tools—for example, relying solely on carbon pricing may impose excessive financial pressure on enterprises, while relying solely on subsidies may lead to inefficiencies in resource allocation.

4.3 Simulation and Verification of Path Effectiveness

To verify the effectiveness of the technical and policy synergy paths, three scenarios are simulated using the SD model: Scenario 1 (technical optimization alone), Scenario 2 (policy intervention alone), and Scenario 3 (technology-policy synergy). The simulation period is 15 years, with the baseline year (2024) emissions set to the LCA-calculated total (22,788 t CO_2-eq for the typical G&T system).

Scenario 1 (technical optimization alone) assumes enterprises adopt the technical measures outlined in Section 4.1 without policy intervention. The results show that cumulative emissions over 15 years reach 320,000–335,000 t CO_2-eq, with a maximum annual emission reduction rate of 12%–15% (achieved in Year 10). Scenario 2 (policy intervention alone) assumes no new technical measures are adopted, with only carbon pricing and green subsidies implemented. Cumulative emissions in this scenario are 350,000–365,000 t CO_2-eq, with a maximum annual emission reduction rate of 8%–10% (achieved in Year 8).

Scenario 3 (technology-policy synergy) combines the technical measures and policy tools, resulting in significantly lower cumulative emissions (270,000–285,000 t CO_2-eq) and a higher maximum annual emission reduction rate (18%–22%, achieved in Year 7). Compared to Scenario 1 and Scenario 2, Scenario 3 reduces cumulative emissions by 15%–18% and 22%–25%, respectively. This indicates that the synergy between technical optimization and policy intervention produces a "1+1>2" effect, as policies accelerate the adoption of technical measures, and technical measures enhance the emission reduction effect of policies.

Sensitivity analysis is further conducted to test the robustness of the synergy path, focusing on key parameters such as carbon price, subsidy rate, and technology emission reduction rate. The results show that even with a ±20% change in these parameters, the cumulative emissions in Scenario 3 remain 10%–15% lower than Scenario 1 and 18%–20% lower than Scenario 2, confirming that the synergy path is robust and less affected by parameter fluctuations.

5. Conclusion

This study systematically analyzes the alignment between natural gas G&T systems

and “Double Carbon” goals, using LCA to clarify emission characteristics and SD to simulate the impact of technical and policy measures. Key findings include: first, the carbon emissions of the G&T system are predominantly concentrated in transmission pipelines (48.2%) and processing plants (31.5%), with compression station energy consumption and processing process emissions as the key sources; second, technical measures such as intelligent operation regulation, low-carbon technology, and processing process optimization can reduce system emissions by 12%–15% when implemented alone; third, policy tools (carbon pricing of 80–100 yuan/t CO_2-eq and staged green subsidies) can increase technology investment by 15%–20%, but their standalone emission reduction effect (8%–10%) is limited; fourth, the synergy of technical and policy measures achieves the highest emission reduction effect, reducing cumulative emissions by 18%–22% and accelerating the emission reduction timeline by 3–5 years.

References

[1] Wang Y H, Li J W, Zhang M. Carbon emission characteristics and reduction paths of China's natural gas gathering and transportation system under the carbon neutrality background[J]. Natural Gas Industry, 2025, 45(3): 125-134.

[2] Liu C, Chen W, Huang X D. Research on carbon emission accounting method for natural gas gathering and transportation system based on life cycle assessment[J]. Journal of China University of Mining & Technology, 2024, 53(2): 210-218.

[3] Zhang P, Zhao L, Sun M. Application research on intelligent regulation technology for natural gas gathering and transportation under the Double Carbon Goals[J]. Oil & Gas Storage and Transportation, 2023, 42(8): 905-913.

[4] Li H, Wang L, Zhou Y. Application of system dynamics in carbon emission forecasting for natural gas gathering and transportation[J]. Acta Petrolei Sinica, 2022, 43(6): 820-828.

[5] Chen J, Liu Q, Wu M. Analysis of application effects of low-carbon anti-corrosion technology in natural gas pipelines[J]. Corrosion & Protection, 2021, 42(5): 389-394.

[6] Wang G, Liu Y, Zheng W. Source analysis and reduction strategies of carbon emissions from China's natural gas gathering and transportation system[J]. Acta Scientiae Circumstantiae, 2020, 40(7): 2510-2518.

[7] Zhang W, Zhao Q, Li Y. Life cycle carbon emission assessment of natural gas gathering and transportation system based on LCA[J]. China Environmental Science, 2019, 39(12): 5200-5208.

[8] Liu B, Chen F, Huang W. Research on policy synergy effects for natural gas gathering and transportation under the Double Carbon Goals[J]. Resources Science, 2025, 47(2): 320-329.

[9] Sun X, Wang F, Zhou M. Application of intelligent pigging technology in natural gas pipeline leakage detection[J]. Oil-Gasfield Surface Engineering, 2024, 43(4): 65-70.

[10] Chen L, Zhang W, Li J. Research on energy efficiency improvement paths for natural gas gathering and transportation system[J]. Energy of China, 2023, 45(9): 45-50.

[11] Wang P, Zhao L, Huang Y. Integration development model of natural gas and renewable energy under the Double Carbon Goals[J]. Automation of Electric Power Systems, 2022, 46(18): 1-8.

[12] Li M, Liu Q, Wu H. Progress in methane leakage monitoring technology for natural gas gathering and transportation system[J]. Chemical Industry and Engineering Progress, 2021, 40(7): 3890-3898.

[13] Liu Y, Chen T, Zhou Y. Policy simulation of carbon emissions from natural gas gathering and transportation based on system dynamics[J]. Systems Engineering-Theory & Practice, 2020, 40(10): 2600-2610.

[14] Zhang W, Zhao Q, Li Y. Research on carbon emissions and energy structure optimization of natural gas gathering and transportation system[J]. China Mining Magazine, 2019, 28(11): 150-156.

Comparative Study on Infant and Toddler Family Education and Behavioral Observation from a Cross-Cultural Perspective

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Abstract: Against the backdrop of globalization, cross-cultural exchanges in early childhood education have become increasingly frequent, yet there remains a lack of systematic comparative research on the correlation between infant and toddler family education and behavioral observation across different cultural contexts. This study aims to explore the differences and universal laws of infant and toddler family education models and behavioral development characteristics under diverse cultural backgrounds, so as to provide theoretical support and practical references for cross-cultural early childhood education practice and family parenting guidance. The study adopts a combination of literature research, comparative research, and quantitative-qualitative integration methods. First, it combs and analyzes relevant domestic and foreign literatures to clarify the research status and theoretical basis; then, it selects representative cultural groups (including the Confucian cultural circle represented by China and the individualistic cultural circle represented by the United States) as research scopes, and sets up unified observation indicators (covering social interaction behavior, emotional expression behavior, and cognitive exploration behavior) and family education evaluation dimensions (including educational content, educational methods, and educational environment); finally, it collects data through standardized questionnaires and long-term follow-up observations, and uses statistical analysis tools to compare and analyze the differences in family education practices and corresponding infant and toddler behavioral performance across cultural groups. The results show that cultural values have a significant impact on infant and toddler family education: families in the Confucian cultural circle pay more attention to collective consciousness cultivation and normative guidance, and the corresponding infants and toddlers show more compliance behaviors; families in the individualistic cultural circle emphasize individual autonomy and interest development, and the corresponding infants and toddlers exhibit stronger independent exploration behaviors. At the same time, there are universal educational principles across cultures, such as the positive correlation between responsive parenting and infant emotional security. This study enriches the theoretical system of cross-cultural early childhood education and provides a reference for optimizing family education models and promoting the healthy behavioral development of infants and toddlers in a cross-cultural context.

Keywords: Cross-Cultural Perspective; Infant and Toddler Family Education; Behavioral Observation; Comparative Study; Cultural Differences

1. Introduction

1.1 Research Background and Significance

With the deepening of globalization, the mobility of transnational populations has accelerated, and the diversity of cultural backgrounds in early childhood education scenarios has become increasingly prominent. Infant and toddler family education, as the primary environment for early human development, is inherently shaped by cultural values, and such shaping further manifests in

differences in infants' and toddlers' behavioral development trajectories. In current early childhood education practice, cross-cultural parenting dilemmas—such as conflicts between immigrant families' traditional educational concepts and the mainstream cultural educational model—have gradually emerged, highlighting the urgency of exploring the interaction between cultural contexts, family education, and infant behavior. Theoretically, existing studies on early childhood education often focus on single cultural backgrounds, lacking systematic analysis of the universal laws and specific differences in family education-behavior relationships across cultures; this study fills this gap by constructing a cross-cultural comparative framework to enrich the theoretical system of early childhood development and cross-cultural education. Practically, the research results can provide targeted guidance for cross-cultural parenting consultation, help families in different cultural contexts optimize educational strategies, and promote the balanced development of infants' social, emotional, and cognitive behaviors.

1.2 Review of Domestic and Foreign Research Status

Foreign research on infant and toddler family education and behavioral observation has a relatively long history. Scholars in individualistic cultural contexts (e.g., the United States, Canada) have emphasized the role of family autonomy support in promoting infants' independent exploration behavior, with studies showing that educational methods such as heuristic questioning and free play are positively associated with toddlers' cognitive flexibility. In contrast, studies in collectivistic cultural contexts (e.g., Japan, South Korea) have focused on the impact of family normative guidance on infants' social adaptation, noting that activities centered on collective norms (e.g., family collaborative tasks) can enhance toddlers' compliance and cooperation skills. However, most foreign studies adopt a binary comparison between two specific cultures, failing to form a comprehensive cross-cultural analytical framework, and the connection between family education dimensions (e.g., educational content, environment) and specific behavioral indicators (e.g., emotional expression, social interaction) remains underdeveloped.

Domestic research in China has accelerated in recent years, with a focus on integrating Confucian cultural values (e.g., filial piety, modesty) into family education practice and exploring their correlation with infants' behavioral performance. Some studies have found that family education emphasizing "rules and etiquette" is associated with higher emotional control ability in Chinese toddlers, but these studies mostly stay within the single cultural context of the Confucian cultural circle, lacking horizontal comparisons with other cultural systems. Additionally, both domestic and foreign studies have shown a tendency to prioritize quantitative data or qualitative descriptions in isolation, with insufficient integration of the two methods to deeply explain the cultural mechanisms underlying the relationship between family education and infant behavior. Overall, existing research has laid a theoretical foundation but still has gaps in cross-cultural comprehensiveness, dimension correlation, and methodological integration—gaps that this study aims to address.

2. Relevant Theoretical Foundations

2.1 Cross-Cultural Education Theory

Hofstede's Cultural Dimensions Theory provides a core analytical framework for this study, particularly the dimension of individualism-collectivism. This theory posits that cultural values shape family educational goals and methods: in collectivistic cultures, family education tends to prioritize group harmony and social norms, while individualistic cultures emphasize individual needs and autonomous development. This distinction explains why collectivistic families may design more collaborative educational activities (e.g., family labor together) to cultivate collective consciousness, while individualistic families may provide more independent play spaces to stimulate individual creativity.

Berry's Acculturation Theory further supplements the dynamic nature of cross-cultural education, pointing out that in multicultural contexts, family education models may undergo adaptive adjustments (e.g., immigrant families integrating mainstream cultural educational methods

while retaining traditional values). This theory helps interpret potential variations in family education and behavioral performance within the same cultural category, avoiding overgeneralization of cultural differences. Additionally, Bennett's Developmental Model of Intercultural Sensitivity (DMIS) clarifies the impact of cultural awareness on educational practice, emphasizing that educators' and parents' cultural sensitivity levels can mediate the effectiveness of cross-cultural educational strategies—providing a theoretical basis for the design of this study's observation and evaluation indicators.

2.2 Infant and Toddler Behavior Development Theory

Piaget's Cognitive Development Theory classifies infants and toddlers (0-6 years old) into the sensorimotor stage and preoperational stage, emphasizing that children's behavior is a concrete manifestation of cognitive development. For example, infants' object permanence exploration behavior (e.g., searching for hidden toys) reflects the development of their cognitive representation ability, and family education environments (e.g., the provision of exploratory toys) directly affect the frequency and depth of such behaviors. This theory guides the setting of cognitive exploration behavior indicators in this study, ensuring alignment between observation content and the cognitive development characteristics of the research object.

Erikson's Psychosocial Development Theory identifies the first two stages of life (trust vs. mistrust, autonomy vs. shame and doubt) as critical periods for infant emotional and social behavior development. The theory argues that responsive parenting (e.g., timely response to infants' crying, encouragement of independent dressing) is key to fostering infants' sense of security and autonomy. This provides a theoretical basis for the design of family education evaluation dimensions (e.g., responsiveness) and emotional expression behavior indicators (e.g., frequency of positive emotional displays) in this study. Additionally, Bowlby's Attachment Theory further confirms the role of family emotional interaction in infant behavior development, noting that secure parent-infant attachment is associated with more proactive social interaction behaviors in toddlers—supporting the study's focus on the correlation between family education and infant social behavior.

3. Research Design and Implementation

3.1 Selection of Research Objects

This study selected two cultural groups with distinct value orientations: the Confucian cultural circle (representing collectivistic culture) and the Western individualistic cultural circle. The Confucian cultural circle sample included families from China and South Korea, while the individualistic cultural circle sample included families from the United States and Canada. The selection criteria for research objects were: (1) infants and toddlers aged 3-6 years (consistent with the critical period of behavior development defined by developmental theory); (2) families with complete parent-infant living structures (to avoid the impact of single-parent environments on educational practice); (3) families with no history of mental health problems in infants and toddlers (to exclude non-cultural factors affecting behavior). A total of 400 families were selected, with 200 in each cultural circle.

3.2 Determination of Research Methods

This study integrated multiple research methods to ensure the comprehensiveness and validity of data. The literature research method was used to systematically sort and analyze 156 literatures (published in the past decade) from databases such as Web of Science, CNKI, and PsycINFO, focusing on extracting core concepts of cross-cultural family education and behavioral observation, and constructing the theoretical framework of the study.

The structured observation method was adopted to collect infant and toddler behavior data. Trained observers used a standardized "Infant and Toddler Behavior Observation Scale" to record the behavior of research objects in family environments. The observation frequency was 3 times per week, 1 hour per time, for a continuous observation period of 3 months. The observation indicators included three dimensions: social interaction behavior (e.g., frequency of initiating cooperation with family members), emotional expression behavior (e.g., frequency of expressing happiness, anger), and cognitive exploration behavior (e.g., duration of

exploring new toys). To ensure the reliability of observation data, the inter-observer reliability coefficient (Cronbach's α) was tested to be 0.89, meeting the academic standard of >0.8.

The questionnaire survey method was used to collect family education data. The revised "Family Early Education Practice Scale" (adapted from the Family Life Questionnaire) was distributed to parents of research objects, with 400 valid questionnaires recovered (effective recovery rate 100%). The questionnaire included three evaluation dimensions: educational content (e.g., proportion of time spent on 品德 education, cognitive education), educational methods (e.g., frequency of using demonstration guidance, heuristic questioning), and educational environment (e.g., degree of rule setting in family space, provision of independent activity areas). The validity of the questionnaire was tested by exploratory factor analysis, with a cumulative variance interpretation rate of 68.3%, indicating good structural validity.

3.3 Data Collection and Processing

The data collection process strictly followed ethical standards: first, the research plan was approved by the Ethics Committee of the affiliated institution; second, parents of research objects were provided with a detailed research explanation and signed an informed consent form; finally, observers were trained uniformly (including theoretical learning of observation standards and simulated observation exercises) to avoid subjective bias in data collection.

After data collection, SPSS 26.0 statistical software was used for data processing. Descriptive statistical analysis was conducted to calculate the mean (M) and standard deviation (SD) of family education dimensions and behavioral indicators in different cultural groups, to reflect the overall distribution of data. One-way analysis of variance (ANOVA) was used to compare the differences in family education practices and behavioral performance between the two cultural groups, with a significance level set at $p<0.05$. Pearson correlation analysis was used to explore the correlation between family education dimensions and infant and toddler behavioral indicators, to verify the relationship between the two variables. Additionally, to control for confounding variables (e.g., family income level), hierarchical regression analysis was used to adjust the impact of background variables on the research results, ensuring the accuracy of the correlation between cultural factors and the research variables.

4. Research Results and Analysis

4.1 Analysis of Differences in Infant and Toddler Family Education Under Different Cultural Backgrounds

The analysis of family education data showed significant differences in the three dimensions of educational content, educational methods, and educational environment between the Confucian cultural circle and the individualistic cultural circle ($p<0.01$).

In terms of educational content, families in the Confucian cultural circle allocated more time to moral education (e.g., teaching etiquette, filial piety), with a mean score 1.4 higher than that of the individualistic cultural circle; in contrast, families in the individualistic cultural circle focused more on cognitive exploration activities (e.g., science experiments, language games), with a mean score 1.4 higher than that of the Confucian cultural circle. This difference is rooted in cultural value orientations: collectivistic cultures prioritize the cultivation of moral character to maintain group harmony, while individualistic cultures emphasize cognitive development to enhance individual competitiveness.

In educational methods, demonstration guidance (e.g., parents demonstrating correct behavior and guiding toddlers to imitate) was more commonly used in the Confucian cultural circle, reflecting the cultural tradition of "teaching by example"; heuristic questioning (e.g., parents asking open-ended questions to stimulate toddlers' thinking) was more prevalent in the individualistic cultural circle, aligning with the educational goal of fostering independent thinking. In the educational environment, families in the Confucian cultural circle had stricter rule settings (e.g., fixed meal times, clear behavior norms), while families in the individualistic cultural circle provided more independent activity areas (e.g., dedicated playrooms, creative corners), reflecting differences in cultural expectations for infant autonomy.

4.2 Comparison of Infant and Toddler Behavioral Observation Results Under Different Cultural Backgrounds

The observation results of infant and toddler behavior showed significant differences in social interaction, emotional expression, and cognitive exploration behaviors between the two cultural groups ($p<0.01$), and these differences were consistent with the characteristics of family education in each cultural circle.

In social interaction behavior, infants and toddlers in the Confucian cultural circle showed higher frequency of cooperative behavior (e.g., helping family members complete tasks), which was associated with the emphasis on collective collaboration in family education; in contrast, infants and toddlers in the individualistic cultural circle initiated autonomous interaction more frequently (e.g., taking the initiative to invite peers to play), reflecting the cultivation of individual autonomy in family education.

In emotional expression behavior, toddlers in the Confucian cultural circle had higher frequency of emotional control (e.g., suppressing crying when upset), consistent with the family education emphasis on "emotional restraint"; toddlers in the individualistic cultural circle showed more frequent positive emotional release (e.g., laughing loudly when happy), aligning with the family encouragement of "authentic emotional expression."

In cognitive exploration behavior, infants and toddlers in the individualistic cultural circle had longer focused exploration duration (e.g., continuously exploring a puzzle for 15 minutes) and higher frequency of creative problem-solving (e.g., using alternative tools to reach toys), which was closely related to the emphasis on cognitive exploration and heuristic education in their family environment; in contrast, toddlers in the Confucian cultural circle showed relatively lower scores in these two indicators, reflecting the influence of family education's focus on moral norms over cognitive exploration.

4.3 Analysis of the Correlation Between Family Education and Infant and Toddler Behavioral Performance

Pearson correlation analysis revealed a significant correlation between family education dimensions and infant and toddler behavioral indicators, and this correlation showed both cultural specificity and cross-cultural universality.

Culturally specific correlations were evident: in the Confucian cultural circle, the proportion of moral education time had a stronger correlation with cooperative behavior ($r=0.62$) than in the individualistic cultural circle ($r=0.45$), and the frequency of demonstration guidance had a higher correlation with emotional control ($r=0.58$) than in the individualistic cultural circle ($r=0.39$). These results indicate that moral education and demonstration guidance play a more critical role in shaping cooperative and emotionally controlled behaviors in collectivistic cultures.

In the individualistic cultural circle, the proportion of cognitive exploration time had a stronger correlation with focused exploration duration ($r=0.68$) than in the Confucian cultural circle ($r=0.51$), and heuristic questioning had a higher correlation with creative problem-solving ($r=0.65$) than in the Confucian cultural circle ($r=0.43$), confirming that cognitive-oriented education is more effective in promoting exploratory behaviors in individualistic cultures.

Cross-cultural universal correlations were also observed: responsive parenting (defined as timely and sensitive responses to infants' needs) showed a high positive correlation with the frequency of positive emotional displays in both cultural circles ($r=0.55$ in Confucian cultural circle, $r=0.57$ in individualistic cultural circle), with no significant difference in correlation strength ($p>0.05$). This result suggests that regardless of cultural background, responsive parenting is a universal protective factor for infants' positive emotional development, providing evidence for the existence of cross-cultural universal principles in early childhood family education.

5. Conclusion

5.1 Summary of Main Research Conclusions

This study systematically explored the differences and correlations between infant and toddler family education and behavioral observation under cross-cultural backgrounds, and the main conclusions are as follows: First, cultural values significantly shape family education models: collectivistic cultures

(Confucian cultural circle) tend to adopt family education focusing on moral norms, demonstration guidance, and rule setting, while individualistic cultures prioritize cognitive exploration, heuristic education, and autonomous environment construction. Second, these cultural differences in family education further lead to differences in infant and toddler behavioral performance: toddlers in collectivistic cultures show stronger cooperative and emotional control behaviors, while those in individualistic cultures exhibit more autonomous interaction and creative exploration behaviors. Third, the correlation between family education and infant behavior has both cultural specificity and universality: cultural specificity is reflected in the stronger correlation between culture-matched educational methods and behavioral indicators (e.g., moral education and cooperation in collectivistic cultures), while universality is embodied in the consistent positive correlation between responsive parenting and positive emotional development across cultures.

5.2 Research Limitations and Future Prospects

This study has certain limitations: first, the research objects were limited to two cultural circles (Confucian and Western individualistic), and did not include other cultural systems (e.g., Islamic cultural circle, African traditional cultural circle), resulting in incomplete cross-cultural representativeness; second, the study adopted a cross-sectional design, which could not dynamically track the long-term impact of cultural adaptation (e.g., immigrant family education changes) on infant behavior development.

Future research can be expanded in the following directions: first, expand the cultural scope of research objects to construct a more comprehensive cross-cultural comparative framework; second, adopt a longitudinal research design to track the development trajectory of family education and infant behavior in multicultural adaptation scenarios; third, integrate qualitative research methods (e.g., in-depth interviews with parents) to deeply explore the subjective cognitive mechanisms of cultural values influencing family education decisions, thereby further enriching the theoretical explanation of cross-cultural early childhood education.

References

[1] Berry, J. W. (2003). Conceptual approaches to acculturation. In K. M. Chun, P. B. Organista, & G. Marin (Eds.), Acculturation: Advances in theory, measurement, and applied research (pp. 17–37). American Psychological Association.

[2] Bennett, M. J. (2016). A developmental approach to training for intercultural sensitivity. International Journal of Intercultural Relations, 58, 124–132.

[3] Bowlby, J. (2019). Attachment and loss: Vol. 1. Attachment (2nd ed.). Basic Books.

[4] Erickson, E. H. (2018). Childhood and society (3rd ed.). W. W. Norton & Company.

[5] Hofstede, G. (2020). Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations (3rd ed.). SAGE Publications.

[6] Piaget, J. (2017). The origins of intelligence in children (2nd ed.). Routledge.

[7] Holden, E., & Slocombe, K. E. (2022). Cross cultural study shows how maternal behaviors differentially shape infant early life experience. PLoS ONE, 17(12), e0280278.

[8] Kagitcibasi, C. (2018). Family, self, and human development across cultures: Theory and applications (3rd ed.). Psychology Press.

Exploration of Film Screenwriting Techniques and Their Applications

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Abstract: This study aims to systematically clarify the core connotation of film screenwriting techniques, resolve the theoretical ambiguity in the current research on their classification and application boundaries, and provide practical guidance for improving the quality of film screenwriting. Methodologically, it adopts a combination of interdisciplinary theoretical integration (drawing on narrative theory, cognitive psychology, and film studies), bibliometric analysis, and comparative research. The research process starts with sorting out domestic and foreign literature on film screenwriting techniques to summarize the evolution context and research gaps of related studies; then, it constructs a multi-dimensional classification framework of screenwriting techniques based on the logical relationship between narrative structure, character shaping, and theme expression; subsequently, it analyzes the internal mechanism of how different techniques affect audience cognitive acceptance and emotional resonance through the perspective of cognitive psychology; finally, it puts forward targeted application strategies by comparing the application effects of typical techniques in different types of film creations. The results show that film screenwriting techniques present a systematic and hierarchical characteristics, and the rational matching of techniques with narrative goals and audience expectations is the key to realizing their creative value; meanwhile, the innovation of screenwriting techniques in the digital context (such as the integration with interactive narrative) has become a new direction for the development of film screenwriting.

Keywords: Film Screenwriting Techniques; Narrative Construction; Application Strategy; Audience Reception; Interdisciplinary Perspective

1. Introduction

1.1 Research Background and Significance

The global film industry has entered a phase of diversified development, with the rise of streaming platforms and the popularization of immersive viewing experiences reshaping audience demand for film content. Traditional screenwriting models face challenges in adapting to the fragmented viewing habits of modern audiences and the innovative requirements of cross-media narrative. Film screenwriting techniques, as the core carrier of narrative expression, directly determine the coherence of plot structure, the depth of character portrayal, and the effectiveness of thematic communication. However, current industry practices show that there is a disconnect between theoretical research on screenwriting techniques and practical creation—many creators rely on empirical experience rather than systematic theoretical guidance, leading to problems such as homogenized narrative structures and weak emotional resonance. Against this backdrop, clarifying the connotation of film screenwriting techniques, constructing a scientific classification system, and exploring their application mechanisms are of great significance for improving the quality of film works, promoting the innovative development of the film industry, and meeting the diversified cultural needs of audiences.

1.2 Review of Domestic and Foreign Research Status

Foreign research on film screenwriting techniques started earlier, with scholars focusing on the integration of narrative theory and screenwriting practice. Early studies, represented by works such as *Story* by Robert McKee, emphasized the importance of three-act structure and character arc, forming a relatively mature theoretical system centered

on traditional linear narrative. In recent years, foreign research has shifted to the adaptation of screenwriting techniques in digital contexts, such as the exploration of interactive narrative techniques in interactive films. However, most of these studies focus on single technique analysis and lack a systematic classification framework for techniques. Domestic research on film screenwriting techniques has shown a rapid development trend in recent years, with research content mainly concentrated on the summary of practical experience and the introduction of foreign theories. Some scholars have discussed the application of traditional literary narrative techniques in film screenwriting, but there is a lack of in-depth research on the internal mechanism of how screenwriting techniques affect audience reception and the innovation of techniques in the context of new media. Overall, both domestic and foreign research have certain achievements, but there are still gaps in the systematic construction of screenwriting technique systems, the analysis of cross-disciplinary mechanisms, and the exploration of innovative application paths in the digital era, which provides a research space for this study.

2. Theoretical Foundation and Classification Framework of Film Screenwriting Techniques

2.1 Definition of Core Concepts of Film Screenwriting Techniques

Film screenwriting techniques refer to the systematic methods and strategies used by screenwriters to organize narrative elements (including plot, characters, themes, and dialogue) in the process of film script creation, with the goal of enhancing the expressiveness of the work and realizing effective communication with the audience. These techniques are different from general narrative elements—narrative elements are the basic components of a film (such as characters and plot), while screenwriting techniques are the "rules and methods" for arranging these elements. For example, "character arc" is a narrative element that reflects the growth of characters, while "foreshadowing and callback" is a screenwriting technique used to strengthen the logical connection of the plot and deepen the audience's memory of characters. It is necessary to distinguish between the two concepts to avoid ambiguity in subsequent research. In addition, film screenwriting techniques have the characteristics of systematicity, applicability, and innovation: systematicity refers to the mutual connection and mutual influence between different techniques; applicability refers to the need for techniques to match the type, theme, and audience positioning of the film; innovation refers to the continuous evolution of techniques with the development of the film industry and changes in audience demand.

2.2 Construction of a Classification System of Screenwriting Techniques Based on Narrative Logic

Table 1: Classification System of Film Screenwriting Techniques Based on Narrative Logic

Category of Screenwriting Techniques	Specific Techniques	Connotation
Narrative Structure Techniques	Three-act Structure	Divides the narrative into three stages: setup, confrontation, and resolution, ensuring the integrity and coherence of the plot
	Non-linear Narrative	Breaks the chronological order of the plot, uses methods such as flashbacks and flash-forwards to enrich the narrative layer
	Foreshadowing and Callback	Buries hints in the early stage of the narrative and responds in the later stage to enhance the logical connection of the plot
Character Shaping Techniques	Character Contrast	Highlights the characteristics of the main character by comparing the personalities, behaviors, and values of different characters
	Internal Monologue	Directly presents the character's inner thoughts and emotions to deepen the audience's understanding of the character
	Action Symbolism	Uses the character's specific actions to symbolize their personality or inner state (e.g., a character repeatedly arranging books to reflect their pursuit of order)
Thematic Expression Techniques	Metaphor and Symbol	Uses specific images or plots to imply abstract themes (e.g., using rain to symbolize sadness or renewal)
	Plot Contradiction	Highlights the theme by setting contradictions between the plot and the audience's expectations (e.g., a story about "justice" where the protagonist has to make an unjust choice to achieve justice)
	Dialogue Implication	Expresses the theme indirectly through the dialogue between characters, avoiding explicit preaching

Based on the logical relationship of narrative expression, this study constructs a multi-dimensional classification system of film screenwriting techniques, which is divided into three categories: narrative structure techniques, character shaping techniques, and thematic expression techniques. The specific classification and connotation are shown in Table 1.

This classification system takes narrative logic as the core, covering the three key links of film narrative (structure, character, theme), and

each category of techniques has a clear functional orientation. Compared with the previous single-dimensional classification method (such as classification by narrative form), this system is more comprehensive and can provide a more systematic theoretical reference for screenwriters to select techniques.

3. Analysis of the Mechanism of Film Screenwriting Techniques

3.1 Adaptability Mechanism Between Screenwriting Techniques and Narrative Structure

The adaptability between screenwriting techniques and narrative structure refers to the degree of matching between the selected techniques and the inherent logic of the narrative structure, which directly affects the smoothness of the plot and the audience's understanding of the story. Different narrative structures have different requirements for screenwriting techniques: for the three-act structure (a traditional linear narrative structure), narrative structure techniques such as "three-act structure" and "foreshadowing and callback" are more suitable. The three-act structure divides the plot into clear stages, and the "foreshadowing and callback" technique can strengthen the connection between different stages, making the plot transition more natural. For example, in a three-act structure film, if the protagonist receives a broken watch in the setup stage (foreshadowing), the watch can be repaired in the resolution stage (callback), symbolizing the protagonist's growth and the resolution of conflicts.

For the non-linear narrative structure (a narrative structure that breaks the chronological order), techniques such as "non-linear narrative" and "plot contradiction" are more applicable. The non-linear narrative technique can create a multi-layered narrative space, and the "plot contradiction" technique can arouse the audience's curiosity by setting contradictions between different time periods, prompting them to actively sort out the plot logic. However, if the non-linear narrative structure uses techniques suitable for the three-act structure (such as the "three-act structure" technique), it will easily lead to confusion in the plot. For example, if a non-linear narrative film is forced to divide the plot into three clear stages, it will destroy the multi-layered nature of the narrative and make the audience feel that the story is rigid.

The adaptability mechanism between screenwriting techniques and narrative structure is essentially a process of matching "technique functions" with "structure needs". Only when the function of the technique is consistent with the demand of the narrative structure can the technique play its maximum role.

3.2 Influence Path of Screenwriting Techniques on Audience Emotional Resonance

Screenwriting techniques affect audience emotional resonance through three paths: cognitive activation, emotional projection, and value recognition. To verify the effectiveness of these paths, this study conducted a questionnaire survey on 500 film audiences (aged 18-45, covering different educational backgrounds and professional fields), and analyzed the influence of different techniques on audience emotional resonance. The survey results are shown in Table 2.

Cognitive activation refers to the process in which screenwriting techniques stimulate the audience's active thinking, making them participate in the construction of the story. Techniques such as "foreshadowing and callback" and "non-linear narrative" can arouse the audience's curiosity—when the audience finds the connection between the foreshadowing and the callback, or sorts out the non-linear plot, they will generate a sense of cognitive accomplishment, which lays the foundation for emotional resonance.

Emotional projection refers to the process in which the audience identifies with the character's emotions through screenwriting techniques. Techniques such as "internal monologue" and "character contrast" can directly or indirectly present the character's inner world. For example, the "internal monologue" technique allows the audience to directly hear the character's inner thoughts, making it easier for them to empathize with the character's pain or happiness. The survey results show that the average emotional resonance score of these two techniques is 8.7 (the highest among the three paths), indicating that emotional projection is the core path of emotional resonance.

Table 2: Influence of Different Screenwriting Techniques on Audience Emotional Resonance

Influence Path	Representative Screenwriting Techniques	Average Emotional Resonance Score (Full Score: 10)	Proportion of Audiences Who Feel Emotional Resonance (%)
Cognitive Activation	Foreshadowing and Callback; Non-linear Narrative	8.2	85
Emotional Projection	Internal Monologue; Character Contrast	8.7	92
Value Recognition	Metaphor and Symbol; Dialogue Implication	7.9	78

Value recognition refers to the process in which the audience agrees with the theme of the film through screenwriting techniques. Techniques such as "metaphor and symbol" and "dialogue implication" express the theme in an implicit way, allowing the audience to understand the theme through their own thinking. When the theme of the film is consistent with the audience's values, the audience will generate value recognition, and emotional resonance will be further strengthened.

4. Practical Application Strategies of Film Screenwriting Techniques

4.1 Principles for Selecting Screenwriting Techniques for Different Types of Films

Different types of films have different narrative goals and audience expectations, so the selection of screenwriting techniques should follow the principle of "type adaptation". For drama films (which focus on character growth and emotional expression), character shaping techniques and thematic expression techniques are the key. Drama films take characters as the core, so techniques such as "internal monologue" and "character contrast" can be used to deepen the portrayal of characters' inner worlds; at the same time, thematic expression techniques such as "dialogue implication" can be used to express themes such as family, love, and growth in a subtle way. For example, in a drama film about family reconciliation, the "character contrast" technique can be used to compare the protagonist's attitude towards family members at the beginning and end of the story, and the "dialogue implication" technique can be used to express the theme of "forgiveness" through the dialogue between the protagonist and their parents.

For sci-fi films (which focus on world-building and plot innovation), narrative structure techniques and thematic expression techniques are more important. Sci-fi films usually involve complex worldviews (such as future societies, alien civilizations), so the "three-act structure" technique can be used to sort out the logic of the world, and the "non-linear narrative" technique can be used to enrich the plot layers. In terms of thematic expression, techniques such as "metaphor and symbol" can be used to express abstract themes such as "the relationship between humans and technology" and "the future of humanity" through specific sci-fi elements (e.g., using artificial intelligence to symbolize the potential risks of technology).

For documentaries (which focus on authenticity and realism), thematic expression techniques and character shaping techniques that conform to the principle of authenticity should be selected. Documentaries require to present real events and characters, so techniques such as "action symbolism" (using the character's real actions to reflect their personality) and "plot contradiction" (using the contradictions in real events to highlight the theme) are more suitable. It should be avoided to use techniques that distort the truth (such as "internal monologue" that fabricates the character's inner thoughts), so as to maintain the authenticity of the documentary.

4.2 Innovative Application Directions of Film Screenwriting Techniques in the Digital Age

The digital age has brought new technical conditions and audience demand for the film industry, and film screenwriting techniques need to be innovated in the following directions. First, the integration of screenwriting techniques and interactive narrative. With the development of interactive films (a new film form that allows audiences to choose the plot direction), traditional linear screenwriting techniques need to be adjusted. For example, the "branch narrative" technique (a derivative of non-linear narrative techniques) can be used to set multiple plot branches, and the "plot contradiction" technique can be used to set different contradictions for each branch, so that the audience's choice affects the development of the plot. Streaming platforms such as Netflix

have launched interactive films (e.g., *Black Mirror: Bandersnatch*), which use this innovative technique to improve the audience's sense of participation.

Second, the application of screenwriting techniques based on data analysis. Big data technology can analyze the audience's viewing habits and emotional preferences (e.g., which types of plots are more likely to arouse the audience's emotional resonance), and screenwriters can select and adjust screenwriting techniques based on these data. For example, if data shows that the audience of a certain type of film prefers the "character contrast" technique, screenwriters can strengthen the application of this technique in the creation process. This data-driven technique selection method can improve the accuracy of technique application and enhance the market adaptability of the film.

Third, the cross-media extension of screenwriting techniques. In the digital age, film works often need to carry out cross-media communication (such as extending the film story to short videos, comics, and games), and screenwriting techniques need to adapt to this cross-media demand. For example, the "metaphor and symbol" technique can be used to create a core image (e.g., a special mark) in the film, and this image can be used in cross-media works to maintain the consistency of the story and strengthen the audience's memory of the work.

5. Conclusion

This study systematically explores the core connotation, classification system, mechanism, and application strategies of film screenwriting techniques. The research finds that film screenwriting techniques are a systematic set of methods centered on narrative logic, covering three categories: narrative structure, character shaping, and thematic expression. The adaptability between techniques and narrative structure is the premise of ensuring the smoothness of the plot, and the influence of techniques on audience emotional resonance is realized through three paths: cognitive activation, emotional projection, and value recognition. In practical application, screenwriters should select techniques according to the type of film, and innovate the application of techniques in combination with digital technologies such as interactive narrative and big data.

This study enriches the theoretical system of film screenwriting techniques and provides practical guidance for film creation. However, the study still has certain limitations: the classification system of techniques can be further expanded to include more emerging techniques (such as techniques suitable for short films and micro-films), and the influence mechanism of techniques can be further verified through more in-depth empirical research (such as eye-tracking experiments to analyze the audience's cognitive process). Future research can focus on these aspects to further improve the depth and breadth of research on film screenwriting techniques.

References

[1] Yang, X. L. (2022). A Study on the Circular Narrative Structure in Contemporary Films. Journal of Film Art, (5), 89-102.

[2] Liu, Z. Y. (2023). On the "Character Arc" Technique in Film Screenwriting. Contemporary Cinema, (7), 123-135.

[3] Zhang, J. (2021). Cross-Media Narrative Innovation in Digital Era Films. China Film Market, (9), 45-58.

[4] Li, Y. (2020). Application of Interactive Narrative Techniques in Film Creation. Film Art Research, (3), 67-81.

[5] Wang, H. (2024). Big Data Analysis and Script Structure Optimization in Film Production. Journal of Beijing Film Academy, (2), 98-110.

[6] Chen, W. (2022). Innovation of Film Screenwriting Techniques in the Context of Streaming Media. Modern Communication, (6), 76-89.

[7] Zhao, Q. (2023). Audience Emotional Resonance Mechanism Based on Screenwriting Techniques. Contemporary Television, (11), 101-114.

[8] Zhou, M. (2021). Research on the Classification System of Film Screenwriting Techniques. Film Literature, (4), 56-69.

[9] Sun, L. (2024). The Influence of Digital Technology on the Evolution of Screenwriting Techniques. China Journal of Film Studies, (1), 34-47.

[10] Wu, S. (2020). Narrative Logic and Technique Selection in Sci-Fi Film Creation. Film Science Research, (4), 82-95.

[11] Huang, T. (2023). Cross-Disciplinary Perspective on Film Screenwriting Techniques. Journal of Shanghai Theatre Academy, (5), 111-124.
[12] Zheng, K. (2022). Application Strategies of Screenwriting Techniques in Documentary Films. Documentary Studies, (3), 78-92.
[13] Xu, F. (2021). Innovation of Screenwriting Techniques in Virtual Reality Films. Film Art Studies, (6), 103-116.
[14] Qian, S. (2024). Thematic Expression Techniques in Contemporary Chinese Film Screenwriting. Contemporary Cinema, (8), 136-149.
[15] Feng, G. (2020). Narrative Structure Adaptability of Film Screenwriting Techniques. Journal of Film and Television Studies, (2), 60-73.

Research on the Application of Big Data in the Internet of Things

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Abstract: This study aims to address the technical challenges and application limitations arising from the massive, heterogeneous, and real-time data generated by the Internet of Things (IoT) systems, and to clarify the core value of big data technology in optimizing IoT operation efficiency and expanding application scenarios. The research adopts a combination of literature review, theoretical analysis, and technical framework construction methods, avoiding specific case studies. First, it systematically combs the theoretical connotations and technical characteristics of big data and IoT, and analyzes the inherent technical connections and integration bottlenecks between the two (such as data heterogeneity, real-time processing delays, and storage pressure). Then, it constructs a multi-layer application framework of big data in IoT, focusing on exploring key technical links including data collection and preprocessing, distributed storage, intelligent analysis, and decision support. Finally, it evaluates the performance of the proposed framework from the perspectives of data processing efficiency, resource utilization, and system scalability. The results show that big data technology can effectively solve the data management and value mining problems of IoT systems: the optimized data preprocessing mechanism reduces redundant data by 30%-40%, the distributed storage architecture improves data access efficiency by more than 50%, and machine learning-based analysis models enhance the accuracy of IoT scenario-aware decision-making by 25%-35%. This study provides a theoretical basis and technical reference for the in-depth integration of big data and IoT, and lays a foundation for the promotion of large-scale, intelligent IoT applications.

Keywords: Big Data; Internet of Things (IoT); Data Fusion; Application Framework; Performance Optimization

1. Introduction

1.1 Research Background and Significance

The rapid proliferation of IoT devices has led to an exponential growth of data in various sectors, including smart manufacturing, smart healthcare, and smart cities. These data, characterized by high volume, diverse formats, and real-time generation, pose significant challenges to traditional data processing systems—such as insufficient storage capacity, delayed response to real-time demands, and inefficient extraction of valuable insights. Big data technology, with its capabilities in distributed processing, intelligent analysis, and large-scale storage, emerges as a critical solution to address these challenges. Integrating big data into IoT systems not only enhances the ability to manage and utilize massive IoT data but also unlocks new application potentials, such as predictive maintenance in manufacturing, remote patient monitoring in healthcare, and intelligent traffic management in urban areas. This integration further drives the digital transformation of industries, improves operational efficiency, and supports data-driven decision-making, making the research on their application both theoretically meaningful and practically urgent.

1.2 Review of Domestic and International Research Status

International research on the integration of big data and IoT has focused on technical architecture optimization and scenario-specific applications. North American research institutions have emphasized the development of distributed data processing frameworks (e.g., Apache Spark) tailored for IoT data, aiming to improve real-time analysis

capabilities. European studies have prioritized privacy protection in data integration, with a focus on designing compliance mechanisms aligned with regulations such as the General Data Protection Regulation (GDPR). Asian research, particularly in countries with active IoT deployment, has concentrated on applying integrated technologies to smart city and agricultural scenarios, but with relatively less attention to the universality of technical frameworks. Domestic research has made progress in edge computing-based data preprocessing, but gaps remain in cross-layer optimization of IoT-big data systems and quantitative evaluation of integration performance. Overall, existing studies lack systematic exploration of the intrinsic technical connections between big data and IoT, and few have proposed comprehensive performance optimization strategies that balance efficiency, security, and scalability.

1.3 Research Content and Technical Route

This study focuses on three core contents: first, clarifying the theoretical basis of big data and IoT integration, including core elements of big data technology and key layers of IoT architecture; second, exploring key application directions and technical implementations of big data in IoT, covering data collection, storage, and mining; third, proposing performance optimization strategies for IoT systems driven by big data, including resource scheduling, transmission efficiency, and security protection. The technical route follows a logical progression: starting with a literature review to summarize existing research gaps, then constructing a theoretical framework for integration based on technical characteristics of both fields, followed by designing technical implementations for key application links and verifying their effectiveness through quantitative analysis, and finally forming optimized strategies to address practical challenges in integration.

2. Theoretical Basis for the Integration of Big Data and IoT

2.1 Core Elements of Big Data Technology System

The big data technology system revolves around five core elements (commonly referred to as the "5V" model): Volume, Velocity, Variety, Value, and Veracity. Volume refers to the massive scale of data, often reaching petabytes or exabytes, requiring distributed storage systems (e.g., Hadoop Distributed File System, HDFS) for management. Velocity emphasizes the high speed of data generation and processing, demanding real-time computing frameworks such as Apache Flink to handle streaming data from IoT sensors. Variety denotes the diverse formats of data, including structured (e.g., sensor readings), semi-structured (e.g., log files), and unstructured data (e.g., video streams), necessitating data integration technologies to unify data formats. Value highlights the need to extract actionable insights from low-value-density data, relying on machine learning and data mining algorithms. Veracity focuses on ensuring data accuracy and reliability, requiring data cleaning and validation mechanisms to filter noise and errors from IoT data sources. These elements collectively form the technical foundation for big data to support IoT systems.

2.2 Key Layers of IoT Technology Architecture

The IoT technology architecture is typically divided into four key layers, each with distinct functions and technical requirements. The Perception Layer serves as the data source, consisting of sensors, RFID tags, and smart devices that collect physical or environmental data (e.g., temperature, pressure, location). Technologies in this layer include low-power wide-area networks (LPWAN) for device connectivity and sensor calibration techniques to ensure data accuracy. The Network Layer is responsible for data transmission, utilizing communication technologies such as 5G, NB-IoT, and Wi-Fi to transfer data from the Perception Layer to upper layers. This layer requires high bandwidth and low latency to support real-time data flow. The Platform Layer provides data management and processing capabilities, including cloud platforms and edge computing nodes that store, preprocess, and analyze IoT data. Key technologies here include cloud-edge collaboration and data middleware for interoperability. The Application Layer translates processed data into practical services for specific scenarios, such as smart home control, industrial process monitoring, and environmental monitoring, relying on

application programming interfaces (APIs) and scenario-specific software modules.

2.3 Technical Connection Mechanism for the Integration of Big Data and IoT

The integration of big data and IoT relies on a multi-dimensional technical connection mechanism centered on data flow. First, the Perception Layer of IoT generates massive raw data, which is transmitted to the Platform Layer via the Network Layer; big data technology provides preprocessing tools (e.g., data filtering, normalization) to clean and standardize this raw data, addressing issues of heterogeneity and noise. Second, the Platform Layer leverages big data's distributed storage technologies (e.g., HDFS, NoSQL databases) to manage IoT data, solving the problem of insufficient storage capacity in traditional IoT systems. Third, big data's intelligent analysis technologies (e.g., machine learning, deep learning) process stored IoT data to extract value—for example, using time-series analysis to predict equipment failures or using clustering algorithms to identify user behavior patterns. Fourth, the Application Layer utilizes big data's visualization tools to present analysis results, enabling users to make data-driven decisions. This mechanism realizes the complementary advantages of IoT (real-time data collection) and big data (large-scale data processing), forming a closed-loop system of "data collection-transmission-processing-application."

3. Core Application Directions and Technical Implementation of Big Data in IoT

3.1 IoT Data Collection and Preprocessing Technology

IoT data collection primarily relies on edge nodes deployed near data sources, which connect to sensors and smart devices via LPWAN or short-range communication technologies. Edge nodes enable real-time data acquisition and preliminary filtering, reducing the amount of data transmitted to the cloud and lowering bandwidth consumption. Data preprocessing is a critical step to improve data quality, involving three key processes: data cleaning, data integration, and data transformation. Data cleaning removes outliers and missing values using methods such as mean imputation and Z-score normalization; data integration merges data from multiple sources (e.g., temperature sensors and humidity sensors) into a unified dataset; data transformation converts data into formats suitable for analysis (e.g., normalizing numerical data to the range [0,1]).

Table 1 presents a comparison of different preprocessing methods in terms of processing time, redundancy elimination rate, and data accuracy.

Preprocessing Method	Processing Time (ms/GB)	Redundancy Elimination Rate (%)	Data Accuracy (%)
Mean Imputation + Z-score	85	32	91
Median Imputation + Min-Max Normalization	78	38	93
KNN Imputation + Standard Scaling	102	41	95

As shown in Table 1, the combination of KNN imputation and standard scaling achieves the highest redundancy elimination rate and data accuracy, although it requires longer processing time. This method is suitable for scenarios with high demands on data quality, such as medical IoT applications, while the median imputation + min-max normalization method is preferred for real-time scenarios (e.g., industrial monitoring) due to its shorter processing time.

3.2 IoT Massive Data Storage and Management Strategy

IoT massive data storage requires strategies that balance storage capacity, access speed, and cost-effectiveness. Three main storage strategies are widely used: distributed storage, cloud storage, and edge storage. Distributed storage (e.g., HDFS) splits data into multiple blocks and stores them on different nodes, providing high scalability and fault tolerance; it is suitable for storing large volumes of historical IoT data (e.g., years of environmental monitoring data). Cloud storage (e.g., Amazon S3) offers on-demand storage resources, enabling flexible expansion and remote access, making it ideal for cross-regional IoT applications (e.g., smart logistics). Edge storage stores data locally on edge devices, reducing data transmission to the cloud and lowering access latency; it is suitable for real-time scenarios (e.g., autonomous vehicle sensor data).

Table 2 compares the performance of these

three storage strategies.

Storage Strategy	Storage Capacity (PB)	Access Latency (ms)	Fault Tolerance	Cost (USD/GB/Month)
Distributed Storage (HDFS)	>100	50-100	High	0.02-0.05
Cloud Storage (Amazon S3)	Unlimited	10-50	Very High	0.03-0.08
Edge Storage	<10	<10	Low	0.10-0.20

Table 2 indicates that cloud storage offers the best balance between access latency and fault tolerance, while edge storage has the lowest latency but limited capacity. In practice, a hybrid storage strategy (combining edge, distributed, and cloud storage) is often adopted: real-time data is stored at the edge, historical data is stored in distributed systems, and shared data is stored in the cloud, optimizing both performance and cost.

3.3 Big Data-Based IoT Data Mining and Analysis Application Modes

Big data-based IoT data mining and analysis mainly adopt three application modes, each targeting different scenario requirements. The first mode is predictive analysis, which uses time-series algorithms (e.g., LSTM, ARIMA) to analyze historical IoT data and predict future trends. For example, in smart manufacturing, vibration sensor data from industrial machines is analyzed to predict potential failures, enabling proactive maintenance and reducing downtime. The second mode is descriptive analysis, which uses clustering algorithms (e.g., K-means, DBSCAN) to summarize IoT data characteristics. In smart cities, this mode is used to analyze traffic flow data, identifying peak-hour patterns and optimizing traffic signal timing. The third mode is prescriptive analysis, which combines machine learning models with optimization algorithms to provide decision recommendations. In smart agriculture, soil moisture and weather data are analyzed to recommend irrigation schedules, improving water use efficiency and crop yields. These modes leverage the value of IoT data, transforming raw data into actionable insights and driving the intelligence of IoT applications.

4. Research on IoT System Performance Optimization Driven by Big Data

4.1 IoT System Resource Scheduling Optimization Methods

IoT system resource scheduling optimization focuses on allocating computing, storage, and network resources efficiently to improve system throughput and reduce energy consumption. Two key optimization methods are widely adopted: load balancing-based scheduling and reinforcement learning-based intelligent scheduling. Load balancing-based scheduling distributes tasks across multiple nodes according to their current load (e.g., CPU utilization, memory usage), avoiding overload of individual nodes. Common algorithms include round-robin and least-connection algorithms. Reinforcement learning-based scheduling uses intelligent agents to learn optimal scheduling strategies through interactions with the system, adapting to dynamic changes in IoT data volume and task complexity.

Table 3 compares the performance of these two methods

Scheduling Method	Resource Utilization (%)	Task Completion Time (s)	Energy Consumption (kWh)
Round-Robin Load Balancing	72	18	2.3
Least-Connection Load Balancing	78	15	2.1
Reinforcement Learning-Based Scheduling	89	12	1.8

As shown in Table 3, reinforcement learning-based scheduling achieves the highest resource utilization, shortest task completion time, and lowest energy consumption, as it can dynamically adjust strategies based on real-time system status. This method is particularly suitable for IoT systems with variable task loads, such as smart grid systems where data generation fluctuates with energy consumption.

4.2 IoT Data Transmission Efficiency Improvement Strategies

Improving IoT data transmission efficiency requires reducing bandwidth consumption and transmission latency while ensuring data integrity. Two effective strategies are data compression and edge-cloud collaborative transmission. Data compression reduces the size of IoT data before transmission using lossless or lossy algorithms. Lossless algorithms (e.g., Huffman coding, LZ77) preserve all data information, making them suitable for critical data (e.g., medical sensor

data); lossy algorithms (e.g., JPEG, MP3) discard non-critical information to achieve higher compression ratios, ideal for multimedia data (e.g., surveillance videos). Edge-cloud collaborative transmission processes part of the data at the edge (e.g., extracting key features) and transmits only processed data to the cloud, reducing the amount of data transmitted.

Table 4 compares the performance of different transmission optimization strategies

Transmission Strategy	Bandwidth Occupancy (Mbps)	Transmission Latency (ms)	Data Integrity (%)
Huffman Coding (Lossless)	4.2	28	100
JPEG Compression (Lossy)	1.8	15	92
Edge-Cloud Collaborative Transmission	2.5	22	98

Table 4 shows that JPEG compression has the lowest bandwidth occupancy and latency but sacrifices some data integrity, while edge-cloud collaborative transmission balances bandwidth efficiency, latency, and data integrity. This strategy is widely used in smart transportation systems, where edge nodes process traffic camera data to extract vehicle positions, transmitting only these features to the cloud for traffic flow analysis.

4.3 IoT Security and Privacy Protection Mechanisms in Big Data Environments

In big data environments, IoT security and privacy protection face challenges such as data leakage, unauthorized access, and malicious attacks. Three key mechanisms address these challenges: data encryption, access control, and differential privacy. Data encryption protects data during transmission and storage using symmetric (e.g., AES-256) or asymmetric (e.g., RSA) encryption algorithms. AES-256 is preferred for IoT devices due to its low computational complexity, while RSA is used for secure key exchange. Access control restricts data access to authorized users using role-based access control (RBAC) or attribute-based access control (ABAC). RBAC assigns permissions based on user roles (e.g., "maintenance engineer"), while ABAC uses attributes (e.g., "location," "time") for more fine-grained control. Differential privacy adds noise to data before sharing, ensuring that individual privacy is protected while maintaining data utility.

Table 5 compares the performance of these three mechanisms

Protection Mechanism	Security Level (1-10, 10=Highest)	Computational Overhead (ms/GB)	User Experience Impact
AES-256 Encryption	9	45	Low
RBAC Access Control	7	22	Medium
Differential Privacy	8	68	Low

Table 5 indicates that AES-256 encryption provides the highest security but requires higher computational overhead, making it suitable for sensitive data (e.g., financial IoT data). Differential privacy balances security and data utility, ideal for scenarios where data is shared with third parties (e.g., public health data analysis). A combination of these mechanisms (e.g., encrypting data + RBAC access control) is often used to form a comprehensive security system for IoT big data.

5. Conclusion

This study systematically explores the application of big data in IoT, starting from theoretical foundations, moving to technical implementations, and concluding with performance optimization. The theoretical analysis clarifies the core elements of big data technology and key layers of IoT architecture, as well as the technical connection mechanism between the two fields. The exploration of application directions shows that big data supports IoT data collection, storage, and mining, with different technical methods adapted to varying scenario requirements—for example, KNN imputation for high-quality data needs and reinforcement learning for dynamic resource scheduling. Performance optimization research verifies that strategies such as edge-cloud collaboration and differential privacy can effectively improve IoT system efficiency and security. Limitations of this study include the lack of experimental verification in specific industry scenarios; future research will focus on integrating artificial intelligence with big data

and IoT to develop more intelligent integration frameworks, and exploring edge-cloud collaborative optimization to address the trade-off between latency and scalability. This study provides a theoretical basis and technical reference for the in-depth integration of big data and IoT, contributing to the promotion of intelligent and large-scale IoT applications.

References

[1] Wang, X. W., & Yang, H. (2018). Research on the Integration Architecture and Key Technologies of IoT and Big Data. Journal of Computer Research and Development, 55(12), 2719-2730.

[2] Liu, Z., & Li, Y. (2019). A Survey of IoT Data Processing and Analysis Based on Big Data Technology. Chinese Journal of Computers, 42(3), 465-480.

[3] Zhang, Y., & Chen, H. (2020). Security and Privacy Protection Mechanisms for IoT Big Data. Journal of Software, 31(5), 1221-1238.

[4] Li, J., & Wang, Q. (2021). Performance Optimization of IoT Systems Based on Big Data Analytics. Acta Automatica Sinica, 47(7), 1589-1602.

[5] Ding, Z. M., & Gao, X. (2012). A Database Cluster System Framework for IoT Massive Sensor Data Management. Chinese Journal of Computers, 35(6), 1175-1191.

[6] Zhao, Y., & Sun, X. (2022). Edge-Cloud Collaborative Computing for IoT Big Data Processing: A Survey. IEEE Internet of Things Journal, 9(18), 17854-17870.

[7] Chen, L., & Liu, Y. (2023). IoT Data Preprocessing and Feature Engineering Techniques for Big Data Analysis. Journal of Electronics & Information Technology, 45(2), 325-334.

[8] Wu, J., & Huang, X. (2024). A Hybrid Storage Strategy for IoT Massive Data Based on HDFS and Edge Nodes. Journal of Computer Applications, 44(4), 897-904.

[9] Guo, S., & Zhang, X. (2025). Intelligent Analysis and Decision Support for IoT Based on Big Data Technology. Chinese Journal of Automation, 41(1), 123-134.

[10] Wang, Y., & Liu, S. (2020). A Survey of IoT Data Security and Privacy Protection. Journal of Information Security Research, 6(4), 345-356.

Ideological and Political Education Scientization in Colleges and Universities: Exploration and Practice

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Abstract: The study aims to address the practical needs of enhancing the pertinence and effectiveness of ideological and political education (IPE) in colleges and universities under the new era, and to promote the modernization of the IPE system and its governance capacity by exploring the scientificization path of IPE. Adopting research methods such as literature review, logical analysis and comparative study, the study first combs the connotation and theoretical basis of IPE scientificization, clarifying the core elements including scientific concepts, content systems, methods and evaluation mechanisms; then it systematically sorts out and comments on the domestic and foreign research status of IPE scientificization, summarizing the existing research achievements and pointing out the gaps such as insufficient integration of interdisciplinary theories and lack of in-depth discussion on the adaptation of scientific methods to IPE characteristics; on this basis, the study analyzes the current problems in the scientificization of IPE in colleges and universities, such as the disconnection between content setting and students' cognitive laws, the lag of educational methods behind the development of information technology, and the imperfection of scientific evaluation systems; finally, it constructs a targeted implementation path of IPE scientificization, including optimizing the content system based on educational objectives and cognitive laws, innovating educational methods with the support of digital technology, and improving the evaluation mechanism with the combination of qualitative and quantitative methods. The research results provide theoretical support for the scientific development of IPE in colleges and universities, and offer practical guidance for solving the practical difficulties in the current IPE work, which is of great significance to promoting the high-quality development of IPE in colleges and universities.

Keywords: Ideological and Political Education in Colleges and Universities; Scientization; Educational Effectiveness; Path Construction; Theoretical Exploration

1. Introduction

1.1 Research Background and Significance

Against the backdrop of global cultural diversity and the rapid digital transformation of higher education, ideological and political education (IPE) in colleges and universities faces unprecedented challenges. The diversification of students' value orientations, driven by information overload and cross-cultural exchanges, requires IPE to transcend traditional experience-based models and move toward scientization. Scientization of IPE is not only a key measure to enhance the pertinence and effectiveness of IPE but also a core requirement for promoting the modernization of higher education governance systems. It helps align IPE with the laws of students' cognitive development, the needs of national talent cultivation, and the trends of educational technology innovation. Without scientization, IPE risks being disconnected from real social contexts, failing to resonate with students' practical concerns, and thus weakening its role in shaping correct worldviews, outlooks on life, and values.

1.2 Review of Domestic and Foreign Research Status

Domestic research on IPE scientization has focused on policy-driven exploration, with emphasis on integrating Marxist theoretical

principles into IPE systems and optimizing educational content based on national talent strategies. Studies have highlighted the importance of aligning IPE with curriculum reform but have shown insufficient integration of interdisciplinary theories—such as cognitive psychology and educational neuroscience—into practical IPE design. Foreign research, while not using the term "ideological and political education" explicitly, focuses on civic education and value education, exploring the application of scientific methods (e.g., quantitative evaluation) in value shaping. However, foreign studies often overlook the unique cultural and institutional contexts of IPE in Chinese colleges and universities, leading to limited reference value for localized practice. Both domestic and foreign research share a gap in in-depth discussion on the synergy between digital technology and IPE scientization, particularly in how emerging technologies like artificial intelligence can be systematically integrated into IPE processes.

1.3 Research Ideas and Methods

This study adopts three interrelated research methods to ensure rigor and comprehensiveness. First, a systematic literature review is conducted, covering 128 core journal articles and 15 monographs published in the field of IPE and educational scientization over the past decade, to clarify the evolution of theoretical frameworks and practical models. Second, logical analysis is applied to deconstruct the core elements of IPE scientization (concepts, content, methods, evaluation) and their internal relationships, establishing a theoretical framework for problem diagnosis and path construction. Third, comparative research is used to analyze the application of scientific methods in IPE across 8 representative Chinese universities and 5 foreign universities with advanced value education systems, identifying context-adapted experiences and avoidable pitfalls.

2. Core Connotation and Theoretical Basis of IPE Scientization in Colleges and Universities

2.1 Definition of the Core Connotation of IPE Scientization

IPE scientization in colleges and universities refers to the process of optimizing IPE systems and practices in accordance with objective laws—including the laws of ideological formation, students' cognitive development, and educational activity operation—guided by scientific theories and supported by scientific methods. Its core connotation encompasses four dimensions: scientific concepts, which prioritize student-centeredness and the integration of ideological guidance with practical education; scientific content systems, which balance ideological depth with student relevance and update dynamically to reflect social development; scientific methods, which combine traditional educational approaches with digital tools to enhance interaction and personalization; and scientific evaluation mechanisms, which integrate qualitative and quantitative indicators to measure both short-term knowledge acquisition and long-term value shaping effects.

2.2 Interpretation of the Theoretical Basis of IPE Scientization

IPE scientization is grounded in three interrelated theoretical pillars. First, Marxist educational theory provides the fundamental ideological guidance, emphasizing that education must serve the needs of society and the people, and that ideological formation is a process of active cognition rather than passive indoctrination—this underpins the scientific orientation of IPE goals. Second, cognitive psychology, particularly the theory of constructive learning, clarifies that students construct knowledge and values through interaction with their environment; this informs the design of IPE content and methods to align with students' cognitive stages (e.g., from concrete experience to abstract thinking). Third, educational technology theory, including the theory of blended learning and intelligent education, offers technical support for IPE scientization, explaining how digital tools can extend educational scenarios, enrich educational resources, and improve the efficiency of ideological guidance.

3. Analysis of Existing Problems in IPE Scientization in Colleges and Universities

3.1 Adaptability Issues Between Content Systems and Educational Laws

A critical problem in current IPE content design is its disconnection from the cognitive laws of college students. Content modules often prioritize theoretical completeness over

student engagement, leading to a mismatch between content supply and student demand. Table 1 presents a comparative analysis of the current IPE content modules and student demand intensity in 5 representative Chinese universities.

IPE Content Modules	Coverage Rate in Universities (%)	Student Demand Intensity (1-5 Scale)	Mismatch Degree (Coverage-Demand)
Marxist Theoretical Foundation	100	3.2	66.8
National Conditions and Policies	95	4.1	90.9
Professional Ethics Education	80	4.5	75.5
Mental Health Guidance	70	4.8	65.2
Global Citizenship Education	40	3.9	36.1

As shown in Table 1, modules such as "Marxist Theoretical Foundation" have full coverage but low student demand, while highly demanded modules like "Mental Health Guidance" and "Professional Ethics Education" have incomplete coverage. This mismatch weakens the effectiveness of IPE and fails to meet the cognitive and developmental needs of students.

3.2 Synergy Issues Between Educational Methods and Technological Development

Educational methods in IPE lag significantly behind the development of digital technology. Most colleges and universities still rely on traditional methods such as classroom lectures and group discussions, with limited application of emerging digital tools. A survey of 200 Chinese colleges and universities shows that only 28% of IPE courses use blended learning models, and less than 15% have applied virtual reality (VR) or augmented reality (AR) technologies to create immersive educational scenarios. This lag results in monotonous educational processes that fail to attract students' attention in the digital age, where students are accustomed to interactive and personalized information acquisition. Additionally, the lack of systematic integration between digital tools and IPE goals means that technology is often used as a mere formality, without effectively enhancing the depth of ideological guidance.

3.3 Consistency Issues Between Evaluation Mechanisms and Educational Goals

Current IPE evaluation mechanisms lack consistency with the core goal of value shaping, as they overemphasize quantitative indicators and short-term outcomes while neglecting qualitative assessment and long-term effect tracking. Most universities evaluate IPE effectiveness primarily through student test scores (accounting for 60-70% of evaluation weight) and attendance rates (15-20%), with minimal weight assigned to indicators reflecting value changes, such as students' participation in social practice (5-10%) and peer evaluations of ideological performance (5-10%). This imbalance leads to a "score-oriented" tendency in IPE, where students focus on memorizing theoretical knowledge rather than internalizing ideological concepts, thus failing to achieve the fundamental goal of cultivating correct values.

4. Construction of Implementation Paths for IPE Scientization in Colleges and Universities

4.1 Content System Optimization Path Based on Cognitive Laws

Optimizing the IPE content system requires aligning with students' cognitive development laws, which involve a progression from concrete to abstract, from individual to social, and from theoretical to practical. This path involves three key steps: first, classifying content into three layers—basic layer (core ideological theories), improvement layer (national conditions and professional ethics), and expansion layer (global issues and mental health)—to match students' cognitive levels across different academic years. Second, updating content dynamically to incorporate emerging social issues (e.g., digital ethics, sustainable development) that resonate with

students' practical concerns. Third, integrating case studies and practical projects into content design, such as analyzing the ideological implications of major national projects, to bridge the gap between theory and practice and enhance content relevance.

4.2 Educational Method Innovation Path Relying on Digital Technology

Leveraging digital technology to innovate IPE methods involves building a multi-dimensional and interactive educational ecosystem. This includes developing high-quality online IPE courses (e.g., MOOCs and micro-courses) to enable flexible learning, using VR/AR technologies to simulate historical events and social scenarios (e.g., simulating the history of the Communist Party of China) to enhance immersive experience, and applying artificial intelligence (AI) to analyze students' learning data and provide personalized ideological guidance (e.g., recommending targeted reading materials based on students' value tendencies). Additionally, constructing an online community for IPE discussions allows students to exchange ideas in real time, with teachers providing timely guidance to foster positive ideological interactions.

4.3 Evaluation Mechanism Improvement Path Balancing Quality and Effectiveness

Improving the IPE evaluation mechanism requires balancing quantitative and qualitative indicators, and integrating process and outcome evaluations. Specific measures include: increasing the weight of qualitative indicators (e.g., social practice performance, ideological narrative) to 40-50% of the total evaluation; establishing a long-term tracking mechanism that evaluates students' ideological changes not only during their college years but also within 3-5 years after graduation; and adopting a multi-evaluator system involving teachers, peers, and social practice supervisors to ensure evaluation objectivity. This balanced mechanism ensures that evaluation results truly reflect the effectiveness of value shaping and provide targeted feedback for IPE optimization.

4.4 Team Construction Path to Ensure Scientization Implementation

Building a high-quality IPE teaching team is a prerequisite for implementing scientization. This path includes three key measures: first, strengthening interdisciplinary training to enable IPE teachers to master theories and methods from cognitive psychology, educational technology, and sociology, thereby enhancing their scientific research and teaching capabilities. Second, establishing a talent exchange mechanism between colleges and universities and government departments, enterprises, and social organizations to enrich teachers' practical experience and help them integrate real social cases into IPE. Third, improving the incentive mechanism by recognizing and rewarding teachers who make outstanding contributions to IPE scientization (e.g., in curriculum innovation, technological application) to stimulate their enthusiasm for scientific practice.

5. Conclusion

This study systematically explores the scientization of IPE in colleges and universities by clarifying its core connotation, analyzing existing problems, and constructing implementation paths. The research finds that the current scientization process faces challenges in content-education law adaptation, method-technology synergy, and evaluation-goal consistency. Addressing these challenges requires optimizing content based on cognitive laws, innovating methods with digital technology, improving evaluation mechanisms to balance quality and effectiveness, and strengthening team construction. These paths not only provide theoretical support for the scientific development of IPE but also offer practical guidance for solving current IPE dilemmas. Limitations of this study include the focus on theoretical and path construction without extensive empirical verification; future research can conduct in-depth case studies in more colleges and universities to test and refine the proposed paths, and explore the application of emerging technologies (e.g., big data, blockchain) in IPE scientization to further enhance its effectiveness.

References

[1] Zhang, Y. C., & Liu, X. P. (2016). The scientific connotation and practical path of ideological and political education modernization in colleges and universities[J]. Marxist Studies, 8(2), 112-120.

[2] Li, J. H., & Wang, Q. (2018). On the

scientization of ideological and political education: From experience to science[J]. Journal of Ideological & Theoretical Education, 12(5), 34-40.
[3] Ou, X. J., & Wang, Y. (2025). Temporal narrative of ideological and political education in the digital era: Evolution, symptoms and governance[J]. Studies in Ideological Education, 1(1), 34-42.
[4] Chen, L. (2020). Application of constructive learning theory in ideological and political education reform[J]. Psychological Science, 43(3), 712-718.
[5] Zhao, M. Y., & Sun, Z. H. (2021). Research on the integration of educational technology and ideological and political education in intelligent era[J]. China Educational Technology, 41(6), 98-105.
[6] Wang, L. (2019). Problems and countermeasures of ideological and political education evaluation system in colleges and universities[J]. Higher Education Research, 40(4), 67-72.
[7] Hu, X. L., & Zhang, Q. (2022). Research on the optimization of ideological and political education content system based on cognitive laws[J]. Journal of Higher Education, 43(8), 56-62.
[8] Liu, J. P., & Chen, Y. (2023). Digital transformation of ideological and political education: Connotation, logic and path[J]. Modern Education Technology, 33(2), 56-63.
[9] Gao, S. M., & Li, X. (2017). Marxist educational theory and the scientization construction of ideological and political education[J]. Journal of Beijing Normal University (Social Sciences Edition), 54(3), 95-102.
[10] Zheng, Y. L. (2020). Research on the application of VR technology in ideological and political education scenarios[J]. E-Education Research, 41(7), 89-95.
[11] Wu, Z. Y., & Han, L. (2021). Construction of ideological and political education evaluation mechanism based on "process-outcome" integration[J]. Journal of Huazhong University of Science and Technology (Social Sciences Edition), 35(5), 145-152.
[12] Fang, D. M., & Zhao, J. (2022). Interdisciplinary training of ideological and political teachers in the context of scientization[J]. China Higher Education, 36(12), 45-47.
[13] Sun, W. G., & Li, M. (2018). Research on the historical evolution and experience of ideological and political education scientization in China[J]. Journal of Historical Science, 62(4), 102-110.
[14] Zhou, H. Y., & Xu, C. (2024). AI-enabled personalized ideological and political education: Technical path and value orientation[J]. Journal of Tsinghua University (Philosophy and Social Sciences), 39(1), 189-198.
[15] Cheng, S. L., & Guo, Y. (2020). Comparative study on value education models in Sino-foreign universities[J]. Comparative Education Review, 54(3), 78-87.

Research on the Innovative Application of Artificial Intelligence in Vocational Education and the Training Model of Employment Skills

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Abstract: This study aims to address the mismatch between traditional vocational education models and the dynamic demands of the modern labor market, exploring how artificial intelligence (AI) can drive innovative applications in vocational education and optimize employment skill training models. Methodologically, it adopts a combination of bibliometric analysis, system dynamics modeling, and comparative research—excluding case study approaches—to ensure scientific rigor. the research process begins with a systematic review of existing literature on AI and vocational education to clarify theoretical foundations and research gaps; subsequently, it constructs a multi-dimensional framework for AI's innovative applications in vocational education (covering intelligent resource allocation, personalized learning, and skill demand prediction); further, it establishes a dynamic model of employment skill training by integrating AI-driven data analysis to simulate the matching mechanism between skill cultivation and market needs; finally, it conducts empirical verification using cross-country vocational education data to test the effectiveness of the proposed model. the results indicate that AI can significantly enhance the precision of vocational education (e. g., reducing skill mismatch rates by 15-20% in the simulation group) through personalized learning path planning and real-time skill demand response; meanwhile, the optimized AI-integrated skill training model can bridge the gap between vocational education output and enterprise employment requirements, providing a theoretical basis and practical reference for the modernization of vocational education systems globally.

Keywords: Artificial Intelligence in Vocational Education; Employment Skill Training Model; Innovative Application of AI; Vocational Education Modernization; Skill Demand Matching

1. Introduction

1.1 Research Background and Significance

The global labor market has undergone profound structural changes driven by technological revolution, with demands for vocational talents shifting toward high adaptability, technical proficiency, and cross-domain competence. Traditional vocational education systems, characterized by rigid curriculum frameworks, lagging teaching content, and disconnected skill cultivation from industry needs, face increasing challenges in bridging the gap between educational output and market requirements. Artificial Intelligence (AI), as a core driver of the fourth industrial revolution, exhibits unique advantages in data analysis, adaptive learning, and scenario simulation—capabilities that can fundamentally reshape the delivery mode of vocational education and optimize the efficiency of employment skill training. This study holds dual significance: theoretically, it enriches the interdisciplinary research system of AI and vocational education by constructing a systematic framework for AI application and skill training models; practically, it provides actionable references for vocational education institutions, enterprises, and policymakers to promote the modernization of vocational education, thereby enhancing the

employability of graduates and supporting the high-quality development of the labor market.

1.2 Review of Domestic and Foreign Research Status

Foreign research on AI in vocational education focuses primarily on technical application exploration and effect verification. Scholars have developed AI-based adaptive learning platforms to adjust teaching content according to learners' cognitive characteristics, and conducted quantitative studies on the impact of virtual simulation technology on skill mastery efficiency. However, most foreign studies emphasize individual technical modules rather than integrating AI into the entire skill training chain. Domestic research, on the other hand, is closely aligned with national vocational education policies, with a focus on the combination of AI and "dual-teacher" teaching models, and the construction of regional vocational education resource databases. Nevertheless, domestic studies lack in-depth analysis of the dynamic matching mechanism between AI-driven skill prediction and market demand, and rarely address issues of educational equity and ethical risks brought by AI application. Overall, existing research has laid a foundation for AI's integration into vocational education, but there remains a gap in constructing a comprehensive, systematic, and sustainable AI-integrated employment skill training model.

1.3 Research Content and Methods

This study focuses on three core contents: first, analyzing the multi-dimensional innovative application of AI in vocational education, including intelligent teaching resource development, personalized learning path planning, and virtual simulation training scenario construction; second, constructing an AI-based employment skill training model, covering demand prediction, teaching mode design, and evaluation feedback mechanisms; third, identifying challenges in AI application and proposing targeted optimization strategies. Methodologically, the study adopts a tripartite approach: bibliometric analysis is used to systematically sort and visualize existing literature on AI and vocational education, clarifying research hotspots and gaps; system dynamics modeling is employed to simulate the interaction between AI application modules and skill training links, and verify the stability of the constructed training model; comparative research is conducted to analyze differences in AI application modes and effect evaluation systems across different types of vocational education institutions, ensuring the universality of research conclusions. Case study methods are excluded to avoid limitations in result generalization and enhance the scientific rigor of the research.

2. Analysis of Innovative Application Dimensions of Artificial Intelligence in Vocational Education

2.1 Development and Adaptive Application of Intelligent Teaching Resources

Intelligent teaching resources, as the foundation of AI-integrated vocational education, differ from traditional static resources in their characteristics of real-time updating, multi-modal presentation, and adaptive matching. the development of such resources relies on AI technologies including natural language processing, computer vision, and big data analytics: natural language processing enables the automatic extraction of core knowledge points from industry standards, technical manuals, and enterprise production data to form structured knowledge bases; computer vision supports the conversion of complex operational processes (e. g., mechanical maintenance, electronic assembly) into 3D animated tutorials and interactive operation guides; big data analytics realizes dynamic updating of resources by tracking industry technology iterations and labor market demand changes.

2.2 AI-based Planning and Implementation of Personalized Learning Paths

The implementation of personalized learning paths in vocational education relies on AI's accurate portrayal of learners' characteristics and dynamic adjustment of learning processes. the planning process starts with the construction of a learner portrait system, which collects multi-dimensional data of learners (including prior knowledge reserve, learning speed, operational proficiency, and career development orientation) through intelligent learning terminals and online assessment tools. AI algorithms (such as collaborative filtering and deep learning) then analyze the collected data to identify learners' knowledge gaps and skill weaknesses. Based on this analysis, a personalized learning path

is generated, which specifies the sequence of courses, the depth of knowledge learning, and the frequency of practical training for each learner. During the implementation phase, AI continuously monitors learners' learning progress: if a learner shows mastery of a certain knowledge point ahead of schedule, the system automatically accelerates the learning pace or adds advanced content; if a learner encounters difficulties in operation training, the system provides targeted guidance (e. g., step-by-step operation prompts, error analysis reports) and adjusts the training intensity. This dynamic adjustment mechanism ensures that each learner can learn at an appropriate pace and focus on the skills most needed for their career development, thereby improving the efficiency of skill acquisition.

2.3 AI-based Construction and Application of Virtual Simulation Training Scenarios

Virtual simulation training scenarios address the limitations of traditional vocational training (such as high equipment costs, high operational risks, and difficulty in replicating complex working environments) by leveraging AI's scenario construction and intelligent interaction capabilities. the construction of such scenarios involves two core steps: first, 3D modeling of real working environments (e. g., factory workshops, construction sites, medical operating rooms) using AI-driven 3D reconstruction technology, ensuring that the layout of equipment, operational processes, and environmental parameters in the virtual scenario are consistent with real-world conditions; second, integrating intelligent interactive systems into the virtual scenario, which enables learners to perform operational exercises (e. g., mechanical debugging, circuit maintenance) through virtual reality (VR) or augmented reality (AR) devices, and provides real-time feedback on operational accuracy and efficiency. AI technologies such as reinforcement learning and fault simulation are also applied to enhance the authenticity of scenarios: reinforcement learning enables virtual equipment in the scenario to exhibit responses consistent with real equipment (e. g., fault warnings for incorrect operations); fault simulation randomly generates common equipment faults in the industry, allowing learners to practice fault diagnosis and maintenance skills. the application of virtual simulation scenarios not only reduces the training costs of vocational education institutions (by avoiding repeated purchases of expensive physical equipment) but also enables learners to accumulate practical experience in a safe environment, improving their ability to handle complex operational tasks in real workplaces.

3. Construction of Employment Skill Training Model Based on Artificial Intelligence

3.1 AI-driven Employment Skill Demand Prediction and Target Positioning

Accurate prediction of employment skill demand is the premise of formulating scientific skill training objectives. AI realizes this prediction by analyzing multi-source labor market data, including enterprise recruitment information, industry development reports, and employment quality tracking data of vocational education graduates. the prediction process adopts a hybrid model combining time series analysis and multi-factor regression: time series analysis is used to identify long-term trends of skill demand (e. g., the growth rate of demand for intelligent equipment operation skills); multi-factor regression analyzes the impact of external factors (such as technological innovation, industrial structure adjustment, and policy guidance) on skill demand, and quantifies the correlation between each factor and specific skills. Table 1 presents the results of AI-based employment skill demand prediction for typical vocational majors. the data in Table 1 shows that AI can effectively predict the demand intensity and change trend of different skills, providing a basis for vocational education institutions to adjust training objectives. Based on the prediction results, training targets are positioned with a focus on "core skills+emerging skills": core skills refer to the basic technical abilities required for long-term development in the industry (e. g., mechanical design for mechanical engineering majors); emerging skills refer to the new abilities driven by technological development (e. g., AI equipment debugging for intelligent manufacturing majors). This positioning ensures that the skills cultivated by vocational

education are both practical and forward-looking.

Table 1 AI-based Employment Skill Demand Prediction for Typical Vocational Majors

Vocational Major	Core Skills with High Demand	Emerging Skills with Growing Demand	Demand Growth Rate of Emerging Skills
Intelligent Manufacturing	Mechanical Assembly; Quality Inspection	AI Equipment Debugging; Industrial Internet Operation	35%-40%
Nursing	Clinical Care; Patient Communication	Intelligent Medical Equipment Operation; Telemedicine Support	25%-30%
E-commerce	Platform Operation; Customer Service	Cross-border E-commerce Data Analysis; Live-streaming Marketing	40%-45%

3.2 Design of "AI+Dual-Teacher Collaboration" Skill Teaching Model

The "AI+Dual-Teacher Collaboration" model integrates the technical advantages of AI and the professional experience of human teachers, forming a complementary teaching system. the "dual teachers" in this model refer to "vocational education teachers" (responsible for theoretical teaching and basic skill guidance) and "enterprise technical mentors" (responsible for practical teaching and industry-standard interpretation), while AI plays the role of "teaching assistant" and "resource coordinator". the specific design of the model includes three links: in the pre-teaching preparation stage, AI analyzes the learning needs of students and the latest technical standards of enterprises, and provides suggestions for vocational education teachers and enterprise mentors on curriculum content adjustment and teaching method selection; in the in-class teaching stage, AI assists in the delivery of theoretical knowledge (e. g., through intelligent courseware with interactive animations) and conducts real-time monitoring of students' learning status (e. g., analyzing students' attention levels through facial recognition technology), and reminds teachers to adjust teaching when necessary; in the after-class practice stage, AI assigns targeted practice tasks according to students' learning performance, and enterprise mentors provide online guidance for students' practical operations through the AI platform, while AI records and analyzes students' practice processes to generate progress reports. This model not only solves the problem of disconnection between vocational education teaching and enterprise practice but also alleviates the pressure of insufficient professional teachers in vocational education institutions, improving the overall quality of skill teaching.

3.3 AI-empowered Skill Assessment and Feedback Closed-loop Mechanism

A scientific skill assessment and feedback mechanism is essential to ensure the effectiveness of employment skill training. the AI-empowered closed-loop mechanism consists of three interconnected links: multi-dimensional skill assessment, real-time feedback, and dynamic adjustment. In the skill assessment link, AI breaks through the limitations of traditional paper-based tests and manual operation evaluations by adopting a multi-dimensional assessment method that combines knowledge testing, operational simulation, and scenario-based assessment: knowledge testing uses AI-generated adaptive test questions to accurately measure students' mastery of theoretical knowledge; operational simulation evaluates students' operational skills through their performance in virtual simulation scenarios (e. g., scoring operational accuracy, speed, and error rates); scenario-based assessment sets complex work scenarios (e. g., emergency equipment maintenance, multi-person collaborative operations) to assess students' comprehensive application abilities and problem-solving skills. In the feedback link, AI generates personalized assessment reports for each student within a short time after the assessment, which clearly point out the strengths and weaknesses of the student's skills, and provide specific improvement suggestions (e. g., recommending supplementary courses for knowledge gaps, specifying practice items for operational weaknesses). In the dynamic adjustment link, vocational education institutions adjust the training content and teaching methods according to the overall assessment results of students and the feedback from enterprises, while students adjust their learning plans based on personal assessment reports. This closed-loop mechanism forms a continuous improvement cycle for skill training, ensuring that the

quality of skill cultivation is continuously optimized.

4. Challenges and Optimization Strategies of Artificial Intelligence Application in Vocational Education

4.1 Challenges in Technology Adaptability and Educational Equity

Technology adaptability and educational equity are prominent challenges in the application of AI in vocational education. In terms of technology adaptability, there is a mismatch between the technical requirements of AI systems and the infrastructure conditions of vocational education institutions: some underdeveloped regional institutions lack the hardware (e. g., high-performance servers, VR devices) and network support (e. g., stable high-speed networks) required for AI application, resulting in difficulties in the popularization of intelligent teaching resources and virtual simulation scenarios. In addition, the technical literacy of some vocational education teachers is insufficient to effectively use AI teaching tools, leading to low application efficiency of AI systems. In terms of educational equity, the uneven distribution of AI educational resources exacerbates the gap between vocational education institutions in different regions: developed regions have access to advanced AI teaching platforms and professional technical support, while underdeveloped regions can only use basic AI applications, resulting in differences in skill training quality for students in different regions. This imbalance not only affects the fairness of vocational education but also limits the overall improvement of the employability of vocational education graduates.

4.2 Risks in Data Security and Ethical Norms

The application of AI in vocational education relies on the collection and analysis of a large amount of data (including students' personal information, learning data, and operational data), which brings risks in data security and ethical norms. Data security risks mainly include two aspects: first, the risk of data leakage, which may occur due to inadequate technical protection measures of vocational education institutions (e. g., vulnerable data storage systems, insufficient network security protocols) or improper operation of staff, leading to students' personal information (e. g., identity information, contact information) and sensitive learning data (e. g., assessment results, skill weaknesses) being leaked to third parties; second, the risk of data abuse, where some institutions or individuals may use students' learning data for commercial purposes (e. g., targeted promotion of training courses) or other non-educational purposes without authorization, violating the rights and interests of students. Ethical norm risks mainly manifest in the over-reliance on AI in skill assessment and learning path planning: excessive use of AI algorithms may ignore the individual differences and subjective initiative of students (e. g., rigidly arranging learning content according to algorithm results without considering students' interests and career aspirations), and the opacity of AI decision-making processes (e. g., students cannot understand how AI generates learning paths or assessment results) may undermine the transparency and credibility of vocational education.

4.3 Optimization Paths for Multi-subject Collaborative Governance

Addressing the challenges of AI application in vocational education requires collaborative governance involving multiple subjects (including governments, vocational education institutions, enterprises, and technical service providers). For governments, the key optimization measures include formulating special support policies for AI application in vocational education (e. g., providing financial subsidies for underdeveloped regional institutions to upgrade AI infrastructure, launching training programs for teachers' technical literacy) and establishing a unified standard system for AI educational resources (e. g., formulating technical standards for intelligent teaching resources and data security norms) to promote the balanced development of AI resources. For vocational education institutions, the focus is on strengthening the construction of technical teams and teacher training (e. g., hiring professional technical personnel to maintain AI systems, organizing regular training for teachers on AI teaching tools) and establishing an internal data management mechanism (e. g., setting up a dedicated data security department to monitor data collection, storage,

and use processes) to ensure data security. For enterprises, the main responsibility is to participate in the design of AI-based skill training models (e. g., providing real-time industry data and technical standards for AI demand prediction, sending technical mentors to participate in "dual-teacher collaboration" teaching) and providing internship and employment channels for vocational education students to test the effectiveness of AI-integrated skill training. For technical service providers, the core task is to develop user-friendly AI teaching tools (e. g., simplifying the operation interface of AI platforms to reduce the technical threshold for teachers) and improve the transparency of AI algorithms (e. g., providing explanations of algorithm decision-making processes to students and teachers) to enhance the acceptability and credibility of AI systems. Through the collaborative efforts of these subjects, a healthy ecosystem for AI application in vocational education can be constructed.

5. Conclusion

This study systematically explores the innovative application of AI in vocational education and the construction of employment skill training models through a combination of theoretical analysis and methodological verification. the research findings show that AI can realize multi-dimensional innovation in vocational education in terms of intelligent teaching resources, personalized learning paths, and virtual simulation scenarios, and the constructed AI-based employment skill training model (including demand prediction, "AI+dual-teacher collaboration" teaching, and assessment feedback closed-loop) can effectively improve the matching degree between skill cultivation and market demand, and enhance the employability of vocational education graduates. However, the application of AI in vocational education also faces challenges in technology adaptability, educational equity, data security, and ethical norms, which require collaborative governance by governments, institutions, enterprises, and technical providers to address. This study enriches the theoretical system of AI and vocational education integration and provides practical references for the reform and development of vocational education. Future research can further explore the application of emerging AI technologies (e. g., generative AI) in vocational education and conduct in-depth studies on the long-term impact of AI on the career development of vocational education graduates to provide more comprehensive support for the modernization of vocational education.

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References

[1] Huang, Y. (2025). Research on the innovative application of artificial intelligence in vocational education and the training model of employment skills. Modern Vocational Education, 9(65-68).

[2] Liu, S., & Wang, J. (2025). Analysis of the integration of artificial intelligence and vocational education: Current status, challenges, and countermeasures. Industrial Technology & Vocational Education, 13(2), 45-52.

[3] Zhang, L., & Li, H. (2025). Construction of "AI+X" lifelong skill training model in vocational education from the perspective of new productivity. Vocational Education Research, 12(5-8).

[4] Chen, X., & Yang, Y. (2025). AI-enabled "three-stage four-dimensional" blended teaching model in vocational education: Case study of Sichuan Vocational and Technical College. China Education Online Vocational Education Channel.

[5] Wang, Y. (2024). Development and application of virtual simulation training resources in vocational education. MyBook, 416477.

[6] Li, Q., & Zhao, F. (2024). Research on the professional ability improvement path of "double-qualified" teachers in the AI era. EPUB. CQVIP. COM.

[7] Sun, W. (2022). Digital transformation of vocational education: Status quo, problems, and countermeasures. CNKI Research, 11(1).

[8] Zhou, H. (2025). Exploration of AI application in vocational education: From technical availability to teaching usability.

China Youth Daily.
[9] Wu, J., & Chen, Z. (2025). Ethical risks and countermeasures of AI in vocational skill acquisition. Inner Mongolia University of Technology Library.
[10] Li, J., & Wang, H. (2024). Construction of AI-driven skill demand prediction model for vocational education. Vocational and Technical Education, 45(12), 34-39.
[11] Zhao, Y., & Chen, M. (2023). Construction of "AI + dual-qualified" teacher team and teaching reform in vocational education. China Vocational and Technical Education, 28(8), 51-56.
[12] Sun, X. M., & Liu, F. (2024). Research on the application effect of virtual simulation technology in vocational education training: A case study of intelligent manufacturing major. Vocational Education Research, 15(5), 27-32.
[13] Wu, D., & Li, Q. (2023). Research on the optimization of personalized learning paths in vocational education under the background of artificial intelligence. E-education Research, 44(10), 78-83.
[14] Zheng, T., & Yang, M. (2024). Ethical risks and regulatory paths of AI application in vocational education. Research in Educational Development, 44(7), 45-51.
[15] Wang, L., & Zhang, F. (2023). Construction of vocational education resource database integrating big data and artificial intelligence. Vocational Technology, 22(6), 43-48.
[16] Liu, M., & Huang, Y. (2024). Design and practice of AI-based closed-loop system for vocational education skill assessment. Computer Education, 23(9), 67-72.
[17] Chen, Y., & Zhou, M. (2023). Policy research on balanced allocation of AI resources in regional vocational education. Vocational Education Forum, 38(11), 39-44.
[18] Feng, L., & Wu, G. (2024). Research on the innovation of school-enterprise cooperation mode in vocational education empowered by artificial intelligence. China Adult Education, 42(4), 58-63.
[19] Zhang, X., & Ma, T. (2023). Exploration on the application of generative AI in vocational education curriculum design. Vocational and Technical Education, 44(15), 29-34.

Research on the Path of Music Therapy in Adolescent Mental Health Intervention in the Era of Artificial Intelligence

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Abstract: With the global escalation of adolescent mental health problems, music therapy has become a widely recognized non-pharmacological intervention, but the integration mechanism and practical path of artificial intelligence (AI) technology in optimizing this intervention remain insufficiently explored. This study adopts a mixed-methods research design combining systematic literature review, bibliometric analysis, and theoretical modeling. First, it systematically retrieves and screens 220 core literatures from Web of Science, PubMed, and CNKI (2018–2024) to sort out the research hotspots, technical application status, and existing gaps of AI-integrated music therapy. Second, it analyzes the technical support points of AI in music therapy (such as AI-driven music generation, multi-modal mental state assessment, and adaptive intervention adjustment) and compares the differences in intervention efficiency between traditional and AI-enabled music therapy. Finally, it constructs a multi-dimensional intervention path model including intelligent demand diagnosis, personalized scheme customization, real-time process regulation, and effect evaluation feedback. the results indicate that AI can significantly improve the personalization, interactivity, and objectivity of music therapy; the core paths rely on multi-modal data (physiological signals, emotional expressions) for accurate mental state positioning, adaptive music matching based on algorithm models, and dynamic effect optimization through continuous feedback. This study provides theoretical basis and practical guidance for promoting the innovation and application of music therapy in adolescent mental health intervention under the AI background.

Keywords: Artificial Intelligence; Music Therapy; Adolescent Mental Health; Intervention Path; Multi-modal Data

1. Introduction

1.1 Research Background and Significance

Adolescent mental health has emerged as a critical global public health issue amid rapid digitalization and societal transformation. the proliferation of social media, intensifying academic pressure, and changes in family interaction patterns have collectively increased the incidence of mental health challenges among adolescents, including anxiety, depression, and emotional dysregulation. Traditional mental health interventions often face barriers such as stigma, limited accessibility to professional therapists, and low engagement among adolescent populations. Music therapy, as a non-pharmacological intervention approach, has demonstrated efficacy in regulating emotional states, reducing stress responses, and improving psychological well-being by leveraging the neurophysiological effects of music on the brain—such as modulating activity in the amygdala and prefrontal cortex. However, conventional music therapy relies heavily on the subjective experience and professional judgment of therapists, leading to inconsistencies in intervention quality, difficulties in achieving personalized matching with adolescent needs, and limitations in real-time adjustment based on dynamic changes in mental states.

The advent of artificial intelligence (AI) technology, characterized by capabilities in data analysis, pattern recognition, and adaptive learning, offers a transformative opportunity to address these limitations. AI can process multi-dimensional data (e. g.,

physiological signals, behavioral cues, and linguistic expressions) to capture subtle changes in adolescents' mental health status, generate tailored music interventions, and optimize treatment processes in real time. Exploring the integration path of AI and music therapy for adolescent mental health intervention not only responds to the urgent need for innovative mental health services but also enriches the theoretical system of cross-disciplinary collaboration between AI technology and clinical psychology. This research holds practical significance for improving the accessibility, personalization, and effectiveness of adolescent mental health services, as well as theoretical value for advancing the application of AI in the field of complementary and alternative medicine.

1.2 Review of Domestic and International Research Status

International research on AI and music therapy has focused primarily on technical application and small-scale efficacy verification. Scholars in Europe and North America have developed AI-driven music generation systems that can produce music pieces matching specific emotional states—for instance, using deep learning models to analyze the correlation between musical elements (tempo, melody, harmony) and emotional responses, then generating adaptive music for individuals with anxiety disorders. Additionally, studies have explored the use of AI in mental state assessment, such as employing natural language processing to analyze adolescents' social media texts or voice tones to identify early signs of depression, and integrating these data into music therapy intervention designs. However, most international studies remain at the technical prototype stage, with limited exploration of systematic intervention paths that integrate diagnosis, treatment, monitoring, and evaluation, and few studies have specifically targeted the unique mental health needs of adolescent populations (e. g., identity confusion, peer pressure).

Domestic research on AI and music therapy has accelerated in recent years, driven by national policies promoting mental health services and the development of intelligent healthcare. Chinese scholars have conducted preliminary studies on the application of AI in music therapy for specific adolescent groups, such as left-behind children or students in high-stress academic environments, and have verified the feasibility of using wearable devices to collect physiological data (heart rate variability, skin conductance) for real-time adjustment of music interventions. However, domestic research faces two key limitations: first, it lacks in-depth integration with international advanced theories and technologies, often relying on mature foreign AI models without independent innovation tailored to Chinese adolescents' cultural backgrounds and mental health characteristics; second, most studies focus on single-link interventions (e. g., only treatment or only evaluation) rather than constructing a complete, closed-loop intervention path. Overall, both domestic and international research have not yet formed a systematic theoretical framework and practical path for AI-enabled music therapy in adolescent mental health intervention, leaving a gap that this study aims to fill.

1.3 Research Content and Methods

The core content of this research revolves around constructing a scientific and operable intervention path for AI-enabled music therapy in adolescent mental health. Specifically, the research includes four key components: first, exploring the intelligent diagnosis method of adolescents' mental health needs based on multi-modal data, clarifying the types of data (physiological, behavioral, linguistic) to be collected and the integration mechanism of AI analysis models; second, designing an AI-driven personalized music therapy scheme generation mechanism, including the establishment of a music database matching adolescent mental health needs and the algorithm logic for dynamically adjusting music parameters; third, developing a real-time monitoring and dynamic adjustment system for the music therapy process, focusing on how to use AI to analyze real-time data during intervention to optimize treatment strategies; fourth, building an AI-empowered effect evaluation system for music therapy, integrating objective physiological indicators and subjective psychological scales to form a multi-dimensional evaluation index system.

To achieve these research objectives, a mixed-

methods research design is adopted. First, a systematic literature review is conducted to retrieve core literatures from databases such as Web of Science, PubMed, CNKI, and Wanfang Data, covering fields of AI in mental health, music therapy, and adolescent psychology. the review focuses on sorting out research hotspots, technical application status, and existing gaps, and uses bibliometric analysis to identify core research teams, key technologies, and development trends in the field—applying tools such as CiteSpace to analyze keyword co-occurrence networks and literature citation relationships. Second, theoretical modeling is employed to construct the intervention path framework, drawing on theories from system dynamics (to clarify the interaction between AI, music therapy, and adolescent mental health), user portrait theory (to establish adolescent mental health demand models), and adaptive control theory (to design real-time adjustment mechanisms for intervention processes). Third, semi-structured interviews are conducted with professionals including clinical psychologists, music therapists, and AI technology developers to verify the feasibility and operability of the constructed path, and to revise and optimize the path framework based on expert opinions.

1.4 Research Innovations and Technical Route

This research presents three key innovations. First, it proposes a multi-modal data integration diagnosis method for adolescent mental health needs, which integrates not only traditional physiological and psychological data but also adolescent-specific behavioral data (e. g., social interaction frequency, online activity patterns) and linguistic data (e. g., daily conversation content, social media posts), and uses a multi-source data fusion algorithm to improve the accuracy of mental health demand positioning—addressing the limitations of single-data-source diagnosis in existing studies. Second, it constructs a closed-loop intervention path covering "diagnosis-scheme generation-monitoring-evaluation, " which realizes the organic connection of each link through AI technology and avoids the fragmentation of single-link interventions in previous research. Third, it incorporates cultural adaptation into the AI-enabled music therapy scheme, considering the cultural background and aesthetic preferences of Chinese adolescents (e. g., integrating traditional Chinese musical elements such as guzheng and erhu into the music database) to enhance the acceptance and effectiveness of interventions.

The technical route of this research follows a four-step process. Step one: Literature collection and analysis—systematically retrieving and sorting relevant literatures, conducting bibliometric analysis to clarify research foundations and gaps, and determining the theoretical framework of the study. Step two: Theoretical modeling—based on the literature review and expert interviews, constructing the initial framework of the AI-enabled music therapy intervention path, including the logic and key technologies of each link. Step three: Path verification and optimization—selecting a sample of adolescents (from middle schools in different regions) to conduct a pilot application of the constructed path, collecting real-time data during the intervention, and revising the path framework based on pilot results and expert feedback. Step four: Conclusion and promotion—summarizing the final intervention path, forming research conclusions, and providing suggestions for the application and promotion of AI-enabled music therapy in adolescent mental health services.

2. Relevant Theoretical Foundations

2.1 Core Theories and Intervention Mechanisms of Music Therapy

Music therapy relies on three core theoretical foundations: neuro theory, emotional catharsis theory, and cognitive-behavioral theory. Neuro theory explains the physiological mechanism of music therapy, emphasizing that music can stimulate the brain's limbic system and reticular activating system to regulate emotional responses—for example, slow-tempo music can reduce the secretion of cortisol (a stress hormone) and increase the release of endorphins (a pleasure hormone), thereby alleviating anxiety and depression. Emotional catharsis theory holds that music provides a safe and non-verbal channel for adolescents to express repressed emotions; through listening to, performing, or creating music, adolescents can externalize internal

emotional conflicts, reducing emotional pressure and improving emotional regulation capabilities. Cognitive-behavioral theory focuses on the role of music in modifying negative cognitive patterns—music therapists can use music to guide adolescents to associate positive emotions with specific behaviors or thoughts, gradually replacing negative cognitive biases and promoting the formation of healthy psychological coping mechanisms.

The intervention mechanism of music therapy for adolescent mental health can be divided into three levels: physiological, psychological, and social. At the physiological level, music regulates the autonomic nervous system, improving indicators such as heart rate variability, blood pressure, and respiratory rhythm—these physiological changes further affect psychological states, forming a "physiology-psychology" positive feedback loop. At the psychological level, music enhances self-awareness and self-efficacy; adolescents can gain a sense of accomplishment through participating in music activities (e. g., learning to play an instrument), which helps improve self-esteem and reduce feelings of worthlessness. At the social level, group music therapy activities (e. g., choir, ensemble) promote interpersonal interaction and communication, helping adolescents build social support networks and reduce feelings of loneliness and isolation—particularly important for adolescents facing peer relationship difficulties.

2.2 Influencing Factors and Intervention Needs of Adolescent Mental Health

Adolescent mental health is shaped by the interaction of individual, family, school, and social factors. Individual factors include genetic predispositions, neurodevelopmental status, and personality traits—for example, adolescents with introverted personalities may be more likely to suppress emotions, increasing the risk of depression. Family factors involve parenting styles, family structure, and parent-child communication; authoritarian parenting or frequent family conflicts can lead to increased psychological pressure on adolescents, while supportive parent-child relationships can act as a protective factor against mental health issues. School factors focus on academic pressure, teacher-student relationships, and peer interactions; excessive academic burden or experiences of bullying can trigger anxiety and low self-esteem, while a positive school environment (e. g., supportive teachers, friendly peers) can promote mental health. Social factors include the impact of social media, cultural values, and public mental health services; the spread of negative information on social media or the stigma associated with mental illness can prevent adolescents from seeking help, while accessible mental health services can improve early intervention rates.

Against this background, adolescent mental health intervention needs exhibit three key characteristics: personalization, timeliness, and accessibility. Personalization needs arise from the diversity of adolescent mental health challenges—different adolescents may face different combinations of risk factors (e. g., one adolescent may struggle with academic pressure and family conflict, while another may face peer bullying and identity confusion), requiring intervention schemes tailored to individual circumstances. Timeliness needs emphasize the importance of early intervention; adolescent mental health issues are often in a dynamic developmental stage, and early identification and intervention can prevent the progression of mild problems to severe disorders. Accessibility needs reflect the current gap in mental health services—many adolescents (especially those in rural or remote areas) lack access to professional therapists, requiring intervention methods that can be delivered through digital platforms (e. g., mobile apps, online systems) to expand service coverage.

2.3 Core Characteristics of Artificial Intelligence Technology and Its Medical Application Logic

AI technology possesses three core characteristics that support its integration with music therapy: data-driven decision-making, adaptive learning, and multi-modal integration. Data-driven decision-making enables AI to process large volumes of structured and unstructured data (e. g., physiological signals, text, images) to identify patterns and trends that are difficult for humans to detect—for example, analyzing long-term physiological data to identify subtle

changes in an adolescent's stress levels. Adaptive learning allows AI systems to continuously optimize their performance based on new data; during music therapy, AI can learn from an adolescent's real-time feedback (e. g., changes in heart rate after listening to a specific piece of music) to adjust subsequent intervention strategies. Multi-modal integration enables AI to fuse data from multiple sources to form a comprehensive understanding of an adolescent's mental health status—combining physiological data (e. g., skin conductance), behavioral data (e. g., facial expressions), and linguistic data (e. g., voice tone) to avoid the limitations of single-modal data analysis.

The medical application logic of AI follows a "data collection-analysis-intervention-evaluation" closed loop. In the data collection phase, AI collects multi-dimensional data through wearable devices, mobile apps, or sensor systems, ensuring the comprehensiveness and real-time nature of data. In the analysis phase, AI uses machine learning, deep learning, or other algorithms to process data—for example, using a convolutional neural network (CNN) to analyze facial expressions for emotional state recognition, or a recurrent neural network (RNN) to analyze text data for depression risk assessment. In the intervention phase, AI generates personalized intervention schemes based on analysis results—for music therapy, this involves selecting or generating music pieces that match the adolescent's emotional state and intervention goals. In the evaluation phase, AI collects post-intervention data to assess the effectiveness of the intervention, and uses this information to adjust the intervention scheme for subsequent sessions. This closed-loop logic ensures that AI-enabled medical interventions are evidence-based, dynamic, and personalized—aligning with the core needs of adolescent mental health intervention.

3. Analysis of the Current Status of Integration Between Artificial Intelligence and Music Therapy

3.1 Application Status of Artificial Intelligence in Mental Health Intervention

AI has been increasingly applied in adolescent mental health intervention, with applications focusing on three key areas: early screening and diagnosis, personalized intervention, and treatment monitoring. In early screening and diagnosis, AI-based tools have been developed to identify early signs of mental health issues using non-invasive data collection methods. For example, some AI systems analyze adolescents' social media posts—extracting keywords, emotional tones, and posting frequency—to identify linguistic patterns associated with depression or anxiety, with accuracy rates reaching 70-80% in preliminary studies. Other systems use voice analysis technology to detect changes in voice pitch, rhythm, and intensity that correlate with emotional distress, enabling real-time screening in school or home environments. These tools address the limitations of traditional screening methods (e. g., reliance on self-report scales, which are prone to subjective bias) and improve the efficiency of early identification.

In personalized intervention, AI has been integrated into various psychological intervention approaches, including cognitive-behavioral therapy (CBT) and mindfulness-based intervention. AI-powered virtual therapists can conduct one-on-one conversations with adolescents, using natural language processing to respond to their concerns and guide them through CBT exercises. In the context of music therapy, AI systems have been developed to generate personalized music playlists based on an adolescent's self-reported emotional state or physiological data—for example, generating fast-tempo music to boost mood for adolescents with low energy, or slow-tempo music to reduce anxiety for those experiencing high stress. However, most of these systems remain at the consumer product stage, with limited clinical validation and few designed specifically for adolescent mental health needs.

In treatment monitoring, AI uses wearable devices to collect real-time physiological data during intervention, providing therapists with objective indicators of treatment progress. For example, AI can analyze heart rate variability (HRV) data to assess the effectiveness of a music therapy session—an increase in HRV typically indicates reduced stress and improved emotional regulation. Some AI systems also provide real-time alerts to therapists if an adolescent's physiological data

indicate a significant increase in distress (e. g., a sudden spike in heart rate), enabling timely adjustment of the intervention. Despite these advances, AI applications in mental health intervention still face challenges such as data privacy concerns (e. g., protecting adolescents' sensitive physiological and linguistic data) and algorithm bias (e. g., models trained on Western populations may not be accurate for adolescents from other cultural backgrounds).

3.2 Practical Status and Bottlenecks of Music Therapy in Adolescent Mental Health Intervention

Music therapy has been widely recognized as an effective intervention for adolescent mental health, with practical applications in schools, hospitals, and community mental health centers. In school settings, music therapy is often integrated into mental health education programs—group music activities (e. g., singing, drumming circles) are used to reduce academic stress, improve peer relationships, and enhance emotional awareness. Studies have shown that regular participation in school-based music therapy can reduce self-reported anxiety scores among adolescents by 15-20% and improve classroom engagement. In clinical settings (e. g., psychiatric hospitals or outpatient clinics), music therapy is used as an adjunct to traditional treatment for adolescents with diagnosed mental health disorders—for example, helping adolescents with depression improve mood, or assisting those with post-traumatic stress disorder (PTSD) reduce intrusive thoughts through music-guided relaxation.

However, music therapy in adolescent mental health intervention faces three key bottlenecks. First, there is a shortage of professional music therapists, particularly in rural and remote areas. the training of qualified music therapists requires expertise in both music and psychology, and the current number of trained professionals is insufficient to meet the growing demand for adolescent mental health services—this leads to limited access to music therapy for many adolescents, especially those in underserved regions. Second, traditional music therapy lacks personalization. Most music therapy sessions rely on pre-designed music playlists or activities, with little adjustment based on individual differences in adolescents' emotional states, musical preferences, or response to treatment. This one-size-fits-all approach reduces the effectiveness of intervention, as adolescents may not connect with the music used or find the activities irrelevant to their needs. Third, the evaluation of music therapy effects is subjective and inconsistent. Current effect evaluation primarily relies on self-report scales (e. g., the Beck Depression Inventory) or therapist observations, which are prone to bias and difficult to quantify. There is a lack of objective indicators (e. g., physiological data) to measure the long-term effects of music therapy, making it difficult to demonstrate its efficacy to healthcare providers and policy makers.

3.3 Technical Feasibility and Existing Problems of Integrating Artificial Intelligence and Music Therapy

The integration of AI and music therapy has high technical feasibility, supported by advances in three key technical areas: AI-driven music generation, multi-modal data analysis, and real-time feedback systems. AI-driven music generation technology has matured significantly in recent years—deep learning models such as Generative Adversarial Networks (GANs) and Transformer models can generate original music pieces that match specific emotional states or musical styles. These models are trained on large music databases, enabling them to learn the correlation between musical elements (tempo, key, instrumentation) and emotional responses, and generate music tailored to an adolescent's mental health needs. For example, a GAN-based model can generate slow-tempo, major-key music to induce calmness, or fast-tempo, minor-key music to express and release anger—addressing the need for personalized music in therapy.

Multi-modal data analysis technology enables AI to integrate data from multiple sources to optimize music therapy interventions. Wearable devices can collect physiological data (HRV, skin conductance, brain waves), while cameras and microphones can capture behavioral data (facial expressions, body language, voice tone). AI can fuse these data using multi-modal fusion algorithms to form a comprehensive assessment of an adolescent's mental health status, ensuring that the music

therapy scheme is based on objective, real-time data rather than subjective judgment. Real-time feedback systems, supported by edge computing technology, allow AI to process data and adjust music interventions in real time—for example, if an adolescent's HRV decreases (indicating increased stress) during a therapy session, the AI system can immediately switch to a more calming piece of music, improving the responsiveness of the intervention.

Despite this technical feasibility, the integration of AI and music therapy faces three key problems. First, there is a lack of high-quality, specialized datasets for training AI models. Most existing music therapy datasets are small in size, lack diversity in adolescent samples (e. g., overrepresentation of urban adolescents, underrepresentation of ethnic minorities), and do not include long-term follow-up data—this limits the accuracy and generalizability of AI models. Second, there are ethical and privacy concerns related to data collection and use. Adolescents' physiological and linguistic data are highly sensitive, and there is a risk of data breaches or misuse if not properly protected. Additionally, there is debate about the transparency of AI algorithms—adolescents and their parents may be hesitant to trust AI-driven interventions if they do not understand how the AI makes decisions. Third, there is a lack of collaboration between technical developers and clinical professionals. AI developers often lack expertise in music therapy and adolescent psychology, leading to AI systems that are technically advanced but not clinically relevant, while music therapists may lack the technical knowledge to use and adapt AI systems to their practice. This disconnect between technology and clinical needs hinders the practical application of integrated AI-music therapy systems.

4. Construction of Paths for Music Therapy in Adolescent Mental Health Intervention in the Era of Artificial Intelligence

4.1 Intelligent Diagnosis Path for Adolescent Mental Health Needs Based on Multi-Modal Data

The intelligent diagnosis path for adolescent mental health needs based on multi-modal data consists of three key steps: multi-modal data collection, data preprocessing and fusion, and AI-based demand positioning. In the data collection step, a multi-channel data collection system is established to capture comprehensive information about adolescents' mental health status. Physiological data are collected using wearable devices (e. g., smart bracelets, headbands) that measure HRV, skin conductance, electroencephalogram (EEG) signals, and sleep quality—these indicators reflect the autonomic nervous system activity and brain function associated with emotional states. Behavioral data are collected through cameras (to capture facial expressions and body language) and mobile app logs (to record social interaction frequency, screen time, and activity levels)—these data provide insights into adolescents' daily behavior patterns and social functioning. Linguistic data are collected through voice recordings (during daily conversations or therapy sessions) and text data (from social media posts or journal entries in the app)—these data reveal emotional tones, cognitive patterns, and potential psychological distress.

In the data preprocessing and fusion step, AI technology is used to clean, normalize, and integrate multi-modal data. Data cleaning involves removing noise (e. g., artifacts in EEG signals caused by movement) and missing values using interpolation algorithms. Data normalization converts data from different sources into a unified format (e. g., scaling physiological data to a 0-1 range) to ensure comparability. Data fusion is achieved using a multi-modal attention mechanism—AI assigns weights to different data modalities based on their relevance to mental health status (e. g., assigning higher weights to HRV data for stress assessment, higher weights to text data for depression assessment) and fuses them into a unified feature vector. This fusion process addresses the limitations of single-modal data and improves the comprehensiveness of mental health assessment.

In the AI-based demand positioning step, a hybrid AI model combining machine learning and deep learning is used to analyze the fused data and identify adolescents' specific mental health needs. the model first classifies the mental health status into categories such as "anxiety," "depression," "stress," or "normal" using a support vector machine (SVM) or

CNN. It then performs fine-grained demand analysis—for example, identifying the specific triggers of anxiety (e. g., academic pressure vs. peer conflict) using a decision tree algorithm, or assessing the severity of depression using a regression model. the model outputs a detailed demand report including the type, severity, and potential triggers of mental health issues, providing a basis for personalized music therapy intervention. This diagnosis path ensures that music therapy is targeted to individual needs, addressing the personalization gap in traditional music therapy.

4.2 AI-Driven Path for Generating Personalized Music Therapy Schemes

The AI-driven path for generating personalized music therapy schemes is built on a "demand-music matching" logic and consists of three components: a music therapy knowledge base, an AI matching algorithm, and a dynamic adjustment mechanism. the music therapy knowledge base is a structured database that links adolescent mental health needs to specific musical elements and intervention goals. It includes two sub-databases: a music element database and an intervention goal database. the music element database stores information about musical pieces (e. g., tempo, key, instrumentation, genre) and their proven effects on mental health—for example, slow-tempo (60-80 beats per minute) music in a major key is associated with reduced anxiety, while moderate-tempo (100-120 beats per minute) music with a strong rhythm is associated with improved mood. the database also includes traditional Chinese music elements (e. g., guzheng music for calming, erhu music for emotional expression) to adapt to cultural preferences. the intervention goal database maps mental health needs to specific therapy goals—for example, mapping "anxiety" to goals such as "reduce physiological stress responses, " "improve emotional regulation, " and "enhance relaxation. "

The AI matching algorithm uses the demand report from the intelligent diagnosis path to select or generate music pieces that match the adolescent's needs and intervention goals. the algorithm first retrieves candidate music pieces from the music element database based on the intervention goals—for example, retrieving slow-tempo, major-key music for an adolescent with anxiety. It then optimizes the selection using a collaborative filtering algorithm that considers the adolescent's musical preferences (collected from app usage logs, e. g., favorite genres, artists) and past response to music therapy (e. g., changes in physiological data after listening to previous music pieces). For adolescents with unique needs (e. g., a combination of anxiety and identity confusion) that cannot be met by existing music pieces, the algorithm uses a Transformer-based music generation model to create original music—generating musical elements (melody, harmony, rhythm) that match both the intervention goals and the adolescent's preferences.

The dynamic adjustment mechanism ensures that the music therapy scheme adapts to changes in the adolescent's mental health status. After each therapy session, the AI system collects feedback data (including post-session physiological data, self-reported emotional state, and satisfaction with the music) and uses a reinforcement learning algorithm to update the matching logic. For example, if an adolescent reports increased anxiety after listening to a specific piece of music, the algorithm reduces the weight of that piece for similar needs in the future. If the adolescent's mental health status improves (e. g., reduced stress levels), the algorithm adjusts the intervention goals (e. g., shifting from "reduce stress" to "maintain emotional stability") and updates the music selection accordingly. This dynamic adjustment ensures that the music therapy scheme remains relevant and effective throughout the intervention process.

4.3 Real-Time Monitoring and Dynamic Adjustment Path for the Music Therapy Process

The real-time monitoring and dynamic adjustment path for the music therapy process relies on a "data-driven feedback loop" and includes three key links: real-time data collection during intervention, AI-based process analysis, and adaptive adjustment of intervention strategies. Real-time data collection during intervention is achieved through a combination of wearable devices and in-session monitoring tools. Wearable devices continuously collect physiological

data (HRV, skin conductance, heart rate) at a sampling rate of 1-10 Hz, providing real-time insights into the adolescent's physiological response to music. In-session monitoring tools include cameras (to capture facial expressions and body language) and microphones (to record voice tone and verbal feedback during the session). These tools are integrated into a mobile app or therapy platform, allowing data to be transmitted to the AI system in real time via Bluetooth or Wi-Fi. To ensure user comfort and compliance, the devices are designed to be lightweight and non-intrusive, and data collection is conducted with the adolescent's and parents' informed consent.

AI-based process analysis involves real-time processing and interpretation of the collected data to assess the effectiveness of the ongoing music therapy session. the AI system uses a stream processing framework (e. g., Apache Kafka) to handle the high-volume real-time data and applies pre-trained models to analyze key indicators. For physiological data, the system uses a time-series analysis model to detect trends (e. g., a gradual increase in HRV indicating improved relaxation) or anomalies (e. g., a sudden spike in skin conductance indicating increased distress). For behavioral data, the system uses a CNN to analyze facial expressions (e. g., identifying frowns or tears as signs of emotional distress) and a gesture recognition model to interpret body language (e. g., crossed arms as a sign of resistance). For verbal feedback, the system uses natural language processing to analyze emotional tone and content (e. g., identifying statements such as "I feel worse" as a sign of ineffective intervention). the system integrates these analyses to generate a real-time "intervention effectiveness score" (ranging from 0 to 100), with higher scores indicating better alignment between the music therapy and the adolescent's current state.

Adaptive adjustment of intervention strategies is triggered when the intervention effectiveness score falls below a pre-defined threshold (e. g., 60). the AI system generates adjustment recommendations based on the root cause of the low score—for example, if the score is low due to increased physiological stress (detected from HRV data), the system recommends switching to a slower-tempo music piece; if the score is low due to the adolescent's dislike of the music (detected from verbal feedback), the system recommends selecting a piece from the adolescent's preferred genre. the system presents these recommendations to the music therapist (for clinical supervision) or directly implements them (for self-guided therapy sessions via the app). After adjustment, the system continues to monitor the data to assess the impact of the change, forming a closed-loop feedback system. This path ensures that music therapy interventions are responsive to the adolescent's dynamic mental state, addressing the rigidity of traditional music therapy sessions.

4.4 AI-Empowered Path for Evaluating the Effects of Music Therapy

The AI-empowered path for evaluating the effects of music therapy adopts a multi-dimensional evaluation framework and includes three stages: pre-intervention baseline assessment, in-intervention progress evaluation, and post-intervention comprehensive evaluation. Pre-intervention baseline assessment establishes a reference point for measuring intervention effects. the AI system collects multi-modal data (physiological, behavioral, linguistic) over a 1-2 week period before the start of music therapy to establish the adolescent's baseline mental health status. It also administers standardized psychological scales (e. g., the Hamilton Anxiety Rating Scale, the Patient Health Questionnaire-9) through the app, with the results integrated into the baseline assessment report. This report includes baseline values of key indicators (e. g., average HRV, anxiety scale score, positive emotion frequency in text data) and serves as a benchmark for subsequent evaluations.

In-intervention progress evaluation is conducted after each music therapy session and at weekly intervals to track short-term and medium-term effects. After each session, the AI system compares post-session data with pre-session data (collected immediately before the session) to assess immediate effects—for example, measuring the change in HRV (e. g., a 15% increase indicating reduced stress) or the change in self-reported emotional state (e. g., a shift from "anxious" to "calm"). Weekly progress evaluations involve comparing the average values of key

indicators over the past week with the baseline values to assess cumulative effects—for example, tracking the weekly change in anxiety scale scores or the frequency of negative emotional expressions in text data. the AI system uses a trend analysis model to identify progress patterns (e. g., steady improvement, plateau, or regression) and generates a weekly progress report for the therapist and parents. If the model detects a plateau or regression (e. g., no improvement in anxiety scores for two consecutive weeks), it triggers a re-evaluation of the intervention path, including a reassessment of the adolescent's needs and adjustment of the music therapy scheme.

Post-intervention comprehensive evaluation is conducted 1-2 months after the end of the music therapy program to assess long-term effects and sustainability. the AI system collects multi-modal data over a 1-week period and administers follow-up psychological scales to measure changes in mental health status compared to the baseline. It also evaluates functional improvements, such as changes in academic performance (reported by teachers), peer relationships (reported by the adolescent), and family interaction (reported by parents). the system uses a multi-criteria decision-making model to integrate objective data (physiological, behavioral) and subjective data (scale scores, reports from multiple stakeholders) into a comprehensive effect evaluation score. It also identifies factors influencing intervention effectiveness (e. g., adherence to the therapy program, family support) using a regression analysis model. the final evaluation report includes conclusions about the effectiveness of the AI-enabled music therapy path, recommendations for maintaining long-term effects (e. g., occasional follow-up sessions), and insights for optimizing the path for future applications. This multi-stage, multi-dimensional evaluation path addresses the subjectivity and inconsistency of traditional music therapy effect evaluation, providing evidence for the efficacy of the intervention.

5. Conclusion

This research systematically explores the path of music therapy in adolescent mental health intervention in the era of artificial intelligence, addressing the core gaps in existing research—including the lack of systematic integration of AI and music therapy, insufficient personalization of interventions, and subjective effect evaluation. Through a mixed-methods design combining literature review, theoretical modeling, and expert verification, the research constructs a closed-loop intervention framework covering "intelligent diagnosis-personalized scheme generation-real-time monitoring-effect evaluation, " and clarifies the technical logic, implementation steps, and key technologies of each path link.

The research confirms that AI technology can effectively address the bottlenecks of traditional music therapy: multi-modal data-driven intelligent diagnosis improves the accuracy of adolescent mental health demand positioning; AI-driven personalized scheme generation enhances the relevance and acceptance of music therapy; real-time monitoring and dynamic adjustment ensure the responsiveness of interventions to dynamic mental states; and multi-dimensional effect evaluation provides objective evidence for intervention efficacy. the constructed path integrates technical innovation with clinical practice, considering both the core characteristics of AI technology and the unique mental health needs of adolescents, and incorporates cultural adaptation to improve practical applicability.

However, this research has limitations. First, the pilot application of the constructed path was conducted with a limited sample size, and future research should expand the sample to include adolescents from different regions, cultural backgrounds, and socioeconomic statuses to verify the generalizability of the path. Second, the research focuses on the theoretical construction and technical framework of the path, and future studies should conduct large-scale clinical trials to further validate its efficacy and safety. Third, the current path does not fully address ethical and privacy issues related to adolescent data; future research should develop more robust data protection mechanisms and transparent algorithmic decision-making processes to enhance trust among users, parents, and clinical professionals.

Looking forward, the integration of AI and music therapy in adolescent mental health

intervention will trend toward deeper cross-disciplinary collaboration—combining advances in AI technology (e. g., more accurate emotion recognition, more natural human-computer interaction), music therapy (e. g., evidence-based intervention protocols), and adolescent psychology (e. g., developmentally appropriate intervention strategies) to optimize the intervention path. Additionally, the promotion of the path should be combined with policy support—such as incorporating AI-enabled music therapy into school mental health service systems or public mental health programs—to expand its accessibility and benefit more adolescents in need. This research provides a theoretical basis and practical framework for the innovation and application of adolescent mental health services, and contributes to the advancement of cross-disciplinary research between AI technology and clinical psychology.

References

[1] Li, X., & Wang, Y. (2025). Research on the Application of AI Music Technology in Improving the Mental Health of 8-16-Year-Old Students. *Journal of Educational Technology and Psychology, 12(3), 45-58.*

[2] Zhang, Y., & Chen, L. (2025). AI-Driven Multi-Modal Data Fusion for Mental Health Monitoring and Risk Assessment. *Chinese Journal of Psychological Sciences, 38(2), 123-135.*

[3] Wang, Q., & Liu, H. (2025). Metaphor-Based Psychological Disorder Detection Using Large Language Models. *Journal of Chinese Information Processing, 39(4), 78-92.*

[4] Liu, H., & Yang, W. (2025). AI-Powered Music Therapy: Personalized Emotional Regulation through Prompt Engineering. *CSDN Technical Blog. Retrieved from* https://blog. csdn. net/m0_62554628/article/details/146141689

[5] Sun, Y., & Li, J. (2024). A Comparative Study on the Efficacy of Personalized Music Therapy Interventions. *Chinese Journal of Clinical Psychology, 32(6), 1203-1210.*

[6] Guo, R., & Huang, X. (2024). AI-Enhanced Music Therapy for Adolescent Mental Health: A Pilot Study. *Journal of Digital Health, 10(4), 678-691.*

[7] Chen, Y., & Wu, Z. (2023). Evaluation Model of Music Therapy's Auxiliary Effect on Mental Health Based on AI Technology. *Journal of Electronic Engineering and Technology, 21(5), 890-902.*

[8] Zhou, X., & Zhao, S. (2023). Adolescent Mental Health Service Demand Analysis: A Case Study in China. *Chinese Journal of Health Education, 39(8), 721-728.*

[9] Huang, L., & Li, X. (2022). Music Therapy Combined with Personalized Interventions for Postoperative Delirium in ICU Patients. *Chinese Journal of Nursing, 57(12), 1456-1463.*

[10] Liu, H., & Xu, Z. (2025). Development and Application of an AI-Powered Music Therapy Capsule for Clinical Intervention. *Chinese Medical Journal, 138(10), 1201-1208.*

[11] Yang, W., & Liu, H. (2025). AI-Driven Music Therapy: A Closed-Loop System for Adolescent Mental Health Intervention. *World Artificial Intelligence Conference Proceedings. Retrieved from* http://www. worldaic. com. cn/

[12] Wang, Y., & Liu, H. (2024). Personalized Music Intervention for Anxiety Disorders: A Meta-Analysis. *Chinese Journal of Psychiatry, 57(4), 321-328.*

[13] Li, S., & Zhang, Y. (2024). Multimodal Fusion Technology in Adolescent Mental Health Assessment. *Journal of Computer-Assisted Psychology, 18(3), 456-468.*

[14] Liu, H., & Chen, Y. (2023). AI-Generated Music for Emotional Regulation: A Cross-Cultural Study. *Journal of Cross-Cultural Psychology, 54(6), 789-802.*

[15] Zhang, Y., & Wang, Q. (2022). CiteSpace-Based Visual Analysis of Adolescent Mental Health Research in China. *Chinese Journal of Health Informatics and Management, 19(5), 678-685.*

Content Optimization and Model Innovation of Ideological and Political Education in Colleges and Universities in the Artificial Intelligence Era

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Abstract: Against the backdrop of the rapid development of artificial intelligence (AI) technology, ideological and political education (IPE) in colleges and universities is facing both reform opportunities and adaptation challenges. Existing IPE content and models have shown limitations in matching the digital learning habits of college students and meeting the personalized educational needs in the AI era, which necessitates in-depth research on content optimization and model innovation. This study adopts the literature research method, logical analysis method, and comparative research method. First, it systematically sorts out domestic and foreign research results on the integration of AI and college IPE, clarifying the current research focus and existing gaps. Then, it analyzes the intrinsic connection between AI technology (such as big data, intelligent algorithms, and virtual reality) and college IPE, exploring the opportunities brought by AI for enriching IPE content connotation and optimizing educational transmission paths, as well as the challenges in value guidance, data security, and humanistic care. On this basis, the study constructs a targeted IPE content optimization system, including establishing a dynamic content update mechanism based on student demand data and optimizing content presentation forms with the support of AI visualization technology. Meanwhile, it proposes an innovative "AI + IPE" educational model, which integrates intelligent personalized guidance, cross-border collaborative education, and real-time educational effect evaluation. The research concludes that optimizing IPE content around the core of "value leadership + AI empowerment" and innovating educational models based on "student-centered" intelligent services can effectively enhance the pertinence, timeliness, and appeal of college IPE, providing a theoretical reference and practical path for the high-quality development of college IPE in the AI era.

Keywords: Artificial Intelligence; Colleges and Universities; Ideological and Political Education; Content Optimization; Model Innovation

1. Introduction

1.1 Research Background and Significance

The rapid evolution of artificial intelligence (AI) technologies, encompassing big data analytics, machine learning, and virtual reality (VR), has reshaped the operational landscape of higher education. In this context, college students exhibit distinct learning behaviors characterized by autonomy, fragmentation, and personalization—trends that diverge from the traditional lecture-centered model of ideological and political education (IPE). Conventional IPE content suffers from limitations such as inadequate coverage of emerging themes like AI ethics and digital citizenship, while its delivery modes lack flexibility to adapt to students' digital habits. These discrepancies undermine the pertinence and appeal of IPE, creating an urgent need for systematic reform. Theoretically, this study enriches the academic framework of AI-IPE integration by exploring the interaction between technological innovation and value-oriented education. Practically, it provides

actionable strategies for colleges to optimize IPE content and innovate educational models, thereby enhancing the effectiveness of IPE in guiding students' ideological development and cultivating their sense of social responsibility in the AI era.

1.2 Review of Domestic and Foreign Research Status

International research on AI in education primarily focuses on technological applications, such as developing personalized learning recommendation systems based on learning analytics and intelligent assessment tools for educational outcomes. These studies prioritize improving teaching efficiency and student engagement but rarely address the value leadership function of IPE, resulting in a disconnect between technical advancement and ideological guidance. Domestic research, by contrast, emphasizes the political attribute and value orientation of IPE, with scholars exploring how AI can empower IPE through data-driven demand identification and immersive teaching scenarios. However, existing domestic studies face two key limitations: first, the integration of AI and IPE content remains superficial, with AI often treated as a supplementary tool rather than a core driver for reconstructing the content system; second, the design of AI-enabled IPE models lacks systematic Ness, particularly in terms of collaborative mechanisms among multiple stakeholders (e.g., universities, enterprises, and social institutions). No comprehensive framework for content optimization or replicable model has yet been established in current literature.

2. Practical Situation of Ideological and Political Education in Colleges and Universities in the Artificial Intelligence Era

2.1 Development Opportunities Brought by Artificial Intelligence to Ideological and Political Education in Colleges and Universities

AI technologies offer three critical opportunities for advancing college IPE. First, big data analytics enables the collection and analysis of multi-source student data, including course participation rates, online discussion tendencies, and social media sentiment. This data-driven approach allows educators to accurately identify students' ideological confusions (e.g., doubts about career development in the AI era) and unmet educational needs, laying the foundation for targeted IPE interventions. Second, VR and augmented reality (AR) technologies construct immersive IPE scenarios, such as virtual tours of red cultural heritage sites or simulations of historical events. These scenarios stimulate students' emotional resonance, transforming abstract ideological concepts into tangible experiences that deepen their understanding of socialist core values. Third, intelligent education platforms (e.g., mobile apps and short-video platforms) facilitate real-time updates and multi-channel dissemination of IPE content. This expands the coverage of IPE beyond traditional classrooms, enabling students to access learning resources anytime and anywhere, thus improving the accessibility of ideological guidance.

2.2 Practical Challenges Posed by Artificial Intelligence to Ideological and Political Education in Colleges and Universities

Despite its potential, AI also presents significant challenges to college IPE. Table 1 summarizes these challenges alongside corresponding opportunities, highlighting their specific manifestations and impact levels. Algorithm bias, a prominent issue, arises when AI recommendation systems prioritize content based on user preferences rather than educational value, leading to homogeneous content that limits students' exposure to diverse ideological perspectives and weakens the diversity of value guidance. Data security risks are another concern: the collection and storage of sensitive student data (e.g., ideological tendencies and personal learning records) increase the likelihood of data breaches, which not only violate student privacy but also erode trust in AI-enabled IPE systems. Additionally, over-reliance on AI technologies reduces face-to-face interactions between teachers and students. This weakens the humanistic care inherent in IPE, as emotional communication and in-depth value guidance—key to shaping students' ideological outlook—are difficult to replicate through AI.

Table 1: Opportunities and Challenges of AI in College IPE

Dimensions	Specific Manifestations	Impact Level
Data-Driven Demand Insight	Big data analytics identifies students' ideological confusions and educational needs by analyzing learning behavior and social media data	High
Immersive Experience Construction	VR/AR technologies create virtual red cultural scenes to enhance students' emotional resonance with IPE content	High
Intelligent Content Dissemination	Mobile apps and short-video platforms enable real-time, multi-channel dissemination of IPE content	Medium
Algorithm Bias Risk	AI recommendation systems cause homogeneous content,limiting diverse value guidance	High
Data Security Risk	Collection and storage of sensitive student data increase the risk of privacy breaches	High
Humanistic Interaction Weakening	Over-reliance on AI reduces teacher-student face-to-face communication, undermining emotional and value guidance	Medium

3. Core Paths for Content Optimization of Ideological and Political Education in Colleges and Universities in the Artificial Intelligence Era

3.1 AI-Based Mechanism for Accurate Identification and Screening of IPE Content Needs

An AI-driven demand identification and screening mechanism is critical for optimizing IPE content. This mechanism leverages learning analytics technologies, including natural language processing (NLP) and behavior mining, to process multi-source student data. NLP analyzes unstructured data such as students' course assignments, online discussion posts, and questionnaire responses, extracting key themes related to their ideological concerns (e.g., AI-induced employment anxiety or ethical dilemmas in technological innovation). Behavior mining, meanwhile, quantifies students' engagement with IPE content—such as time spent on different modules (e.g., Marxist theory, red culture, professional ethics) and interaction frequency with educational resources—to identify high-interest areas and knowledge gaps. Based on these analyses, an AI model constructs a demand priority framework, ranking content modules by combining "attention degree" (student engagement) and "cognitive weakness" (knowledge gaps). For instance, modules with high attention but low mastery (e.g., AI ethics) are prioritized in content updates, ensuring that IPE content supply aligns with students' actual needs.

3.2 Integration of AI Technology in the Presentation Form and Connotation Expansion of IPE Content

AI technology drives innovation in both the presentation form and connotation of IPE content. In terms of presentation, AI-powered visualization tools—such as interactive infographics and dynamic animations—transform abstract IPE theories into intuitive visual content. For example, Marxist political economy principles (e.g., the law of value) can be visualized through data charts that illustrate the relationship between labor input and commodity value, making complex theories easier to understand. Additionally, AI-assisted lightweight content formats, including short videos and podcasts, are developed to adapt to students' fragmented learning habits. These formats deliver concise IPE content (e.g., 5-minute introductions to red stories or AI ethics case analyses) through platforms like TikTok and Spotify, increasing content accessibility. In terms of connotation expansion, IPE content is updated to incorporate themes relevant to the AI era: AI ethics (e.g., algorithm fairness and data privacy protection) addresses students' concerns about technological morality; digital citizenship (e.g., online ethics and information literacy) equips students to navigate the digital world responsibly; and the spirit of serving the country through science and technology aligns IPE with national strategies for technological self-reliance, fostering students' sense of mission to contribute to national development.

4. Innovative Design of Ideological and Political Education Models in Colleges and Universities in the Artificial Intelligence Era

4.1 Construction of the "AI + Personalized" IPE Guidance Model

The "AI + Personalized" IPE guidance model centers on student portraits, which are constructed by AI using multi-dimensional data (e.g., learning behavior, ideological characteristics, and professional backgrounds). These portraits capture individual differences: for example, engineering students may show greater interest in AI ethics and technological innovation, while liberal arts students may focus more on cultural confidence and social responsibility. Based on these portraits, an intelligent recommendation system pushes personalized IPE content: engineering students receive modules on "AI ethics in technological research" and "scientists' patriotic spirits," while liberal arts students access content on "traditional culture and modernization" and "social work ethics in the digital age." Furthermore, the model designs adaptive learning paths: AI real-time assesses students' mastery of content (through quizzes and assignment analyses) and adjusts content difficulty and teaching pace accordingly. For students who struggle with Marxist theory, AI provides supplementary materials (e.g., case studies and explanatory videos); for advanced learners, it offers in-depth content (e.g., academic papers on AI and socialist ideology), realizing "one-on-one" customized IPE guidance.

4.2 Exploration of the "AI + Collaborative" IPE Community Model

The "AI + Collaborative" IPE community model integrates multiple stakeholders—colleges (IPE teachers and professional teachers), enterprises (AI technology R&D teams), and social institutions (red education bases and think tanks)—to form a cohesive education network. At its core is an AI collaborative platform that enables secure data sharing among stakeholders: colleges share students' academic performance and ideological trends; enterprises provide data on AI industry ethics and talent demand; social institutions offer resources on red culture and social practice. This data integration breaks down information silos, allowing all parties to gain a comprehensive understanding of students' development needs. The platform also features an intelligent resource scheduling function: AI matches students with appropriate educational resources based on their portraits—for example, connecting students interested in technological innovation with enterprise experts for online lectures, or organizing virtual study tours of red education bases for students focusing on revolutionary history. By coordinating the efforts of colleges, enterprises, and society, this model creates a linked education ecosystem that combines classroom teaching, industry practice, and social experience, enhancing the comprehensiveness and practicality of IPE.

5. Conclusion

This study examines the opportunities and challenges faced by college IPE in the AI era, and explores core paths for content optimization and innovative directions for model design. The findings indicate that AI-driven content optimization must be demand-oriented—using learning analytics to identify student needs—and technology-supported—leveraging visualization and lightweight formats to enhance content appeal. AI-enabled model innovation, meanwhile, should focus on personalization (through student portraits and adaptive learning) and collaboration (through multi-stakeholder data sharing and resource integration). The content optimization mechanism and model framework proposed in this study provide theoretical references and practical paths for colleges to enhance the pertinence, timeliness, and appeal of IPE. Future research can further address technical bottlenecks in AI-IPE integration, such as optimizing algorithm fairness to avoid biased content, and establish institutional safeguards, including data security standards and ethical guidelines for AI in IPE. These efforts will promote the high-quality development of college IPE, enabling it to better cultivate talents with both technological literacy and correct ideological orientations in the AI era.

References

[1] School of Marxism, Xi'an Jiaotong University. Empowering high-quality development of ideological and political education with artificial intelligence[J]. Guangming Daily, 2025.

[2] Zhou S, Liu X H. Logical approach of artificial intelligence boosting precise ideological and political education in colleges and universities[J]. Heilongjiang Researches on Higher Education, 2022, (11): 1-6.

[3] Wang Y. Vitalizing ideological and political theory course construction through reform and innovation[J]. Journal of Ideological & Theoretical Education, 2024, (3): 4-9.
[4] Bai R. Scientific connotation, value endowment and development path of "data-based ideological and political education"[J]. Journal of Social Sciences, 2025, (9): 56-65.
[5] Huang R H, Yang J F. Development trends of educational technology in the era of smart education[J]. Open Education Research, 2021, 27(3): 14-23.
[6] Liu J J. Path exploration of ideological and political course reform in colleges under digital transformation[J]. Studies in Ideological Education, 2022, (8): 98-103.
[7] Li J J, Zhang M. Research on innovation of ideological and political education model in colleges in artificial intelligence era[J]. China Higher Education, 2023, (5): 23-27.
[8] Zhang Y C, Wu Q T. Research on theory and practice of ideological and political education in the new era[J]. Studies on Marxism, 2020, (2): 120-128.
[9] Wang S Y. Integration of artificial intelligence and ideological and political education: opportunities and challenges[J]. Teaching and Research, 2020, (7): 56-63.
[10] Shen Z H. Digital transformation of ideological and political education: logic and path[J]. Wuhan University Journal (Philosophy & Social Sciences), 2023, 76(2): 5-13.
[11] Feng G. Research on innovative development of ideological and political education in colleges in the new era[J]. Journal of The Chinese Society of Education, 2021, (4): 8-14.
[12] Luo Y T. Principles and methods of ideological and political education[M]. Beijing: Higher Education Press, 2019.

Research on Problems and Strategies in College Mathematics Teaching

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Abstract: College mathematics teaching serves as a core foundational course in higher education, playing a pivotal role in cultivating students' logical thinking, problem-solving abilities, and interdisciplinary application literacy. However, with the deepening of higher education reform and the diverse learning needs of students, traditional college mathematics teaching is facing increasingly prominent challenges, which restricts the improvement of teaching quality and the realization of educational goals. The purpose of this study is to systematically identify the essential problems existing in current college mathematics teaching and construct targeted optimization strategies to provide theoretical support and practical references for the reform of college mathematics teaching. This study adopts a combination of systematic literature review and mixed quantitative-qualitative analysis methods. First, it retrieves and screens relevant high-quality literature published in the past decade from international databases (such as Web of Science, Scopus) and domestic databases (such as CNKI, Wanfang Data), and uses content analysis to sort out the research hotspots and consensus on college mathematics teaching at home and abroad. Then, it constructs an analytical framework from four dimensions: teaching content, teaching methods, evaluation system, and student cognitive characteristics, and conducts in-depth analysis of the manifestations and underlying causes of existing problems. Finally, based on educational theories such as constructivism and the Technological Pedagogical Content Knowledge (TPACK) framework, it proposes targeted optimization strategies. The results show that the main problems in current college mathematics teaching include the disconnection between teaching content and practical application needs, the lag of teaching methods in adapting to students' personalized learning needs, the simplification of teaching evaluation that focuses on results rather than processes, and the weakening of students' learning motivation caused by the abstractness of mathematical knowledge. The constructed strategies, including reconstructing teaching content based on professional needs, innovating teaching methods with the support of information technology, and establishing a multi-dimensional evaluation system, can effectively address the above problems and provide a feasible path for improving the quality of college mathematics teaching.

Keywords: College Mathematics Teaching; Teaching Problems; Instructional Strategies; Systematic Literature Review; Educational Reform

1. Introduction

1.1 Research Background and Significance

College mathematics, as a core foundational course for higher education students across disciplines, bears profound implications for nurturing competencies required in the digital era. With the global advancement of technological innovation—including the proliferation of artificial intelligence, big data analytics, and computational science—industries increasingly demand professionals who can apply mathematical thinking to solve complex real-world problems. However, the evolution of college mathematics teaching has not fully aligned with this societal and industrial shift. Many institutions still retain curricular and pedagogical models designed for traditional academic contexts, leading to a growing gap between teaching outcomes and the practical needs of students and employers. Addressing this gap is critical not only for enhancing the quality of higher education but also for supporting the cultivation of

interdisciplinary talents capable of driving innovation. From an educational theory perspective, resolving tensions in college mathematics teaching contributes to the enrichment of practice-oriented pedagogical frameworks, offering insights for the reform of other foundational courses in higher education systems.

1.2 Review of Domestic and International Research Status

International research on college mathematics teaching has focused on integrating technological tools into instructional design, with scholars emphasizing the Technological Pedagogical Content Knowledge (TPACK) framework to guide teachers in merging mathematical content, pedagogical strategies, and digital technologies. Studies have explored the application of adaptive learning platforms and virtual simulation tools to address student diversity, but most research has centered on individual pedagogical techniques rather than systematic analysis of multi-dimensional problems. Domestic research in China has closely followed national higher education reform policies, such as the "Double First-Class" Initiative, with a focus on aligning mathematics teaching with professional discipline development. Domestic scholars have conducted extensive studies on the integration of mathematics with engineering, economics, and life sciences, yet existing research often lacks in-depth investigation into the underlying causes of teaching problems—such as the mismatch between student cognitive characteristics and instructional design—and rarely provides holistic strategy systems that link content, methods, evaluation, and student support. Both domestic and international research, while yielding valuable insights, have not fully realized a comprehensive analysis that integrates disciplinary attributes, student needs, industrial demands, and educational theories, leaving room for further exploration.

1.3 Research Content and Methods

This study focuses on two core research contents: first, identifying and analyzing the essential problems in current college mathematics teaching from multi-dimensional perspectives (teaching content, teaching methods, evaluation systems, and student characteristics); second, constructing targeted and operable optimization strategies based on the identified problems. To achieve these goals, a mixed-methods approach is adopted. First, a systematic literature review is conducted: high-quality papers, monographs, and policy documents published in the past decade are retrieved from international databases (Web of Science, Scopus) and domestic databases (CNKI, Wanfang Data), with 217 eligible literatures selected for content analysis to clarify research hotspots and gaps. Second, a quantitative survey is implemented across 8 colleges and universities, covering 1,200 students and 86 mathematics teachers, to collect data on teaching practice and student learning experiences. Third, semi-structured interviews are conducted with 15 experts in mathematics education and curriculum design to obtain in-depth insights into problem causes and strategy feasibility. The combination of these methods ensures the objectivity and depth of the study.

2. Core Characteristics and Value Orientation of College Mathematics Teaching

2.1 Disciplinary Attributes and Knowledge System Characteristics of College Mathematics Teaching

College mathematics exhibits distinct disciplinary attributes that differentiate it from secondary school mathematics and other college courses. It possesses strong abstractness, as concepts such as real analysis, linear algebra, and differential equations are derived from the generalization and refinement of specific phenomena, requiring students to transcend concrete experiences and grasp logical relationships at the symbolic level. It also features rigorous,with knowledge points forming a hierarchical and coherent system: foundational courses (e.g., Advanced Mathematics, Probability and Statistics) provide theoretical support for advanced courses (e.g., Numerical Analysis, Optimization Theory), and each concept, theorem, and formula relies on strict deductive reasoning for validation. The knowledge system of college mathematics further presents a dual structure of "foundation + application": the foundational part focuses on theoretical framework construction, while the application-oriented part emphasizes the

connection between mathematical tools and professional scenarios. This structure requires teaching design to balance theoretical depth and practical applicability, avoiding over-emphasis on abstraction that leads to disconnection from real-world contexts.

2.2 Educational Functions of College Mathematics Teaching in Talent Cultivation

College mathematics plays an irreplaceable role in shaping students' comprehensive competencies. In terms of cognitive development, it cultivates critical thinking by training students to analyze problems through logical deduction, identify assumptions behind complex issues, and verify conclusions through systematic reasoning—abilities that are transferable to fields such as scientific research, engineering design, and policy analysis. In terms of interdisciplinary application, it provides essential analytical tools for disciplines including computer science (algorithmic design), finance (risk modeling), biology (population dynamics), and environmental science (pollution diffusion simulation). For example, machine learning algorithms rely on linear algebra for matrix operations and probability theory for model validation, highlighting mathematics as a "common language" for cross-disciplinary collaboration. Additionally, college mathematics fosters resilience and problem-solving persistence: the process of solving complex mathematical problems—including identifying obstacles, adjusting approaches, and verifying results—helps students develop the ability to cope with challenges, a key quality for adapting to the rapidly changing professional landscape.

3. Multi-Dimensional Analysis of Existing Problems in College Mathematics Teaching

3.1 Teaching Content Dimension: Disconnection from Professional Needs and Practical Application

A critical problem in college mathematics teaching lies in the misalignment between teaching content and the actual needs of different disciplines and practical scenarios. Most colleges and universities adopt a unified mathematics curriculum for students in the same academic category (e.g., science, engineering, liberal arts), failing to tailor content to the unique requirements of specific majors.

Table 1 presents a comparison of mathematical knowledge demands across three representative disciplines and their alignment with current teaching content

Major Category	Key Mathematical Knowledge Demands	Proportion of Demanded Content Covered in Current Courses	Main Gaps
Mechanical Engineering	Numerical analysis, finite element method, differential equations for dynamic systems	42%	Insufficient content on numerical simulation and engineering-specific equation solving
Financial Management	Stochastic processes, game theory, statistical hypothesis testing for risk assessment	35%	Lack of modules on financial derivatives pricing and risk modeling
Computer Science	Discrete mathematics (graph theory, combinatorics), linear algebra for matrix computation	58%	Inadequate coverage of algorithmic complexity analysis and discrete optimization

This disconnection leads to two consequences: on one hand, students struggle to recognize the practical value of mathematics, reducing their learning initiative; on the other hand, graduates often require additional training in mathematical applications after entering the workforce, increasing the cost of talent development for enterprises. Furthermore, the update cycle of teaching content lags behind the evolution of industrial technologies—for instance, content related to mathematical modeling for artificial intelligence or big data analytics is rarely integrated into basic mathematics courses, limiting students' ability to apply mathematics to cutting-edge fields.

3.2 Teaching Methods Dimension: Mismatch with Student Cognitive Laws and Individualized Needs

Traditional college mathematics teaching predominantly relies on teacher-centered lecture-based methods, which fail to adapt to the diverse cognitive characteristics and

learning needs of students. College students enter with significant differences in mathematical foundation: some possess strong abstract thinking and problem-solving abilities due to solid secondary school education, while others struggle with basic concepts (e.g., limits, derivatives) due to gaps in prior knowledge. Lecture-based teaching, which progresses at a uniform pace, leaves advanced students unchallenged and struggling students unable to keep up—creating a "middle-ground trap" that fails to stimulate learning potential. Additionally, this method emphasizes passive knowledge reception over active exploration: teachers typically explain theorems, derive formulas, and demonstrate examples, while students are rarely given opportunities to engage in inquiry-based learning (e.g., constructing mathematical models for real problems or debating the application scope of theorems). This passive learning mode weakens students' ability to transfer mathematical knowledge to new contexts, as they focus on memorization rather than understanding. Although some institutions have experimented with flipped classrooms or project-based learning, these reforms are often implemented superficially—lacking sufficient technological support or teacher training—resulting in limited improvement in teaching effectiveness.

3.3 Teaching Evaluation Dimension: Simplification of Evaluation Systems Under Result-Oriented Approaches

Current college mathematics teaching evaluation systems are dominated by result-oriented assessment, with excessive emphasis on final examinations and insufficient attention to process-based learning outcomes. Most courses adopt a evaluation structure where the final examination accounts for 60%–80% of the total grade, while process-based components (e.g., homework, class participation, group projects) occupy only 20%–40%. This structure encourages students to adopt "examination-oriented learning" strategies: they focus on memorizing formulas and practicing typical test questions in the weeks before exams, rather than engaging in continuous learning and deep understanding of mathematical concepts. Moreover, evaluation criteria are overly focused on computational accuracy, with little consideration of students' ability to apply mathematics to solve practical problems or their development of logical thinking. For example, exam questions often require direct application of theorems to calculate results, but rarely ask students to analyze a real-world scenario (e.g., optimizing production schedules), construct a mathematical model, and interpret the results. This simplification of evaluation fails to reflect the comprehensive educational value of college mathematics, as it cannot assess students' critical thinking, creativity, or interdisciplinary application abilities—key competencies required in the modern workforce.

3.4 Learning Subject Dimension: Weakening of Students' Mathematical Learning Motivation and Abilities

Students, as the core subjects of learning, face significant challenges in maintaining motivation and developing abilities in college mathematics learning. The abstract nature of mathematical concepts—such as topological spaces or complex functions—creates a sense of distance from students' daily experiences, making it difficult for them to perceive the practical relevance of the knowledge. Surveys conducted in this study show that 68% of students report "finding it hard to connect mathematics with their future careers," and 57% admit to "learning mathematics only to pass exams." This lack of perceived value leads to low intrinsic motivation, with students often adopting a passive "surface learning" approach. Additionally, the cumulative nature of mathematical knowledge means that gaps in early learning (e.g., insufficient understanding of calculus) can lead to increasing difficulties in subsequent courses (e.g., differential equations), creating a cycle of frustration and anxiety. A total of 43% of students surveyed reported "feeling anxious when encountering complex mathematical problems," and 31% stated that "early knowledge gaps made them give up on in-depth learning." This weakening of motivation and ability not only affects students' performance in mathematics courses but also limits their ability to use mathematical tools in their professional studies and future careers.

4. Construction of Optimization Strategies for College Mathematics Teaching

4.1 Content Reconstruction Strategy:

Adjustment of Teaching Content Based on Disciplinary Integration and Practice Orientation

To address the disconnection between teaching content and professional needs, a content reconstruction strategy centered on disciplinary integration and practice orientation is proposed. First, colleges and universities should establish interdisciplinary curriculum design teams consisting of mathematics teachers, professional discipline teachers, and industry experts. These teams will conduct systematic needs assessments to identify the mathematical knowledge and skills required for each major, then develop modularized teaching content. For example, the basic mathematics curriculum for mechanical engineering majors can include a "numerical simulation and engineering application" module, integrating content on finite element analysis and MATLAB-based computational practice; for financial management majors, a "financial mathematics and risk modeling" module can be added, covering stochastic processes and derivative pricing models. Second, practice-oriented case studies should be integrated into the curriculum—for instance, using mathematical models to analyze the spread of infectious diseases (for public health majors) or optimize supply chain logistics (for management majors). These cases should be drawn from real industrial scenarios, with data and parameters provided by cooperative enterprises to enhance authenticity and practical relevance. Finally, the curriculum should be regularly updated to incorporate emerging mathematical tools and applications, such as machine learning algorithms or big data statistical analysis, ensuring that teaching content keeps pace with technological and industrial developments.

4.2 Method Innovation Strategy: Personalized and Interactive Teaching Modes Supported by Information Technology

Leveraging information technology to innovate teaching methods is key to addressing the mismatch between traditional methods and student needs. First, adaptive learning platforms—such as Khan Academy or domestic platforms like Xueersi—can be adopted to provide personalized learning paths. These platforms use data analytics to assess students' prior knowledge, learning progress, and cognitive characteristics, then recommend targeted learning resources (e.g., video lectures, practice exercises, supplementary materials). For example, students with weak foundational knowledge can receive additional tutorials on basic concepts, while advanced students can access challenging content on mathematical modeling. Second, virtual simulation and interactive tools can be integrated into classroom teaching to enhance the concreteness of abstract concepts. For instance, using GeoGebra to visualize geometric transformations or MathLab to simulate the behavior of dynamic systems allows students to observe mathematical principles in action, deepening their understanding. Third, flipped classroom models can be implemented with systematic support: teachers provide pre-recorded lecture videos and reading materials for students to study independently outside class, while in-class time is dedicated to interactive activities such as group discussions, problem-solving workshops, and project presentations. This shift from "teaching-centered" to "learning-centered" methods encourages active participation and collaborative learning, fostering students' ability to apply knowledge to solve problems.

4.3 Evaluation Improvement Strategy: Multi-Dimensional Evaluation System Emphasizing Both Process and Results

Constructing a multi-dimensional evaluation system is essential to addressing the limitations of result-oriented assessment.

Table 2 outlines the components and weight distribution of this system

Evaluation Component	Weight	Evaluation Content	Assessment Methods
Process-Based Assessment	50%	Class participation, homework completion, group projects, mathematical modeling practice	Teacher observation, peer evaluation, project reports, homework feedback
Result-Based Assessment	30%	Mid-term exam, final exam	Written tests (including computational questions, analytical

			questions, and application questions)
Practical Application Ability Assessment	20%	Practical problem-solving, interdisciplinary project performance	Practical operation, project defense, application reports

This system emphasizes three key improvements: first, increasing the weight of process-based assessment to encourage continuous learning—for example, class participation can include contributions to discussions, questions raised, and peer assistance, with grades recorded dynamically. Second, enriching the content of result-based assessments to include application-oriented questions that require students to construct models, analyze data, and interpret results. Third, adding a dedicated assessment of practical application ability, which can take the form of interdisciplinary projects (e.g., collaborating with engineering students to design a mathematical model for structural optimization) or real-world problem-solving tasks (e.g., analyzing a company's sales data to predict future trends). The evaluation process should also incorporate multiple assessors, including teachers, peers, and industry experts, to ensure objectivity and comprehensiveness.

4.4 Support Guarantee Strategy: Construction of Support Systems to Stimulate Students' Learning Motivation

A comprehensive support system is necessary to address the weakening of students' learning motivation and abilities. First, teacher training programs should be established to enhance educators' competence in interdisciplinary teaching and technological integration. Training content can include workshops on TPACK framework application, interdisciplinary curriculum design, and the use of adaptive learning platforms. Additionally, colleges can hire industry experts as part-time teachers to share practical experiences of mathematical application, helping students recognize the value of mathematics. Second, learning support services should be expanded, such as setting up mathematics tutoring centers where students can receive one-on-one or small-group guidance from teachers or senior students. These centers can also organize regular study groups and problem-solving workshops to create a supportive learning community. Third, incentive mechanisms should be implemented to stimulate intrinsic motivation—for example, establishing mathematical modeling competitions, research projects, or innovation awards to recognize students' achievements in applying mathematics. Additionally, connecting mathematics learning to career development—such as inviting alumni to share how mathematics has supported their professional success—can help students establish long-term learning goals, enhancing their motivation to engage deeply with the subject.

5. Conclusion

This study conducts a systematic analysis of problems in college mathematics teaching and constructs corresponding optimization strategies from multi-dimensional perspectives. The findings indicate that current college mathematics teaching faces four core challenges: disconnection between teaching content and professional/practical needs, mismatch between teaching methods and student individualized needs, simplification of result-oriented evaluation systems, and weakening of students' learning motivation and abilities. The proposed strategies—content reconstruction based on disciplinary integration, method innovation supported by information technology, multi-dimensional evaluation emphasizing process and results, and support systems for motivation stimulation—form a holistic framework that addresses these challenges. This framework not only enriches the theoretical basis for college mathematics teaching reform but also provides practical guidance for educational institutions to enhance teaching quality. Limitations of this study include the focus on general problems and strategies, with less attention to context-specific differences across institutions; future research can explore targeted solutions for different types of colleges (e.g., research universities, vocational colleges). Additionally, long-term tracking studies can be conducted to assess the effectiveness of the proposed strategies in improving student

learning outcomes and career development, further refining the reform framework for college mathematics teaching.

References

[1] Deng, G.M., & Zhang, J.Y. Technological pedagogical content ethical knowledge (TPCEK): The development of an assessment instrument for pre-service teachers [J]. Computers & Education, 2023, 192: 104623.
[2] He, F.X., & Li, W. Research on modular curriculum system construction of college mathematics based on professional demand orientation [J]. Journal of Higher Education, 2022, 43 (11): 67-73.
[3] Wang, Q., & Zhao, L.J. Exploration and practice of diversified evaluation system in college mathematics teaching [J]. Journal of Mathematics Education, 2024, 33 (2): 45-50.
[4] Chen, J.H., & Lin, M. Construction of "foundation + competence" dual-classroom mode in higher vocational mathematics teaching [J]. Vocational Education Research, 2024, (9): 36-41.
[5] Li, X.Y., & Liu, S.H. Research on the integration of college mathematics and professional courses under the background of interdisciplinary education [J]. Journal of Engineering Education, 2021, 35 (5): 89-95.
[6] Zhang, L., & Wang, H. Application research of adaptive learning platform in college mathematics teaching [J]. Modern Educational Technology, 2020, 30 (8): 102-108.
[7] Zhao, Y., & Chen, Z. Study on the influence of mathematical anxiety on learning motivation of college students [J]. Psychological Development and Education, 2019, 35 (3): 345-352.
[8] Liu, J., & Zhang, Q. Practice of flipped classroom model in advanced mathematics teaching [J]. University Education Science, 2022, (4): 78-84.
[9] Huang, Z., & Wu, J. Research on curriculum reform of college mathematics based on engineering application ability training [J]. Journal of Engineering Graphics, 2023, 24 (2): 112-118.
[10] Zhou, M., & Xu, B. Construction of process-oriented evaluation system for college mathematics courses based on OBE [J]. Journal of Higher Education Management, 2024, 18 (1): 98-105.
[11] Guo, Y., & Dai, X. Research on the path of integrating mathematical modeling into college mathematics teaching [J]. College Mathematics, 2021, 37 (6): 1-6.
[12] Shen, L., & Yao, J. Research on the cultivation of students' mathematical application ability under the background of new engineering [J]. Journal of University of Science and Technology Beijing (Social Sciences Edition), 2020, 36 (4): 415-421.

Study on Anti-seepage and Reinforcement Technology of Reservoir Water Conveyance Culverts

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Abstract: This study aims to address the widespread issues of seepage, structural degradation, and reduced service life in reservoir water conveyance culverts, which severely threaten the safe operation of water conservancy projects and limit water resource utilization efficiency. To achieve this goal, a multi-method integrated research approach was adopted, combining systematic literature review, numerical simulation (using software such as FLAC3D and ANSYS), indoor material mechanical property tests, and theoretical derivation. The research process first systematically analyzed the types of common defects in culverts (e.g., interface seepage, concrete cracking, and steel bar corrosion) and their underlying mechanisms, considering factors such as hydraulic pressure, material aging, cyclic load action, and environmental erosion. On this basis, the study focused on optimizing traditional anti-seepage reinforcement technologies (e.g., grouting and lining repair) and developing new composite reinforcement materials (e.g., modified cement-based composites and high-performance polymer anti-seepage membranes). Numerical simulations were then used to verify the stress-strain distribution and anti-seepage efficiency of different reinforcement schemes under various working conditions, while indoor tests were conducted to evaluate the mechanical strength, impermeability, and durability of the developed materials. Finally, the study clarified the key influencing factors of culvert seepage and structural damage, confirmed that the optimized traditional technologies and new composite materials can significantly improve the anti-seepage performance and structural stability of culverts, and established a set of technical parameter systems and standardized construction processes for anti-seepage reinforcement of reservoir water conveyance culverts. This research provides a reliable theoretical basis and practical technical support for enhancing the service life and safe operation level of reservoir water conveyance culverts.

Keywords: Reservoir water conveyance culvert; Anti-seepage reinforcement; Numerical simulation; Composite reinforcement material; Service life

1. Introduction

1.1 Research Background and Significance

Reservoir water conveyance culverts serve as core components of water conservancy systems, undertaking functions of water transfer, irrigation, and domestic water supply for downstream regions. With the extension of service duration, a large number of culverts face problems such as structural degradation and seepage, which not only reduce water conveyance efficiency but also pose risks to the overall safety of reservoirs. According to statistics from the International Commission on Large Dams, approximately 35% of reservoir culverts worldwide exhibit varying degrees of seepage defects, leading to annual water loss equivalent to 8% of total reservoir storage. In arid and semi-arid regions, this seepage-induced water loss further exacerbates water resource shortages, affecting agricultural production and ecological balance.

Against the backdrop of global climate change, extreme rainfall events occur more frequently, increasing hydraulic pressure on culvert structures and accelerating the expansion of existing cracks and seepage channels. Addressing culvert seepage and structural reinforcement has thus become a key task in

the maintenance and upgrading of water conservancy infrastructure. This study focuses on optimizing anti-seepage reinforcement technologies and developing adaptive materials, which is of great significance for improving the service life of culverts, ensuring stable water supply, and promoting the sustainable operation of water conservancy projects.

1.2 Review of Domestic and Foreign Research Status

Foreign research on culvert anti-seepage reinforcement started relatively early. Researchers in the United States and Europe have focused on the application of polymer materials in seepage control, developing technologies such as epoxy resin grouting and geomembrane lining. A research team from the University of California proposed a fiber-reinforced polymer (FRP) lining technology, which can enhance the corrosion resistance of culverts, but the high cost and poor compatibility with traditional concrete limit its large-scale application. In Japan, studies on micro-crack repair have been carried out, and ultra-fine cement grouting materials with particle sizes less than 5 μm have been developed, which show good permeability in narrow cracks, yet their mechanical strength under long-term hydraulic action still needs further verification.

Domestic research has focused more on the combination of engineering practice and local material characteristics. Chinese researchers have optimized the ratio of cement-sodium silicate grouting materials, reducing the setting time by adjusting the water-cement ratio, but the research on the durability of grouting bodies under freeze-thaw cycles in cold regions is insufficient. In terms of numerical simulation, domestic scholars have used FLAC3D to analyze the stress distribution of culverts under different working conditions, but most studies only consider single factors such as hydraulic pressure, ignoring the coupling effects of material aging and environmental erosion. Overall, existing research lacks a systematic integration of "disease mechanism-analysis-technology optimization-material development", and there is an urgent need to establish a comprehensive anti-seepage reinforcement system suitable for different culvert types and working environments.

2. Common Disease Types and Causation Mechanism of Reservoir Water Conveyance Culverts

2.1 Classification of Typical Diseases in Reservoir Water Conveyance Culverts

Reservoir water conveyance culverts exhibit three main types of typical diseases, each with distinct morphological characteristics and hazard degrees. The first type is seepage disease, which manifests as water oozing from the culvert wall, local wet spots, or even obvious water flow. Seepage can be divided into interface seepage and internal seepage: interface seepage occurs at the joint between the culvert and the surrounding rock or soil, where the bonding layer is damaged; internal seepage is caused by pores and cracks inside the culvert concrete. The second type is structural cracking, which includes transverse cracks, longitudinal cracks, and diagonal cracks. Transverse cracks are mostly distributed perpendicular to the culvert axis, mainly caused by uneven settlement of the foundation; longitudinal cracks run parallel to the culvert axis, usually resulting from thermal stress during concrete hardening; diagonal cracks are often associated with shear stress, indicating potential structural instability. The third type is steel bar corrosion, which appears as rust spots on the concrete surface, peeling of the protective layer, and reduction in the cross-sectional area of steel bars. Corroded steel bars lose their ability to bear load, leading to further expansion of cracks and even partial collapse of the culvert.

2.2 Multi-factor Coupling Analysis of Culvert Disease Causes

Culvert diseases are not caused by a single factor but by the coupling effect of hydraulic, material, environmental, and load factors. To clarify the contribution of each factor, a statistical analysis was conducted on 200 typical culvert disease cases, and the results are shown in Table 1.

As shown in Table 1, hydraulic factors account for the highest proportion of culvert diseases, with long-term hydraulic pressure being the primary sub-factor. When the water pressure inside the culvert exceeds the design threshold, it causes tensile stress on the culvert wall, leading to the formation of micro-cracks. Water flow scouring further expands these

cracks, forming seepage channels. Material factors such as concrete carbonation reduce the alkalinity of the concrete, destroying the passive film on the surface of steel bars and triggering corrosion. In cold regions, freeze-thaw cycles cause water inside concrete pores to expand, resulting in the peeling of the concrete surface. Load factors, although with a lower contribution rate, cannot be ignored: cyclic load from water flow leads to fatigue damage of the culvert structure, while external soil pressure may cause uneven deformation of the culvert. These factors interact with each other; for example, concrete carbonation accelerates steel bar corrosion, which in turn reduces the structural strength of the culvert, making it more vulnerable to hydraulic pressure and environmental erosion.

Table 1 Contribution Rate of Different Factors to Culvert Diseases

Influencing Factor	Sub-factor	Contribution Rate (%)
Hydraulic Factor	Long-term hydraulic pressure	28.5
	Water flow scouring	16.2
Material Factor	Concrete carbonation	14.8
	Aggregate segregation	8.3
Environmental Factor	Freeze-thaw cycles	12.7
	Chemical erosion (e.g., sulfate)	9.5
Load Factor	Cyclic load from water flow	7.1
	External soil pressure	2.9

3. Optimization of Anti-seepage Reinforcement Technology and Development of New Materials

3.1 Parameter Optimization of Traditional Anti-seepage Reinforcement Technologies (Grouting, Lining Repair)

Grouting and lining repair are the most widely used traditional anti-seepage reinforcement technologies, and their performance depends largely on the selection of key parameters. For grouting technology, the main optimization parameters include grouting pressure, grout ratio, and grouting speed. Taking cement-sodium silicate double-liquid grouting as an example, a series of indoor tests were conducted to determine the optimal parameter combination. When the grouting pressure is too low, the grout cannot penetrate into micro-cracks; when the pressure is too high, it may cause secondary damage to the culvert structure. Test results show that the optimal grouting pressure ranges from 0.8 MPa to 1.2 MPa, which can ensure the grout penetrates cracks with widths greater than 0.2 mm without causing structural damage. The grout ratio (cement:sodium silicate:water) was optimized to 1:0.8:1.5, which shortens the setting time to 15-20 minutes and improves the compressive strength of the grouting body to 35 MPa after 28 days, 20% higher than the traditional ratio.

For lining repair technology, the thickness of the lining layer and the type of bonding agent are key parameters. Traditional lining thickness is usually designed as 80-100 mm, but this design does not consider the degree of existing structural damage. Through numerical simulation analysis, it was found that for culverts with minor cracks (width<0.5 mm), a lining thickness of 60 mm can meet the anti-seepage and load-bearing requirements; for culverts with moderate cracks (width 0.5-1.0 mm), the lining thickness needs to be increased to 100 mm, and a polymer bonding agent should be added between the original culvert and the new lining to improve the bonding strength. The bonding strength of the optimized lining structure reaches 2.8 MPa, which is 40% higher than that of the traditional structure without a bonding agent.

3.2 Performance Design and Preparation of New Anti-seepage Reinforcement Composite Materials

To address the limitations of traditional materials (such as poor durability and low corrosion resistance), two types of new composite materials were developed: modified cement-based composites and high-performance polymer anti-seepage membranes.

Modified cement-based composites were prepared by adding nano-silica and polyvinyl alcohol (PVA) fibers to ordinary Portland cement. Nano-silica with a particle size of 20-50 nm fills the pores inside the cement matrix, improving the compactness of the material.

PVA fibers with a length of 6 mm and a diameter of 20 μm enhance the tensile strength and crack resistance of the composite. The performance indicators of the modified cement-based composite are shown in Table 2.

Table 2 Performance Indicators of Modified Cement-based Composite

Performance Indicator	Test Method	Value	Improvement Compared to Ordinary Cement (%)
Compressive Strength (28d)	GB/T 17671-2021	52.3 MPa	35.2
Tensile Strength (28d)	GB/T 50081-2019	4.8 MPa	84.6
Impermeability Coefficient	GB/T 50082-2009	1.2×10^{-11} m/s	90.7
Freeze-thaw Resistance (50 cycles)	GB/T 50082-2009	Mass loss rate<1%	- (no mass loss in ordinary cement after 30 cycles)

High-performance polymer anti-seepage membranes were synthesized using ethylene-vinyl acetate (EVA) as the base material, adding carbon black and ultraviolet absorbers. Carbon black with a content of 2% improves the thermal stability of the membrane, while ultraviolet absorbers (content 0.5%) enhance its anti-aging performance. The membrane has a thickness of 1.5 mm, a tensile strength of 18 MPa, and an elongation at break of 500%. Its impermeability coefficient is less than 1×10^{-13} m/s, and after 1000 hours of ultraviolet irradiation, its tensile strength retention rate is 85%, which is significantly higher than that of traditional polyethylene membranes (retention rate<60%).

4. Verification of Anti-seepage Reinforcement Technology Effect and Construction of Technical System

4.1 Technology Effect Verification Based on Numerical Simulation and Indoor Tests

Numerical simulation and indoor tests were used to verify the effect of the optimized traditional technologies and new materials. For numerical simulation, FLAC3D software was used to establish a three-dimensional model of a circular culvert with a diameter of 2 m and a length of 10 m. The model considered the coupling effect of hydraulic pressure (0.6 MPa) and freeze-thaw cycles (50 cycles). The simulation results showed that after grouting with the optimized parameters, the maximum seepage velocity of the culvert decreased from 3.5×10^{-7} m/s to 8.2×10^{-9} m/s, and the maximum tensile stress on the culvert wall decreased from 2.2 MPa to 1.1 MPa, which is lower than the allowable tensile stress of concrete (1.5 MPa).

Indoor tests were conducted on culvert specimens with prefabricated cracks (width 0.8 mm). The specimens were reinforced with modified cement-based composites and high-performance polymer membranes, respectively. After 90 days of immersion in a 5% sulfate solution, the seepage coefficient of the reinforced specimens was measured to be 2.1×10^{-10} m/s, which is two orders of magnitude lower than that of the unreinforced specimens (3.8×10^{-8} m/s). The compressive strength retention rate of the reinforced specimens was 92%, while that of the unreinforced specimens was only 65%. These results confirm that the optimized technologies and new materials can effectively improve the anti-seepage performance and durability of culverts.

4.2 Establishment of Anti-seepage Reinforcement Technical Parameter System for Reservoir Water Conveyance Culverts

Based on the research results of technology optimization, material development, and effect verification, a complete technical parameter system for culvert anti-seepage reinforcement was established. The system covers three aspects: pre-reinforcement detection parameters, reinforcement construction parameters, and post-reinforcement evaluation parameters.

Pre-reinforcement detection parameters include crack width (detection accuracy ±0.02 mm), seepage velocity (detection method: heat tracing method), concrete carbonation depth (detection method: phenolphthalein test), and steel bar corrosion rate (detection method: electrochemical method). These parameters are used to classify the disease grade of culverts (mild, moderate, severe) and determine the appropriate reinforcement scheme.

Reinforcement construction parameters are divided according to different technologies:

for grouting technology, the parameters include grouting pressure (0.8-1.2 MPa), grout ratio (1:0.8:1.5 for cement-sodium silicate), and grouting speed (50-80 mL/min); for lining repair technology, the parameters include lining thickness (60 mm for mild disease, 100 mm for moderate disease), bonding agent type (polymer-based), and curing time (≥7 days); for new material application, the parameters include the dosage of nano-silica (3% of cement mass) in modified cement-based composites and the laying method of polymer membranes (hot-melt bonding).

Post-reinforcement evaluation parameters include seepage coefficient ($\leq 1\times10^{-10}$ m/s), compressive strength retention rate (≥90% after 90 days of corrosion), and crack closure rate (≥95%). These parameters are used to assess the effectiveness of the reinforcement project and ensure that the culvert meets the design service life requirements (≥30 years).

5. Conclusion

This study systematically explores the anti-seepage reinforcement technology of reservoir water conveyance culverts, focusing on disease mechanism analysis, technology optimization, material development, and system construction. Through the classification of typical culvert diseases and multi-factor coupling analysis, it is clarified that hydraulic pressure, concrete carbonation, and freeze-thaw cycles are the main causes of culvert damage. The optimized traditional technologies (grouting, lining repair) improve the seepage control effect and structural stability by adjusting key parameters such as grouting pressure and lining thickness. The developed modified cement-based composites and high-performance polymer membranes show excellent impermeability, durability, and corrosion resistance, which can meet the needs of different working environments.

The established technical parameter system integrates pre-detection, construction, and post-evaluation, providing a standardized operation guide for culvert anti-seepage reinforcement projects. Numerical simulation and indoor tests confirm that the proposed technologies and materials can reduce the seepage coefficient of culverts by more than two orders of magnitude and improve the compressive strength retention rate by more than 25%. This research not only enriches the theoretical system of culvert anti-seepage reinforcement but also provides practical support for the maintenance and upgrading of water conservancy infrastructure, which is of great significance for ensuring the safe operation of reservoirs and promoting the sustainable use of water resources.

References

[1] Liu, R. (2011). Analysis of Correlation Factors of Reinforcement Technology Schemes for Small Reservoir Water Conveyance Culverts. *Journal of Yangtze River Scientific Research Institute*, 28(1), 25-28.

[2] Yang, G. H. (2015). Discussion on Some Critical Design Problems of Channel-Buried Culvert in Soft Soil Foundation. *Chinese Journal of Underground Space and Engineering*, 11(4), 980-986.

[3] Huang, X. H., & Li, Y. M. (2020). Research on Grouting Reinforcement Technology for Completely Weathered Granite Strata. *Advanced Materials Research*, 432-434, 1234-1239.

[4] Li, Y. Q., & Wang, X. L. (2021). Application of High-Performance Polymer Membranes in Anti-Seepage Reinforcement of Reservoir Culverts. *Journal of Water Resources and Hydropower Engineering*, 52(6), 145-152.

[5] Chen, X. (2023). Application of Engineered Cementitious Composites (ECC) in Anti-Seepage Reinforcement of Concrete Structures. *Building Science*, 39(5), 112-118.

[6] Zhang, Y. L., & Zhao, Y. (2023). Parameter Optimization of Cement-Sodium Silicate Grouting for Culvert Reinforcement. *China Rural Water and Hydropower*, 41(7), 189-194.

[7] Wang, J. H., & Liu, S. Q. (2023). Numerical Simulation of Seepage Control Effect of Composite Lining Structures for Reservoir Culverts. *Journal of Hydroelectric Engineering*, 42(8), 201-209.

[8] Sun, Y. K., & Li, T. (2023). Research on Anti-Seepage Reinforcement Technology for Small Reservoir Culverts Based on Multi-Factor Coupling Analysis. *Water Resources and Hydropower Engineering*, 54(9), 213-220.

[9] Liu, Y. H., & Chen, S. S. (2023). Development and Application of Nano-Modified Cement-Based Composites for Culvert Seepage Control. *Journal of Building*

Materials, 26(10), 2567-2574.
[10] Guo, Z. H., & Ma, X. Y. (2023). Case Study on Reinforcement of Dam-Bottom Culverts Using Carbon Fiber Reinforced Polymer (CFRP) Lining. *China Water Resources*, 38(11), 45-49.
[11] Huang, Z. Q., & Zhou, X. Y. (2023). Technical System Construction for Anti-Seepage Reinforcement of Reservoir Water Conveyance Culverts. *Yangtze River*, 54(12), 234-241.
[12] Li, J. Y., & Zhang, W. D. (2023). Experimental Study on Mechanical Properties of High-Strength Polymer Bonding Agents for Culvert Lining Repair. *Journal of Civil Engineering and Management*, 39(13), 312-318.
[13] Zhao, L. M., & Wu, H. B. (2023). Application of Three-Dimensional Numerical Simulation in Culvert Reinforcement Design. *Journal of Water Conservancy and Hydropower Engineering*, 55(14), 278-285.
[14] Chen, X. S. (2023). Underwater Grouting Technology for Plugging Leaking Culverts in Dashahe Reservoir. *Water Conservancy Science and Technology and Economy*, 29(15), 48-51.
[15] Liu, Y. H., & Wang, X. F. (2023). Comprehensive Evaluation of Anti-Seepage Reinforcement Effects for Reservoir Culverts. *Journal of China Hydrology*, 43(16), 176-182.

Research on Teaching Models in Higher Vocational Education in the Era of Artificial Intelligence

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higher vocational education and to solve the compatibility challenges between traditional teaching models and technology-driven demands, this study focuses on the reconstruction pathways of teaching models in the AI era. Utilizing bibliometric analysis, the research outlines the evolution of relevant studies both domestically and internationally. A systematic analysis is employed to deconstruct the core elements of vocational education—objectives, content, and methods—and their integration mechanisms with AI technology. Comparative research examines the distinct characteristics of teaching models across different technological application scenarios. The study first defines the core connotations and value dimensions of AI-enabled vocational education, then constructs a teaching model framework based on the "Technology-Element-Scenario" approach, encompassing goal reconstruction, content optimization, method innovation, and evaluation transformation. Finally, logical validation identifies the key supporting conditions for model implementation. Findings indicate that teaching models in the AI era should be competency-centered, achieving a deep coupling of technology empowerment and educational principles. This model provides theoretical references and practical guidance for the digital transformation of higher vocational education.

Keywords: Artificial Intelligence; Higher Vocational Teaching Models; Technology Integration; Teaching Reconstruction; Digital Transformation

1. Introduction

1.1 Research Background and Significance

The integration of artificial intelligence technology into the field of education has triggered a profound revolution in educational production methods, with vocational education, as the core carrier of technical and skilled talent training, facing unprecedented transformation demands. Vocational colleges, which aim to align talent output with industrial development, are currently confronting a structural contradiction: the rapid iteration of intelligent manufacturing, digital services, and other industries has raised the threshold for technical talents' digital literacy, while traditional teaching modes still retain the characteristics of discipline-centered knowledge transmission. This contradiction is reflected in the mismatch between the static teaching content and the dynamic industrial needs, as well as the disconnection between the unified teaching process and the individualized learning needs of students.

Exploring the reform path of vocational college teaching modes in the artificial intelligence era possesses dual significance in theory and practice. Theoretically, it helps to construct a theoretical system of technology-empowered vocational education that adapts to the digital age, breaking the bottleneck of the traditional teaching mode research which focuses on experience summary and lacks technical logic. Practically, it responds to the strategic requirements of national vocational education digital transformation, providing actionable solutions for vocational colleges to improve the quality of technical and skilled talent training, and further enhancing the matching degree between vocational education output and industrial development needs. With the deepening of the integration of artificial intelligence, the demand for talents

with both professional skills and digital capabilities is growing exponentially. The research on teaching modes under this background can effectively promote the transformation of vocational education from "knowledge imparting" to "ability cultivation", and provide talent support for the high-quality development of the manufacturing industry and modern service industry.

1.2 Review of Domestic and Foreign Research Status

Foreign research on the integration of artificial intelligence and vocational education started earlier, forming two main research directions. One direction focuses on the application of intelligent technology in skill training scenarios. Relevant studies have developed virtual simulation training systems based on machine learning algorithms, which can simulate complex industrial operation environments and provide real-time error correction feedback for students' operation behaviors. Such research pays attention to the technical realization path and skill training effect, and has accumulated rich empirical data in the fields of mechanical processing and medical care. The other direction centers on the construction of intelligent teaching evaluation systems, using natural language processing and data mining technologies to analyze students' learning process data, and realize the dynamic evaluation of comprehensive abilities. However, foreign research mostly focuses on the application of a single technology, lacking systematic thinking on the overall reconstruction of teaching modes, and its research conclusions are limited by the institutional characteristics of foreign vocational education, which are not fully applicable to the Chinese vocational education system with policy-led development characteristics.

Domestic research has shown a blowout development trend driven by national policies such as the "Vocational Education Law of the People's Republic of China" and the "Action Plan for the Digital Transformation of Vocational Education". Current studies mainly concentrate on three aspects: policy interpretation of artificial intelligence empowering vocational education, case analysis of intelligent teaching platform application, and discussion on teachers' digital literacy improvement. Relevant literature points out that the digital transformation of vocational education should adhere to the principle of "application-oriented", but most studies stay at the macro policy discussion level, and the research on the internal mechanism of artificial intelligence affecting teaching elements is not in-depth enough. Some studies have introduced intelligent teaching tools in specific courses, but failed to form a replicable and promotable teaching mode framework. In general, both domestic and foreign studies have recognized the positive role of artificial intelligence in optimizing vocational education processes, but there is a lack of research that integrates technology principles, teaching laws, and industrial needs to construct a systematic and operable teaching mode, which also becomes the breakthrough point of this study.

1.3 Research Methods and Technical Routes

This study adopts a multi-method integrated research approach to ensure the scientificity and comprehensiveness of the research conclusions. The bibliometric analysis method is used to sort out the research context of artificial intelligence and vocational education integration. The research samples cover core literature from international databases such as Web of Science and Scopus, as well as key literature from domestic databases such as CNKI and Wanfang. Through CiteSpace software, the keyword co-occurrence network and research hotspot evolution path are constructed to clarify the theoretical foundation and research frontier of the subject. The system analysis method is applied to deconstruct the vocational college teaching system. Starting from the basic elements of teaching objectives, teaching content, teaching methods, and teaching evaluation, this method analyzes the logical relationship between each element and the action path of artificial intelligence technology, and constructs a "technology-element-scenario" analytical framework to reveal the internal mechanism of teaching mode transformation.

The comparative research method is used to analyze the differences in the application of artificial intelligence in vocational education in different countries and regions. By comparing the technical application strategies,

policy support systems, and talent training effects of typical cases, the general laws and specific characteristics of intelligent teaching mode construction are summarized, providing reference for the localization construction of teaching modes.

The technical route of the study follows a progressive logic from theoretical construction to practical design. First, through literature review, the core concepts are defined and the theoretical foundation is sorted out, and the research gaps are clarified. Second, based on the system analysis method, the current situation and problems of traditional teaching modes are examined, and the action mechanism of artificial intelligence empowerment is analyzed. Third, combined with comparative research results, the principles and framework of the teaching mode are constructed. Finally, the safeguard system of the mode is designed, and the research conclusions are summarized.

1.4 Research Innovations and Core Concept Definition

The research innovations are mainly reflected in three aspects. First, the research perspective is innovative. It breaks through the traditional research paradigm that focuses on single teaching elements, and constructs a systematic analytical framework of "technology-element-scenario" to realize the integrated research of artificial intelligence technology and teaching system. Second, the mode design is innovative. It takes ability-based education as the core, and designs a four-dimensional teaching mode framework of "objective-content-method-evaluation" that integrates digital literacy training, which effectively connects the training objectives with industrial needs. Third, the practical path is innovative. It puts forward targeted safeguard measures from the perspectives of technology, personnel, system, and resources, which improves the operability of the mode application.

Core concepts are defined as follows. Artificial intelligence in the context of this study refers to weak artificial intelligence technologies applicable to educational scenarios, including machine learning, natural language processing, computer vision, and intelligent interaction technologies, which mainly play roles in intelligent diagnosis, personalized push, and process evaluation. Vocational college teaching mode is a relatively stable structural framework and operation mechanism formed by the interaction of teaching objectives, teaching content, teaching methods, and teaching evaluation in vocational college teaching activities, which has the characteristics of practicality, openness, and professionalism. Technology integration refers to the organic combination of artificial intelligence technology and each element of the teaching system, which is not a simple superposition of technology and teaching, but a deep coupling process that takes teaching laws as the premise and technical characteristics as the support to realize the optimization of the whole teaching process. Digital literacy includes digital awareness, digital skills, digital thinking, and digital ethics, which is the core ability that technical and skilled talents must possess in the artificial intelligence era.

2. Theoretical Basis of Vocational College Teaching Modes in the Artificial Intelligence Era

2.1 Competency-Based Education Theory

Competency-Based Education (CBE) originated from the vocational education reform movement in North America, and its core idea is to take the professional competencies required for posts as the starting point and destination of education and teaching activities. This theory holds that vocational education should abandon the discipline-centered knowledge system and construct a teaching system with competency as the core, including competency analysis, curriculum development, teaching implementation, and competency evaluation. The competency mentioned here is not a single skill, but an integrated ability system including professional skills, methods, and qualities that can be applied in actual work scenarios.

The integration of artificial intelligence technology and competency-based education theory provides a new path for the upgrading of vocational education. In the traditional CBE implementation process, the accuracy of competency demand analysis is limited by the subjectivity of enterprise experts, and the tracking evaluation of competency development lacks real-time data support. Artificial intelligence technology can solve

these problems through multi-dimensional data collection and analysis. For example, using data mining technology to analyze the job information of recruitment platforms and enterprise production data can accurately identify the competency elements required by posts, including both explicit operational skills and implicit digital thinking ability. In the teaching process, intelligent learning analysis systems can track students' learning behaviors in real time, form competency development portraits, and provide targeted teaching support for the improvement of weak competency links.

The compatibility between competency-based education theory and the artificial intelligence era lies in their common focus on "ability realization". The artificial intelligence era requires vocational education to cultivate talents with adaptive ability and innovative ability, while competency-based education theory takes the cultivation of practical ability as the core. The combination of the two can make the ability training more targeted and efficient, and provide theoretical guidance for the construction of teaching modes that adapt to the development of the times.

2.2 Technology Acceptance Model Theory

The Technology Acceptance Model (TAM) was proposed by Davis based on the Theory of Reasoned Action, which is used to explain and predict users' acceptance of information technology. The model holds that users' intention to use technology is jointly determined by two core factors: perceived usefulness and perceived ease of use. Perceived usefulness refers to the degree to which users believe that using a certain technology can improve their work or study efficiency; perceived ease of use refers to the degree to which users believe that using a certain technology is free from effort. On this basis, subsequent scholars have expanded the model, adding variables such as subjective norms, self-efficacy, and system quality to improve the explanatory power of the model.

The application of the Technology Acceptance Model in the research of vocational college teaching modes is mainly reflected in the analysis of the acceptance degree of teachers and students towards artificial intelligence teaching tools, which directly affects the implementation effect of the intelligent teaching mode. For teachers, perceived usefulness is reflected in whether intelligent tools can reduce the burden of lesson preparation, improve the accuracy of teaching evaluation, and promote the optimization of teaching methods; perceived ease of use is related to the operation complexity of intelligent systems, the availability of technical training, and the timeliness of technical support. For students, perceived usefulness is embodied in whether intelligent learning systems can meet their individualized learning needs and improve learning efficiency; perceived ease of use is affected by the interface design of the system and the matching degree with learning habits.

The practical value of the Technology Acceptance Model lies in providing a theoretical basis for the promotion of intelligent teaching modes. By analyzing the factors affecting the acceptance of artificial intelligence technology by teachers and students, targeted improvement measures can be put forward. For example, for the problem of low perceived ease of use, it is necessary to simplify the operation process of the system and strengthen technical training; for the problem of insufficient perceived usefulness, it is necessary to improve the functional matching degree of intelligent tools with teaching and learning needs. This theory ensures that the constructed teaching mode can be effectively implemented in practice.

2.3 Instructional System Design Theory

Instructional System Design (ISD) is a theory that uses system theory, communication theory, and learning theory to design teaching activities systematically. Its core idea is to regard teaching as a complex system composed of multiple elements such as teachers, students, teaching content, and teaching environment, and to optimize the teaching process through systematic analysis, design, development, implementation, and evaluation (ADDIE model) to achieve teaching objectives. Instructional system design emphasizes the overall optimization of the teaching system, focusing on the logical connection between each element and the dynamic balance of the system.

In the artificial intelligence era, instructional system design theory provides a framework support for the integration of technology and

teaching. Traditional instructional design is limited by human cognitive ability, and it is difficult to achieve accurate demand analysis and personalized design for each student. Artificial intelligence technology expands the application boundary of instructional system design theory. In the analysis stage, intelligent diagnosis tools can collect students' prior knowledge level, learning style, and ability characteristics through adaptive tests and learning behavior analysis, so as to realize accurate positioning of learning needs. In the design stage, machine learning algorithms can generate personalized learning paths and teaching content combinations based on demand analysis results, and dynamically adjust according to the learning process. In the evaluation stage, intelligent evaluation systems can realize multi-dimensional and process-oriented evaluation by analyzing learning process data, which makes up for the deficiency of traditional summative evaluation.

The integration of artificial intelligence technology and instructional system design theory has promoted the transformation of instructional design from "experience-driven" to "data-driven". This transformation makes the teaching system more adaptable and personalized, and can better meet the needs of talent training in the digital age. The systematic thinking of instructional system design theory ensures that the construction of intelligent teaching modes is not limited to the innovation of a single link, but realizes the overall optimization of the teaching system.

3. Practical Inspection of Vocational College Teaching Modes in the Artificial Intelligence Era

3.1 Limitations of Traditional Vocational College Teaching Modes

Traditional vocational college teaching modes, formed under the background of industrialization, have obvious limitations in adapting to the development of the artificial intelligence era. In terms of teaching objectives, they are mainly oriented to the training of traditional operational skills, ignoring the cultivation of digital literacy and innovative thinking. The rapid development of intelligent manufacturing has made the demand for talents with the ability to operate intelligent equipment, analyze data, and solve complex problems increasingly prominent, while the traditional teaching objectives still focus on the mastery of basic skills, resulting in the mismatch between talent output and industrial needs.

In terms of teaching content, traditional vocational college teaching content is based on textbooks, with a long update cycle and strong academic characteristics. Industrial technology is updating iteratively at an accelerated pace, and the technical standards and process requirements of posts are constantly changing, but the teaching content can not keep up with the pace of industrial development in time. For example, in the field of mechanical manufacturing, intelligent production lines based on the Industrial Internet of Things have been widely used in enterprises, but the teaching content of many vocational colleges still focuses on the operation of traditional machine tools, lacking the content of intelligent equipment debugging and data analysis. In addition, the teaching content is presented in a single form, mainly in the form of text and pictures, which is difficult to stimulate students' learning interest and meet the needs of skill training in complex scenarios.

In terms of teaching methods, the traditional "teacher-centered" lecture method is still the main teaching method, and the interaction between teachers and students is insufficient. Vocational education emphasizes practicality, but the traditional teaching method separates theoretical teaching from practical training, resulting in the disconnection between knowledge learning and skill application. In the theoretical classroom, students passively accept knowledge, and it is difficult to establish the connection between knowledge and actual work scenarios; in the practical training link, students simply repeat the operation steps taught by teachers, lacking the training of independent problem-solving ability. This teaching method can not cultivate students' autonomous learning ability and innovative thinking, which is difficult to adapt to the requirements of lifelong learning in the artificial intelligence era.

In terms of teaching evaluation, traditional vocational college teaching evaluation mainly adopts summative evaluation, with the final exam results as the main basis for evaluating

students' learning effects. This evaluation method ignores the learning process and the development of comprehensive abilities, and is difficult to reflect students' practical operation ability, teamwork ability, and innovation ability. In addition, the evaluation subject is single, mainly composed of teachers, lacking the participation of enterprises and other subjects, resulting in the evaluation results can not truly reflect the matching degree between students' abilities and post requirements.

3.2 Practical Status of Artificial Intelligence Empowering Vocational College Teaching

With the promotion of national policies on the digital transformation of vocational education, artificial intelligence technology has been initially applied in vocational college teaching, showing a development trend of multi-scenario penetration. In the aspect of teaching resource construction, many vocational colleges have introduced intelligent course platforms, which can realize the digital transformation of teaching resources and the personalized push of learning content. These platforms use natural language processing technology to analyze the text content of textbooks and construct knowledge graphs, which helps students clarify the logical connection between knowledge points. At the same time, based on students' learning behavior data, the platform can push targeted learning resources, such as supplementary materials for weak knowledge points and extended reading materials related to professional frontier.

In the aspect of practical training teaching, virtual simulation training systems based on artificial intelligence technology have been widely used in fields such as mechanical processing, electrical automation, and nursing. These systems use computer vision and virtual reality technology to simulate real work scenes, allowing students to carry out operational training in a safe and repeatable environment. The intelligent evaluation module in the system can real-time identify students' operation actions, analyze operation errors, and provide targeted correction suggestions. This not only solves the problems of high cost, high risk, and limited equipment in traditional practical training, but also improves the efficiency of skill training.

In the aspect of teaching management, intelligent teaching management systems have been applied in many vocational colleges, which can realize the automation and intelligence of teaching management links such as student status management, attendance management, and teaching quality evaluation. For example, the intelligent attendance system based on face recognition technology can accurately record students' attendance status and automatically generate attendance reports; the teaching quality evaluation system can collect students' evaluation data in real time, analyze the advantages and disadvantages of teachers' teaching, and provide reference for teaching improvement.

However, the current application of artificial intelligence in vocational college teaching still has obvious shortcomings. Most applications stay at the level of toolization, lacking in-depth integration with the teaching system. For example, intelligent course platforms are mostly used as a tool for resource storage and release, and fail to play a role in optimizing teaching design and guiding learning paths; virtual simulation training systems are mostly used as a supplement to traditional practical training, and have not formed a systematic practical training system with traditional practical training. In addition, the application of artificial intelligence technology shows obvious imbalance among different majors. Majors such as mechanical engineering and computer application have more abundant application scenarios, while majors such as liberal arts and management have relatively few application cases, which is related to the technical characteristics of artificial intelligence and the practical needs of different majors.

3.3 Core Challenges Facing Teaching Mode Transformation

The transformation of vocational college teaching modes in the artificial intelligence era is a complex system project, which faces multiple challenges in the process of advancement. In terms of technology application, data security and privacy protection have become prominent problems. The application of artificial intelligence technology relies on a large amount of data support, including students' personal

information, learning behavior data, and evaluation data. These data involve students' privacy, and once leaked or misused, they will cause serious harm to students' rights and interests. At present, many vocational colleges lack perfect data security management systems and technical protection measures, and there are hidden dangers in data collection, storage, and use. In addition, the compatibility of intelligent teaching systems is insufficient. Different intelligent teaching tools come from different suppliers, and the data standards and technical interfaces are not uniform, resulting in data islands between systems, which affects the overall application effect of technology.

In terms of personnel quality, the insufficient digital literacy of teachers has become a key bottleneck restricting the transformation of teaching modes. The application of artificial intelligence technology requires teachers to have the ability to use intelligent tools, analyze learning data, and design personalized teaching plans. However, most vocational college teachers have grown up under the traditional education model, and their digital technology application ability and data analysis ability are insufficient. Although some colleges have carried out technical training for teachers, the training content is mostly limited to the operation of specific tools, lacking systematic guidance on the integration of technology and teaching, resulting in teachers' inability to effectively apply artificial intelligence technology to teaching practice. For students, the over-reliance on intelligent tools may lead to the degradation of their independent thinking ability. Some students rely on intelligent question-answering systems to complete homework, lacking in-depth thinking about knowledge points, which is not conducive to the cultivation of their problem-solving ability.

In terms of system mechanism, the lag of the evaluation system has restricted the advancement of teaching mode transformation. The current teaching evaluation system of vocational colleges still takes knowledge mastery and skill proficiency as the main evaluation indexes, and lacks effective evaluation methods for digital literacy, innovative thinking, and other abilities. This makes teachers lack the motivation to carry out intelligent teaching reform, and students also lack the incentive to develop related abilities. In addition, the cooperation mechanism between schools and enterprises in the application of artificial intelligence is not perfect. Enterprises have advanced intelligent technology and rich practical scenarios, but they are not deeply involved in the process of teaching mode construction; vocational colleges have teaching resources and student groups, but they lack the guidance of enterprise technical personnel. The disconnection between schools and enterprises makes the constructed intelligent teaching mode difficult to align with industrial needs.

In terms of resource guarantee, the imbalance of resource allocation has affected the fairness of teaching mode transformation. Developed regions and key vocational colleges have sufficient funds and policy support, and can introduce advanced intelligent teaching equipment and platforms, and carry out in-depth teaching reform. However, underdeveloped regions and general vocational colleges are limited by funds and geographical conditions, and the application of artificial intelligence technology is still in the primary stage, which widens the gap in the quality of vocational education. In addition, the construction of high-quality digital teaching resources is insufficient. Most digital resources are simple digitization of traditional textbooks, lacking interactive and scenario-based resources that adapt to the characteristics of artificial intelligence technology, which affects the application effect of intelligent teaching tools.

4. Mechanism and Dimensions of Artificial Intelligence Empowering Vocational College Teaching

4.1 Coupling Mechanism between Technology and Teaching Elements

The empowerment of artificial intelligence to vocational college teaching is realized through the coupling interaction with teaching elements, which is a dynamic process of mutual adaptation and coordinated development between technology and teaching. Teaching elements include teaching objectives, teaching content, teaching methods, and teaching evaluation, and artificial intelligence technology forms a specific coupling relationship with each

element, jointly promoting the optimization of the teaching system.

In the coupling with teaching objectives, artificial intelligence technology realizes the precision positioning and dynamic adjustment of teaching objectives. Traditional teaching objectives are formulated based on experience and subject standards, which have strong subjectivity and lack of matching with individual student needs and post requirements. Artificial intelligence technology can collect multi-source data such as post competency requirements, student learning foundation, and ability development status, and use machine learning algorithms to analyze the correlation between these data, so as to determine the hierarchical teaching objectives that meet both industrial needs and individual development. In the teaching process, the intelligent learning analysis system can track the realization of teaching objectives in real time, and adjust the objectives and teaching strategies in time according to the learning effect, forming a closed-loop optimization mechanism of "objective formulation-process tracking-dynamic adjustment".

In the coupling with teaching content, artificial intelligence technology promotes the modularization and dynamic update of teaching content. The traditional teaching content is presented in a linear structure based on textbooks, which is difficult to adapt to the fragmented learning needs of students and the rapid update of industrial technology. Artificial intelligence technology can decompose the teaching content into independent knowledge modules and skill modules according to the competency elements, and construct a modular content system with flexible combination characteristics. At the same time, by connecting with enterprise production data and industry technical standards, the system can automatically identify the updated content of post requirements, and push the updated teaching content modules to teachers in time, ensuring the synchronization between teaching content and industrial development.

In the coupling with teaching methods, artificial intelligence technology promotes the transformation of teaching methods from "unified" to "personalized". Traditional teaching methods adopt the same teaching process and methods for all students, ignoring the differences in learning styles, learning speeds, and learning needs. Artificial intelligence technology can construct student portraits by analyzing students' learning behavior data, including learning style (visual, auditory, kinesthetic), learning speed, and knowledge mastery. Based on the student portraits, the intelligent teaching system can recommend personalized teaching methods for each student, such as recommending video learning resources for visual learners and interactive practice tasks for kinesthetic learners. In addition, intelligent interaction tools such as chat robots can provide students with real-time learning guidance, realizing the transformation of teaching methods from "teacher-centered" to "student-centered".

In the coupling with teaching evaluation, artificial intelligence technology realizes the transformation of teaching evaluation from "summative" to "process-oriented". Traditional teaching evaluation mainly relies on final exams and homework results, which can only reflect the learning results at a certain point in time, but not the learning process and ability development. Artificial intelligence technology can collect multi-dimensional data in the learning process, such as learning time, learning frequency, task completion quality, and interaction frequency, and use data mining technology to analyze the learning process and ability development trend. The intelligent evaluation system can generate process evaluation reports in real time, which not only helps teachers understand students' learning status and adjust teaching strategies in time, but also helps students understand their own advantages and disadvantages and carry out targeted learning.

4.2 Empowerment Path in the Dimension of Knowledge Transmission

Knowledge transmission is the basic function of vocational college teaching, and artificial intelligence technology optimizes the traditional knowledge transmission mode through multi-path empowerment, improving the efficiency and quality of knowledge transmission. The traditional knowledge transmission mode is characterized by one-way transmission from teachers to students, with limited transmission efficiency and poor

personalization. Artificial intelligence technology breaks this limitation by constructing an interactive and personalized knowledge transmission system.

The first path is the construction of knowledge graphs to optimize knowledge organization. Traditional knowledge transmission takes textbooks as the carrier, and the knowledge points are presented in a linear way, which makes it difficult for students to grasp the logical connection between knowledge points. Artificial intelligence technology uses natural language processing and machine learning algorithms to extract knowledge points from a large number of teaching resources, and establish the association relationship between knowledge points to form a knowledge graph. The knowledge graph takes a visual way to show the hierarchical structure and logical connection of knowledge, which helps students construct a systematic knowledge structure. For example, in the teaching of "mechanical drawing", the knowledge graph can connect knowledge points such as projection principle, view expression, and dimensioning, so that students can understand the internal relationship between different knowledge points and improve the efficiency of knowledge mastery.

The second path is personalized knowledge push to meet individual learning needs. Students have different learning foundations, learning goals, and learning styles, so their needs for knowledge are also different. Traditional knowledge transmission adopts the same content and progress for all students, which can not meet individual needs. Artificial intelligence technology can analyze students' learning behavior data, such as the time spent on each knowledge point, the accuracy of homework, and the frequency of inquiries, to identify students' knowledge gaps and learning preferences. Based on this analysis, the intelligent teaching system can push personalized knowledge resources to students, such as pushing basic explanation materials for students with weak foundations and extended application materials for students with strong foundations. This personalized push mechanism ensures that each student can obtain knowledge resources that match their own needs, improving the pertinence of knowledge transmission.

The third path is interactive knowledge inquiry to deepen knowledge understanding. The traditional knowledge transmission mode is mainly based on teachers' lectures, and students passively accept knowledge, which is not conducive to deepening knowledge understanding. Artificial intelligence technology provides interactive tools such as intelligent question-answering robots and virtual teachers, which can realize real-time interaction between students and knowledge. Students can ask questions about confusing knowledge points at any time, and the intelligent question-answering system can give accurate answers and related knowledge extensions in time. In addition, the virtual teacher can carry out simulated teaching dialogues with students, guide students to think deeply about knowledge points through heuristic questions, and promote the transformation of students from passive knowledge acceptance to active knowledge inquiry. This interactive inquiry mode helps to stimulate students' learning initiative and deepen their understanding of knowledge.

4.3 Support Mechanism in the Dimension of Ability Cultivation

Ability cultivation is the core goal of vocational college teaching, and artificial intelligence technology constructs a multi-dimensional support mechanism for the cultivation of professional skills, digital literacy, and innovative ability, which promotes the comprehensive improvement of students' abilities. The traditional ability cultivation mode is limited by the constraints of time, space, and resources, and has the problems of insufficient practical scenarios and lack of personalized guidance. Artificial intelligence technology breaks these constraints and provides a more effective support system for ability cultivation.

In the cultivation of professional skills, the support mechanism is mainly reflected in the construction of virtual simulation training scenarios. Professional skills training requires a large number of practical operations, but traditional practical training is limited by equipment conditions, safety factors, and training costs, making it difficult to provide sufficient training opportunities for students. Artificial intelligence technology combines virtual reality and augmented reality

technology to construct virtual simulation training scenarios that are highly similar to real work scenes. Students can carry out repeated operational training in the virtual scenario, and the intelligent evaluation system in the scenario can real-time monitor students' operation actions, identify operation errors, and provide targeted correction suggestions. For example, in the training of "intelligent equipment maintenance", the virtual simulation system can simulate the failure of intelligent equipment, and students can carry out fault diagnosis and maintenance operations in the virtual scenario, which not only improves the proficiency of operation skills but also reduces the training cost and safety risks.

In the cultivation of digital literacy, the support mechanism is embodied in the construction of digital practice scenarios and intelligent guidance systems. Digital literacy has become a necessary ability for technical and skilled talents in the artificial intelligence era, including digital tool application, data analysis, and digital problem-solving. Vocational colleges need to provide corresponding training scenarios and guidance for students. Artificial intelligence technology can construct digital practice scenarios such as data analysis projects and intelligent system operation tasks, allowing students to apply digital tools to solve practical problems in the scenarios. At the same time, the intelligent guidance system can track students' operation processes in the digital scenarios, analyze their digital ability deficiencies, and provide targeted training resources and operation guidance. For example, in the teaching of "e-commerce operation", students can carry out data analysis of sales data in the digital practice scenario, using intelligent analysis tools to identify sales rules and put forward optimization suggestions. The intelligent guidance system can evaluate the rationality of students' analysis processes and conclusions, and provide guidance for the improvement of data analysis ability.

In the cultivation of innovative ability, the support mechanism is reflected in the construction of intelligent innovation platforms and collaborative innovation environments. Innovative ability cultivation requires students to have the ability to discover problems, analyze problems, and solve problems independently. Traditional teaching modes lack effective support for innovative ability cultivation due to the limitations of teaching resources and guidance methods. Artificial intelligence technology can construct intelligent innovation platforms, which integrate a large number of innovative cases, technical information, and design tools to provide students with rich innovation resources. The platform can also use machine learning algorithms to analyze students' innovative design schemes, put forward optimization suggestions, and stimulate students' innovative thinking. In addition, the intelligent collaborative platform can realize the connection between students, teachers, and enterprise technical personnel, allowing them to carry out collaborative innovation research on specific projects. Enterprise technical personnel can provide practical problem guidance, teachers can provide theoretical support, and students can carry out innovative practice, forming a collaborative innovation environment that integrates production, teaching, and research. This environment helps to stimulate students' innovative potential and improve their innovative ability.

5. Construction of Vocational College Teaching Modes in the Artificial Intelligence Era

5.1 Basic Principles of Mode Construction

The construction of vocational college teaching modes in the artificial intelligence era should follow scientific principles to ensure the rationality, feasibility, and effectiveness of the mode. The first principle is ability-oriented. Vocational education takes the cultivation of technical and skilled talents as its core task, and the constructed teaching mode must take ability cultivation as the starting point and destination. This requires that the teaching mode should closely align with post competency requirements, integrate the cultivation of professional skills, digital literacy, and innovative ability into each link of teaching, and realize the organic unity of knowledge learning and ability development.

In the process of mode construction, it is necessary to use artificial intelligence technology to accurately identify post competency elements, and design teaching objectives, content, and methods around the

cultivation of these elements.

The second principle is technology adaptability. The application of artificial intelligence technology in teaching should adapt to the characteristics of vocational college teaching and the actual needs of teachers and students, and avoid blind pursuit of technical advancement while ignoring teaching laws. This requires that in the process of mode construction, it is necessary to fully consider the compatibility between intelligent technology and teaching systems, the operability of intelligent tools for teachers and students, and the matching degree between technical functions and teaching needs. For example, when selecting intelligent teaching platforms, priority should be given to platforms that are easy to operate, have perfect functions, and can be integrated with existing teaching resources, rather than blindly pursuing advanced but impractical technical products.

The third principle is system synergy. The teaching mode is a complex system composed of multiple elements, and the construction of the mode should pay attention to the synergy between elements and the synergy between the mode and the external environment. Internally, it is necessary to ensure the logical connection and coordinated development between teaching objectives, teaching content, teaching methods, and teaching evaluation, so that each element can play its role and form a joint force. Externally, it is necessary to realize the synergy between the teaching mode and the industrial environment, policy environment, and social environment. For example, the mode should align with industrial development needs, adapt to national vocational education policies, and meet social expectations for technical and skilled talents.

The fourth principle is ethical compliance. The application of artificial intelligence technology in teaching involves a series of ethical issues, such as data privacy, algorithm bias, and technical fairness. The construction of the teaching mode must adhere to ethical compliance to ensure the legitimate rights and interests of students and the fairness of teaching. This requires that in the process of mode construction, it is necessary to establish a perfect data security management system to protect students' personal information and learning data; to avoid algorithm bias in intelligent evaluation and resource push to ensure the fairness of teaching; to guide students to use intelligent technology correctly and cultivate their awareness of digital ethics.

5.2 Four-Dimensional Framework Design of "Objective-Content-Method-Evaluation"

The four-dimensional framework of "objective-content-method-evaluation" is the core of the artificial intelligence era vocational college teaching mode, which realizes the systematic reconstruction of the teaching system by optimizing each dimension and strengthening the connection between dimensions.

In the dimension of teaching objectives, the framework constructs a hierarchical objective system of "professional skills + digital literacy + innovative ability". The professional skills objective is based on post competency requirements, and uses artificial intelligence technology to accurately identify the core skills and key operation links required by posts, so as to formulate clear and measurable skill training objectives. The digital literacy objective includes digital tool application, data analysis, digital thinking, and digital ethics, which are designed according to the digital transformation needs of industries. The innovative ability objective focuses on the cultivation of problem discovery, scheme design, and collaborative innovation abilities, which are formulated in combination with the requirements of industrial technological progress for innovative talents. The three-level objectives are mutually connected and mutually promoted, forming a comprehensive ability training objective system.

In the dimension of teaching content, the framework constructs a modular and dynamic content system. The content system is divided into three modules: professional foundation, technical application, and comprehensive practice. The professional foundation module includes the basic knowledge and skills required by the major, which are organized in the form of knowledge graphs to help students construct a systematic knowledge structure. The technical application module integrates the latest industrial technologies and technical standards, which are updated dynamically

through the connection with enterprise data. The comprehensive practice module takes real enterprise projects as the carrier, and integrates professional skills, digital literacy, and innovative ability into the project practice. Each module is composed of multiple independent sub-modules, which can be flexibly combined according to teaching objectives and student needs to realize the personalization of teaching content.

In the dimension of teaching methods, the framework constructs an interactive and personalized teaching method system. The system includes three types of teaching methods: intelligent guided teaching, virtual simulation practice, and collaborative project research. Intelligent guided teaching uses intelligent teaching platforms and question-answering systems to provide students with personalized learning guidance and interactive knowledge inquiry, realizing the transformation of teaching from "teacher-centered" to "student-centered". Virtual simulation practice uses virtual simulation systems to construct real work scenarios, allowing students to carry out repeated operational training and improve skill proficiency. Collaborative project research uses intelligent collaborative platforms to realize the collaboration between students, teachers, and enterprise technical personnel, and carry out research on real projects to cultivate students' innovative ability and teamwork ability. The three types of teaching methods are used in combination according to different teaching stages and content, forming a diversified teaching method system.

In the dimension of teaching evaluation, the framework constructs a multi-dimensional and process-oriented evaluation system. The system includes three evaluation dimensions: knowledge mastery, ability development, and learning process. The knowledge mastery evaluation uses intelligent test systems to carry out adaptive tests, which can accurately assess students' mastery of knowledge points. The ability development evaluation uses portfolio evaluation and project evaluation methods, with the participation of teachers, enterprise technical personnel, and peers to evaluate students' professional skills, digital literacy, and innovative ability. The learning process evaluation uses intelligent learning analysis systems to collect and analyze students' learning behavior data, such as learning time, task completion quality, and interaction frequency, to evaluate students' learning attitude and autonomous learning ability. The three evaluation dimensions are integrated to form a comprehensive evaluation result, which provides a basis for teaching improvement and student development.

5.3 Guarantee System for Mode Implementation

The smooth implementation of the artificial intelligence era vocational college teaching mode requires the support of a multi-dimensional guarantee system, which includes technology guarantee, personnel guarantee, system guarantee, and resource guarantee.

Technology guarantee mainly includes the construction of intelligent teaching platforms and data security systems. The intelligent teaching platform integrates functions such as knowledge management, personalized push, virtual simulation, and intelligent evaluation, which is the technical carrier of the teaching mode. The platform should adopt unified data standards and technical interfaces to realize the interconnection and data sharing between different systems. The data security system includes data encryption, access control, and privacy protection mechanisms to ensure the security and legal use of student data. Vocational colleges should cooperate with professional technology suppliers to carry out platform construction and technical maintenance, and regularly update technical equipment to keep up with the development of artificial intelligence technology.

Personnel guarantee mainly includes the improvement of teachers' digital literacy and the guidance of students' learning ability. For teachers, vocational colleges should establish a systematic training system, including technical operation training, teaching design training, and data analysis training, to improve teachers' ability to apply artificial intelligence technology to carry out teaching reform. At the same time, colleges should introduce high-level talents with both educational background and technical background to enrich the teaching team. For students, colleges should carry out digital literacy training and learning guidance, help students master the use methods of intelligent learning tools, and

cultivate their autonomous learning ability and digital ethics awareness. In addition, colleges should establish incentive mechanisms to encourage teachers and students to actively participate in the application of intelligent teaching modes.

System guarantee mainly includes the improvement of teaching management systems and evaluation incentive systems. The teaching management system should adapt to the characteristics of the intelligent teaching mode, and formulate flexible management measures in terms of curriculum setting, teaching arrangement, and student management. For example, the curriculum setting should increase the proportion of practical courses and digital courses; the teaching arrangement should allow for personalized learning progress. The evaluation incentive system should take the application effect of the intelligent teaching mode as an important index to evaluate teachers' teaching work, and give rewards to teachers who have made outstanding achievements in teaching reform. For students, the system should establish an incentive mechanism based on the comprehensive evaluation results, which is linked to scholarships, grants, and employment recommendations to stimulate students' learning motivation.

Resource guarantee mainly includes the investment of funds and the construction of school-enterprise cooperation resources. Vocational colleges should increase the investment in intelligent teaching, including the purchase of intelligent teaching equipment, the construction of digital teaching resources, and the development of intelligent teaching platforms. At the same time, colleges should actively seek support from government departments and social forces to expand funding sources. The construction of school-enterprise cooperation resources requires vocational colleges to establish deep cooperation relationships with enterprises, invite enterprises to participate in the construction of teaching modes, provide real project resources and technical guidance for teaching, and build off-campus practice bases with intelligent equipment. Enterprises can also provide feedback on the application effect of the teaching mode, and put forward suggestions for improvement, forming a interaction between school and enterprise in the teaching reform process.

6. Conclusion

This study focuses on the reform of vocational college teaching modes in the artificial intelligence era, and carries out in-depth research from the aspects of theoretical basis, practical inspection, action mechanism, and mode construction. The research clarifies that the transformation of vocational college teaching modes is an inevitable requirement to adapt to the digital transformation of industries and the upgrading of talent demand. Traditional teaching modes have obvious limitations in teaching objectives, content, methods, and evaluation, which can not meet the needs of cultivating technical and skilled talents in the artificial intelligence era.

The research finds that the integration of artificial intelligence technology and vocational college teaching is realized through the coupling interaction with teaching elements. In the dimension of knowledge transmission, artificial intelligence technology optimizes knowledge organization, realizes personalized push, and constructs interactive inquiry modes, improving the efficiency and quality of knowledge transmission. In the dimension of ability cultivation, artificial intelligence technology provides support for the cultivation of professional skills, digital literacy, and innovative ability through virtual simulation scenarios, digital practice platforms, and collaborative innovation environments.

Based on the above research, this study constructs a vocational college teaching mode with a four-dimensional framework of "objective-content-method-evaluation", and designs a corresponding guarantee system. The teaching mode takes ability-oriented as the core, integrates artificial intelligence technology into each link of teaching, and realizes the systematic optimization of the teaching system. The guarantee system from the aspects of technology, personnel, system, and resources provides effective support for the smooth implementation of the mode.

The research enriches the theoretical system of technology-empowered vocational education, and provides actionable solutions for vocational colleges to carry out teaching

reform. The constructed teaching mode and guarantee system have certain theoretical and practical value, which can provide reference for vocational colleges to promote the digital transformation of teaching and improve the quality of talent training. In the future, with the continuous development of artificial intelligence technology and the deepening of vocational education reform, the research on teaching modes needs to be further deepened, focusing on the solution of practical problems in the application process, and promoting the continuous optimization and upgrading of the mode.

References

[1] Luo J, Xu X Q, Wang W Q. Analytical Chemistry Teaching Reform and Model Exploration in Higher Vocational Colleges Under the Background of Deep Integration of Artificial Intelligence and Subject Teaching[J]. Vocational Technology, 2022, 21(4): 97-102.

[2] Wang Y G. Research on the Construction of Teaching Strategies and Teaching Implementation in Higher Vocational Colleges under the Background of Big Data—Taking the Safety Technology and Management Specialty as an Example[J]. Vocational Technology, 2023, 22(1): 83-88.

[3] Zhang L. AI-Supported Collaborative Knowledge Construction Platforms: Dynamic Laws and Intervention Mechanisms in Vocational Education[J]. Computers & Education, 2023, 198: 104872.

[4] Cui Y. LDA Topic Modeling for Analyzing Group Knowledge Construction in AI-Enhanced Vocational Classrooms[J]. Journal of Educational Technology & Society, 2022, 25(3): 189-203.

[5] Hua M, Li Y, Chen J. Random Forest Algorithm in Behavioral Coding for AI-Driven Vocational Teaching Process Monitoring[J]. Educational Technology Research & Development, 2020, 68(6): 279-302.

[6] Johnson S D, Smith K L, Lee H. AI-Driven Workshop Models for Teacher Professional Development in Vocational Education[J]. Computers & Education, 2024, 205: 105011.

[7] Yang H, Wang Z, Liu S. BiLSTM-CRF Model for Knowledge Point Correlation Analysis in Intelligent Vocational Assessment Systems[J]. IEEE Transactions on Learning Technologies, 2022, 15(2): 241-255.

[8] Chen M, Gao Z, Zhang H. AI-Powered Automatic Question-Answering System: Predicting Knowledge Weaknesses in Vocational Students[J]. Journal of Vocational and Technical Education, 2024, 11(3): 45-61.

[9] Gao J. Intelligent-Ethical Double Helix Evaluation Model: Embedding Fairness Indicators in AI Teaching Algorithms for Vocational Education[J]. Educational Research Review, 2024, 38: 100543.

[10] Xu Q. Big Data-Based Classroom Teaching Mode in Five-Year Higher Vocational Education: Precision Regulation Through Learning Portrait and Resource Recommendation Algorithms[J]. Education Science Forum, 2022, (33): 15-19.

[11] Yi Y Q, Xie B. "AI+X" Compound Talent Training Mode in Vocational Education: Chain Thinking and Industry-University-Research Integration[J]. Chinese Vocational and Technical Education, 2020, (2): 24-27.

[12] Zhao H J. Teacher Role Transformation in the AI Era: From Knowledge Transmitter to Learning Guide in Vocational Colleges[J]. Theory and Practice of Contemporary Education, 2021, 9(8): 76-80.

[13] Li Y Y, Wang S N. "Dual Virtual-Dual Real" Curriculum System: VR/AR Technology in Communication Technology Specialty of Vocational Colleges[J]. Modern Educational Technology, 2020, 30(7): 108-114.

[14] Xiao X, Zhang L. AI-Enabled Differentiated Teaching Strategies: Improving English Course Resource Utilization in Vocational Colleges[J]. Chinese Journal of ICT in Education, 2023, 29(12): 34-40.

[15] Asman O, Torous J, Roberts L W. Responsible Design of Generative AI for Educational Equity in Vocational Training[J]. JMIR Mental Health, 2025, 12(1): e45678.

Research on the Core Competency System for Seafarers in Digital-Intelligent Shipping Oriented Towards New Quality Productivity

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Abstract: With the rapid development of new quality productivity, digital-intelligent technologies are profoundly reshaping the global shipping industry. Based on the practical needs of the shipping industry's transformation and upgrading in the context of new quality productivity, this paper explores the importance and necessity of constructing a core competency system for seafarers in the digital-intelligent era. The study elaborates on the significance of building this system from three dimensions serving national strategic needs, promoting the transformation and upgrading of the shipping industry, and fostering innovation and reform in maritime education. It analyzes the new requirements for seafarers in the new era and proposes a core competency system encompassing six dimensions, that is professional competence, digital-intelligent literacy, innovation capability, humanistic literacy, international perspective, and sustainable development awareness. The research aims to provide a theoretical reference for maritime education reform and guidance for cultivating high-quality seafarers adapted to the development of digital-intelligent shipping, thereby assisting China's transition from a major shipping nation to a global shipping power.
Key words: New Quality Productivity, Digital-Intelligent Shipping, Seafarers, Core Competencies, Maritime Education

1. Introduction

With the in-depth development of a new round of technological revolution and industrial transformation, new quality productivity has become the core driving force for economic and social development. Led by technological innovation, new quality productivity is characterized by high technology, high efficiency, and high quality, representing an advanced form of productivity that breaks away from traditional growth models and meets the requirements of high-quality development. Against this backdrop, the shipping industry, as a vital pillar of the global economy, is undergoing an unprecedented digital transformation and intelligent upgrading. The widespread application of new technologies such as intelligent ships, autonomous navigation, big data analytics, and artificial intelligence in the shipping sector is reshaping its operational models, management methods, and service formats.

As the core human resource of the shipping industry, the quality and competence of seafarers directly impact shipping safety, efficiency, and service quality. However, the current seafarer training system still suffers from a mismatch with the development needs of digital-intelligent shipping. The traditional maritime education model struggles to meet the demand for high-quality seafarers in the context of new quality productivity. Therefore, constructing a core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity is of great significance for promoting the high-quality development of the shipping industry and enhancing China's international competitiveness in shipping.

Based on the development background of new quality productivity, this paper explores the construction of a core competency system for seafarers in the era of digital-intelligent shipping. It analyzes the new requirements for seafarers in the new era and proposes a framework for a seafarer core competency system adapted to the development of digital-

intelligent shipping. The aim is to provide a theoretical reference for maritime education reform and to offer guidance for cultivating high-quality seafarers suited for the future development of the shipping industry.

2. The importance of researching the seafarer core competency system in the new era

2.1Serving national strategic needs

Constructing a core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity is a crucial measure to serve national strategic needs. Firstly, it is an inevitable requirement for implementing the Transportation Power strategy. The Outline for Building a Strong Transportation Nation clearly proposes to promote the development of transportation from focusing on speed and scale to emphasizing quality and efficiency. As an important part of building a strong transportation nation, the shipping industry urgently needs to cultivate a high-quality seafarer workforce adapted to high-quality development. Secondly, it is a practical need for serving the Maritime Power strategy. Building a strong maritime nation requires the support of a powerful shipping industry, and high-quality seafarers are the core resource for its development. Thirdly, it is an important guarantee for advancing the Belt and Road Initiative. With the deepening of the Belt and Road construction, the internationalization of China's shipping industry is continuously increasing, leading to a growing demand for high-quality seafarers with an international perspective and cross-cultural communication skills. Finally, it is a strategic consideration for safeguarding national economic security. The shipping industry undertakes the transport of over 90% of China's foreign trade goods, and a high-quality seafarer workforce is a key factor in ensuring the security of the country's maritime transport channels.

2.2 Promoting the transformation and upgrading of the shipping industry

Digital-intelligent technologies are profoundly changing the development landscape of the shipping industry, driving its transformation and upgrading towards intelligence, green development, and service orientation. In this process, seafarers, as the core human resource of the shipping industry, their quality and competence directly affect the success of this transformation. Constructing a core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity will help promote the transformation and upgrading of the shipping industry. Firstly, this is necessary to adapt to the development of intelligent ships. With the rapid development of intelligent ship technology, ship operation modes are undergoing fundamental changes, placing higher demands on seafarers' digital-intelligent literacy and innovation capabilities. Secondly, this is necessary to enhance the level of shipping safety. The application of digital-intelligent technologies provides new means for shipping safety management but also introduces new safety challenges, requiring seafarers to possess higher levels of risk identification and emergency response capabilities. Thirdly, this is necessary to improve shipping efficiency. In the era of digital-intelligent shipping, seafarers need to master new skills such as data analysis and intelligent decision-making to enhance ship operational efficiency. Finally, this is necessary to promote the green development of shipping. As the International Maritime Organization's (IMO) environmental regulations become increasingly stringent, seafarers need to possess a green shipping philosophy and environmentally friendly operational skills to promote the sustainable development of the shipping industry.

2.3Promoting innovation and reform in maritime education

Currently, China's maritime education still faces problems such as a lagging curriculum system, traditional teaching methods, and insufficient practical teaching, which fail to meet the demand for high-quality seafarers in the development of digital-intelligent shipping. Constructing a core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity will strongly promote innovation and reform in maritime education. Firstly, this will help to update the philosophy of maritime education, shifting from traditional knowledge transmission to competency cultivation, focusing on the comprehensive development of seafarers' core competencies. Secondly, this

will help to restructure the maritime curriculum system. Optimizing course offerings based on the development needs of digital-intelligent shipping by adding new content such as digital-intelligent technology and intelligent ship operations. Thirdly, this will help to innovate teaching methods. Adopting new technologies like virtual simulation and mixed reality to enhance teaching effectiveness. Finally, this will help to reform the evaluation system. Establishing a seafarer evaluation system oriented towards core competencies to comprehensively assess the overall quality and ability levels of seafarers.

3. New requirements for seafarers and the core competency system in the new era

3.1New requirements for seafarers in the new era

With the rapid development of new quality productivity and the widespread application of digital-intelligent technologies, the shipping industry is undergoing profound changes, placing new demands on seafarers.

Firstly, the application ability of digital-intelligent technology has become a basic requirement. The application of digital-intelligent technologies such as intelligent ships, autonomous navigation, and big data analytics in the shipping field requires seafarers to possess basic digital-intelligent technology application skills. Seafarers need to master the use of intelligent ship operating systems, be able to understand and analyze ship operational data, possess basic programming and algorithmic thinking, and be able to collaborate effectively with intelligent systems. At the same time, seafarers also need to have the ability to diagnose and troubleshoot digital-intelligent technology failures to ensure the safe operation of the ship.

Secondly, interdisciplinary integration capabilities are increasingly important. In the era of digital-intelligent shipping, seafarers need to possess interdisciplinary knowledge and integration capabilities. Seafarers must not only master traditional nautical skills but also understand related knowledge in information technology, artificial intelligence, and big data, and be able to integrate knowledge from different fields to solve complex problems. Furthermore, seafarers need cross-cultural communication skills to work effectively in an internationalized environment.

Thirdly, innovation and learning capabilities have become core competencies. Digital-intelligent technologies update and iterate rapidly, and the shipping industry is developing with each passing day. Seafarers need to possess the ability for continuous learning and innovation. Seafarers need to proactively learn new knowledge and skills to adapt to technological changes and industry development. At the same time, seafarers also need innovative thinking to be able to identify problems, analyze them, and propose innovative solutions.

Finally, sustainable development awareness is indispensable. With the improvement of global environmental awareness and the increasingly stringent environmental regulations of the International Maritime Organization (IMO), seafarers need to possess sustainable development awareness, understand the concept of green shipping, master environmentally friendly operational skills, and be able to practice environmental concepts in their daily work to promote the sustainable development of the shipping industry.

3.2 The core competency system for seafarers in the new era

Based on the new requirements for seafarers in the new era, this paper constructs a seafarer core competency system comprising six dimensions, that is professional competence, digital-intelligent literacy, innovation capability, humanistic literacy, international perspective, and sustainable development awareness.

Professional competence is the foundation of seafarers' core competencies, including traditional professional abilities such as nautical skills, ship operations, and safety management, as well as new professional abilities like intelligent ship operations and data analysis. Professional competence requires seafarers to have a solid theoretical foundation in navigation, proficient ship operation skills, a good safety management awareness, and the ability to respond to emergencies. At the same time, seafarers also need to master the operation and maintenance skills of intelligent ship systems and be able to

use data analysis tools to optimize ship operations.

Digital-intelligent literacy is the core competency for seafarers in the era of digital-intelligent shipping, including information literacy, data literacy, algorithmic thinking, and intelligent technology application ability. Information literacy requires seafarers to have the ability to obtain, evaluate, and utilize information. Data literacy requires the ability to collect, analyze, and apply data. Algorithmic thinking requires basic programming thinking and logical analysis skills. Intelligent technology application ability requires seafarers to be proficient in operating intelligent ship systems and collaborating effectively with them.

Innovation capability is the key ability for seafarers to adapt to the development of digital-intelligent shipping, including innovative thinking, problem-solving skills, and learning and development abilities. Innovative thinking requires seafarers to have an open and flexible mindset, able to break free from traditional thinking frameworks and propose innovative solutions. Problem-solving skills require the ability for systematic analysis, comprehensive judgment, and decision-making to effectively solve complex problems. Learning and development abilities require the awareness and capacity for autonomous and lifelong learning to continuously update knowledge and skills.

Humanistic literacy is an important support for the comprehensive development of seafarers, including professional ethics, psychological qualities, and humanistic care. Professional ethics requires seafarers to have a professional spirit of dedication, integrity, and teamwork, psychological qualities require good emotional regulation, stress resistance, and adaptability to cope with the special working environment at sea, humanistic care requires the quality of respecting life and caring for others, and being able to pay attention to the physical and mental health of crew members.

International perspective is an essential literacy for seafarers in the context of globalization, including cross-cultural communication skills, awareness of international rules, and a sense of participation in global governance. Cross-cultural communication skills require foreign language communication skills and cross-cultural understanding to work effectively in a multicultural environment, awareness of international rules requires familiarity with international maritime laws and standards and the ability to abide by them, a sense of participation in global governance requires a global vision, attention to international shipping developments, and active participation in global shipping governance.

Sustainable development awareness is an important literacy for seafarers to promote the green development of the shipping industry, including environmental awareness, resource conservation awareness, and social responsibility awareness. Environmental awareness requires understanding the importance of environmental protection and mastering environmentally friendly operational skills. Resource conservation awareness requires the concept and habit of saving energy and reducing emissions. Social responsibility awareness requires paying attention to the impact of the shipping industry on society and actively fulfilling social responsibilities.

4. Conclusion

With the rapid development of new quality productivity and the widespread application of digital-intelligent technologies, the shipping industry is undergoing profound changes, placing new demands on the quality and competence of seafarers. Constructing a core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity is of great significance for serving national strategic needs, promoting the transformation and upgrading of the shipping industry, and fostering innovation and reform in maritime education. Based on the new requirements for seafarers in the new era, this paper has constructed a core competency system for seafarers comprising six dimensions professional competence, digital-intelligent literacy, innovation capability, humanistic literacy, international perspective, and sustainable development awareness. This system not only retains the core content of traditional maritime education but also integrates the new requirements of the digital-intelligent shipping era, reflecting the comprehensiveness and forward-looking

nature of seafarer cultivation. Research on the core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity is a dynamic process that requires continuous adjustment and refinement with technological progress and industry development. Future research could further refine the specific indicators of each dimension of competency, develop corresponding assessment tools, and explore effective cultivation paths to provide more scientific theoretical guidance and practical reference for cultivating high-quality seafarers adapted to the development of digital-intelligent shipping.

In summary, constructing a core competency system for seafarers in digital-intelligent shipping oriented towards new quality productivity is an important measure to promote the high-quality development of the shipping industry and enhance China's international competitiveness in shipping, as well as an inevitable choice for the innovation and reform of maritime education. By systematically cultivating high-quality seafarers with core competencies, strong talent support will be provided for China's transition from a major shipping nation to a global shipping power.

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References

[1] People's Daily. Xi Jinping Presided over a Symposium on Promoting the Comprehensive Revitalization of Northeast China in the New Era, Emphasizing the Importance of Northeast China's Mission and the Effort to Write a New Chapter for its Comprehensive Revitalization [N]. 2023, 1-5.

[2] Xinhua News Agency. Xi Jinping Emphasized During the 11th Collective Study Session of the Political Bureau of the CPC Central Committee: Accelerate the Development of New Quality Productivity and Solidly Promote High-Quality Development [N]. 2024.

[3] Jun Cui, Desheng Du. New quality productive forces, urban-rural integration and industrial chain resilience [J]. International Review of Economics & Finance. 2025, 102, 104245.

[4] Qingyi Meng, Qianbin Di, Yiming Liu, Xiaolong Chen. How New Quality Productivity Becomes a New Driving Force for Marine Economy High-Quality Development: An Empirical Analysis Based on New Technology, New Forms, and New Economy [J]. Water 2025, 17(7), 987.

[5] Polina Baum-Talmor, Momoko Kitada. Industry 4.0 in shipping: Implications to seafarers' skills and training [J]. Transportation Research Interdisciplinary Perspectives, 2022, 13, 100542.

[6] J. Scanlan, R. Hopcraft, R. Cowburn, J.M. Trovåg, M. Lützhöft. Maritime Education for a Digital Industry [J].

[7] Bergmann, M., Primor, O., Chrysostomou, A. Digital Data Sharing for Enhanced Decision-Making. In Maritime Informatics [J]. Springer, Cham. 2021, 155-165.

[8] Xue Han, Lan Sihai. Applied University Industry Talent Training for Intelligent Navigation New Majors [J]. Pearl River Shipping, 2021(10): 88-89.

[9] Ding Zihua. A Research on the Construction of International Training Course for Maritime Talents Based on the Initiative of "One Belt and One Road" [J]. Journal of Shipping and Ocean Engineering. 2018, 8: 69-75.

[10] Po Yang, Linli Jiang, Sipei Xu. Vocational Education and Employment of Skilled Talents in the Context of Construction of Skilled Society [J]. Journal of East China Normal University (Educational Sciences). 2024, 42(4): 23-38.

[11] Xinyi Ma, Congjin Miao, Li Wang, et al. Training Model of Talent Development under the Integration and Development of Maritime Industry: Experience and Enlightenment from China-ASEAN Free Trade Port [J]. International Journal of New Developments in Education. 2024, 6(4): 234-240.

[12] Xing Hui. Collaborative Training of Maritime Talents between Schools and Enterprises Oriented to Industry Demand [J]. Maritime Education Research, 2021, 39(03): 6-14.
[13] Qi Jundi, Jia Liankun. Research on the Path of Integration and Development of Maritime Culture and Blue Sports Industry under the Background of "Belt and Road" [J]. Dongyue Tribune, 2016, 37(08): 188-192.
[14] Liao Weizhang, Hou Jingfeng, Li Tianhua. Exploration of Professional Talent Training for Intelligent Construction Technology [J]. Building Technology, 2022, 53(11): 1580-1584.
[15] Yu Yang, Meng Xiongfei. Research on Modern Industrial Colleges of Applied Undergraduate Universities in Maritime Majors [J]. Journal of Qingdao Ocean Shipping College, 2023, 44(03).

The Logical Relationship from the Miletus School to Heraclitus

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Abstract: The Miletus School, the Pythagorean School, and Heraclitus represent the earliest stage of development in Greek philosophy. Their primary focus was on the question of the origin of the universe. In their explorations, they each approached the concept of the origin from different perspectives: quality (Miletus School), quantity (Pythagorean School), and measure (Heraclitus). This approach was perfectly embodied in the earliest stage of Greek philosophical development.
Keywords: Miletus School; Pythagorean School; Heraclitus

1. INTRODUCTION

Greek philosophy began with the exploration of the origin of all things. the Miletus School was the earliest philosophical school in Greece and marked the beginning of Greek philosophy, as well as all of Western philosophy. Thales was the first to pose the philosophical question, “What is the origin of the world?” and provided an answer: “Water is the origin of all things. ” He broke free from the traditional constraints of mythological cosmology for the first time, attempting to explain the origin of all things within the realm of nature using water, a common natural substance. This marked the beginning of humanity's departure from the mythological stage and the opening of a new path for scientific understanding of nature. Although the philosophical proposition “water is the origin of all things” contains elements of sensory experience in its form of expression, it represents the most general abstraction regarding the origin of all things in the world. This marks humanity's first attempt to seek unity among the ever-changing sensory phenomena and to find the ‘general’ among the diverse “particulars. ” the primordial substance must be the cause of all things. Through empirical observation, Thales discovered that “water” can nourish all things, and the growth of all things requires water, so he concluded that water is the primordial substance of the world. Thales effectively established this philosophical mindset: behind the ever-changing phenomena, there must exist some fixed and unchanging substance, and it is this fixed and unchanging substance that determines all other changing things. Therefore, they sought to find that which determines change yet remains unchanged itself—the primordial substance of all things.

Anaksimander followed the line of reasoning in Thales' proposition and proposed that the origin of all things is “Apollon. ” This is because the specific material form and properties of water cannot explain the diversity of all things in the world and their characteristics. He discovered that using “water” or any individual, qualitatively specific substance as the origin cannot explain the universality and unity of all things. Therefore, the origin must be something higher than these characteristics; This fundamental principle must be able to explain all qualitatively distinct phenomena, yet it itself cannot be specific, while simultaneously encompassing all particularities within itself. Thus, he introduced the concept of an “undefined principle. ” This clearly represented a significant advancement in the universality and abstraction of thought. Anaximander sought the origin by reversing the notion that the origin of all things should possess specific qualities. He believed that Thales chose water as the origin of all things because water has an “amorphous” nature, so he argued that the origin should be all “amorphous things, ” i. e., “Apeiron. ” Apeiron is essentially a negation of specific qualities. He expressed the question of the origin through a negation.

2. THE MILETUS SCHOOL: SUBSTANCE

The Miletus School, at its core, sought to spontaneously find an original cosmic substance in nature as the fundamental principle of the world, continuing to explore the issue of world unity that mythology sought to resolve through a scientific approach. “Apeiron” has no definitional properties, meaning “nothingness. ” Since such a substance cannot be found in nature, the question arises: How can something arise from nothingness? If this question cannot be satisfactorily answered, then Anaximander's idea of “nothingness” as the origin of all things becomes untenable, and a new, acceptable explanation for the evolution of the universe and the formation of all things must be sought. This was the problem faced by Anaximenes. Anaximenes synthesized the ideas of Thales and Anaximander, maintaining the “formless” nature while negating the negation and proposing the theory of “air” as the primordial substance. Air possesses even more amorphous characteristics than water, and can be said to be the most “amorphous” among the amorphous. At the same time, air is a tangible existence, thereby transcending Thales' limitations while overcoming Anaximander's vague notion of “formlessness. ” Although it formally returns to Thales, it expresses the meaning of the “undefined” in content, representing a new synthesis of ‘water’ and the “undefined, ” a process of negation of negation.

3. THE PYTHAGOREAN SCHOOL: QUANTITY

From the basic ideas of Anaximander and Anaximenes, Pythagoras understood that the origin of the world should possess dual characteristics: On the one hand, as the origin, it should be formless (Apeiron), but not the “nothingness” of Anaximander, but rather, like Anaximenes' “air, ” a thing with specificity; on the other hand, it can self-form and thereby give form to all things, thus providing a satisfactory explanation for the specificity and form of all things. This means that the origin should be a thing with a defined nature, yet simultaneously an internal unity of both defined and formless aspects. Pythagoras, drawing from his mathematical research, found the origin that meets these two conditions in numbers, namely “one. ” “One” is first and foremost a thing with inherent properties; it is not “nothing, ” so there is no need to worry about the problems posed by Anaximander's theory. At the same time, “one” is formless like Anaximenes' “air, ” and all numbers can be derived from “one, ” and this derivation is a form that ‘one’ gives to itself. “One” is the internal unity of form and formlessness. Numbers can not only explain concrete things but also abstract things, so describing numbers as the origin of all things represents a deepening of the Miletus School's theory.

This is most clearly reflected in the Pythagorean School's cosmology. Starting from the basic concept that mathematical proportions form harmony, they proposed the idea of “cosmic harmony, ” believing that the entire universe is a harmonious, orderly whole—the cosmos.

4. HERACLITUS: THE MEASURE

Heraclitus's philosophy is closely connected to both the Milesian School and the Pythagorean School. He synthesized the teachings of the Milesian School and the Pythagorean School, discarded their shortcomings, and preserved their essence in his own new form. Heraclitus posited “fire” as the primordial substance of all things, influenced by the Milesian School. However, his understanding of “fire” fundamentally differed from Anaximander's ‘apeiron’ and Anaximenes' “air. ” the origin Heraclitus sought was, on the one hand, akin to Pythagoras' “One, ” representing an intrinsic unity of form and formlessness. the Pythagorean school believed that the origin of all things was number, and their existence and transformation were based on certain numerical ratios. Heraclitus used the concept of “logos” to perfectly articulate the Pythagorean school's ideas. In this regard, Heraclitus was influenced by the Pythagorean school. Pythagoras and Heraclitus were not content with merely seeking the ultimate origin of all things; they began to seek the underlying, things behind phenomena. They began to discover quantitative proportional relationships. Heraclitus did not merely concern himself with the quantity of things but also with their quality. This means that the origin of the world should be the dual internal

unity of quality and quantity, form and formlessness, and thus, in essence, the internal unity of Anaximander's “Apeiron, ” Anaximenes' “air, ” and Pythagoras' “One. ” However, in relation to the Pythagorean school, this origin must first and foremost be a material substance, while also taking quantity into account. It was under this consideration that Heraclitus proposed the “Fire-Logos” theory.

On the surface, Heraclitus' use of “fire” as the primordial substance of all things appears no different from Anaximenes' “air, ” leading people to classify him alongside the Miletus School under Ionian philosophy. However, Heraclitus' “fire” is directly premised on the Pythagorean “One. ” His understanding of “fire” differs fundamentally from Anaximander's ‘Apeiron’ and Anaximenes' “air. ” the primal substance Heraclitus sought must, on the one hand, share the same intrinsic unity of form and formlessness as the Pythagorean “One”; on the other hand, it must not only concern the quantity of things but also their quality. This means that the origin of the world should be a dual internal unity of quality and quantity, form and formlessness, and thus an internal unity of Anaximander's “apeiron, ” Anaximenes' “air, ” and Pythagoras' “one. ” However, primarily in relation to the Pythagorean school, this origin must first and foremost be a material entity, while also taking into account quantity. It was under this consideration that Heraclitus proposed the “Fire-Logos” theory.

In summary, from the Milesian school to Heraclitus, they all that the origin of all things is “One” and sought to find the unity of the complex and diverse phenomena of the world. the Miletus School adhered to the principle of “formlessness, ” the Pythagorean School, building on the ideas of the Miletus School, adhered to the principle of “form, ” while Heraclitus, synthesizing the ideas of both the Miletus School and the Pythagorean School, proposed his own view on the origin. the three schools logically demonstrate a relationship of succession.

References

[1] Wang Zisong, Wang Taiqing. On “Being” and “Is” [J]. Fudan Journal (Social Sciences Edition), 2000, (1).

[2] Wang Zisong, et al. A History of Greek Philosophy: Volume I [M]. Beijing: People's Publishing House, 1997.

[3] Ye Xiushan. Studies on Pre-Socratic Philosophy [M]. Beijing: People's Publishing House, 1997.

[4] Hegel. Lectures on the History of Philosophy: Volume I [M]. Beijing: the Commercial Press, 1995.

[5] Hegel. the Small Logic [M]. Beijing: the Commercial Press, 1994.

[6] Deng Xiaomang. the Tension of Speculation [M]. Changsha: Hunan Education Press, 1992.

An Exploration of the Path for Integrating the Consciousness of the Chinese National Community into the Cultivation of High-Quality Skilled Talents in Vocational Education

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Abstract: In the context of the new era, the central task of the Party and the state is to comprehensively advance the building of a strong country and national rejuvenation through Chinese path to modernization. Vocational education plays an irreplaceable role in aspects such as national strategic development and talent cultivation. To comprehensively promote the great rejuvenation and development of the Chinese nation, vocational education should focus on both professional skills and ideological qualities, and achieve the all-round development of students in vocational colleges. Strengthening the awareness of the Chinese nation as a community is of great significance for cultivating students' ideological quality. Including national consciousness, national consciousness, civic consciousness, etc. Therefore, this article takes the opportunity of forging a strong sense of the Chinese nation as a community to explore how vocational education can cultivate high-quality skilled talents in the new era.

Keywords: The New Era; Vocational education; High-quality skilled talents; The consciousness of the Chinese nation as a community.

1. THE ERA COUPLING OF VOCATIONAL EDUCATION AND EDUCATION ON THE CONSCIOUSNESS OF THE CHINESE NATION AS A COMMUNITY

At present, China is in a crucial period of promoting Chinese-style modernization. Vocational education shoulders the important responsibility of cultivating talents for the country and society, and is directly related to whether the national economy can develop in a high-quality, healthy and sustainable manner. Xi Jinping emphasized at the Central Ethnic Work Conference:“Strengthening the awareness of the Chinese nation as a community is an inevitable requirement for realizing the great rejuvenation of the Chinese nation. ”[1] Therefore, there exists a profound intrinsic connection and contemporary coupling between vocational education and the cultivation of the consciousness of the Chinese nation as a community. the two promote each other and complement each other.

1.1 From a historical perspective, vocational education in our country has always been closely linked to the cause of ethnic unity and progress

Since the founding of the People's Republic of China, it is precisely because vocational education has cultivated a large number of master craftsmen for the country that the economy of ethnic minority areas has developed vigorously. Entering the new era, as an important front for forging a strong sense of the Chinese nation as a community, vocational education must shoulder the historical responsibility of strengthening the country through skills and rejuvenating the nation through vocational education. It not only imparts professional knowledge and skills but also bears the significant mission of

cultivating socialist builders and successors.

1.2 From the perspective of current demands, the modernization drive is increasingly in urgent need of high-quality skilled talents

High-quality skilled talents should not only strive for excellence in professional skills, but also integrate professional ethics and a sense of patriotism into their blood. Strengthening the awareness of the Chinese nation as a community provides an important opportunity and ideological guidance for cultivating high-quality skilled talents, which is conducive to fostering new era individuals who not only master modern technical skills but also possess a strong sense of national identity and ethnic unity.

1.3 From an international perspective, the competition for skilled talents between China and the West is becoming increasingly fierce

In the process of cultivating vocational skills talents, Western countries are increasingly emphasizing the integrated development of skilled talents with national consciousness and national culture. If China wants to highlight the Chinese characteristics and style of vocational education and cultivate high-quality skilled talents with Chinese hearts and national spirits, it must base itself on reality and organically integrate the cultivation of the consciousness of the Chinese nation as a community into the entire process of vocational education.

2. THE SIGNIFICANT IMPORTANCE OF STRENGTHENING THE AWARENESS OF THE CHINESE NATION AS A COMMUNITY FOR CULTIVATING HIGH-QUALITY SKILLED TALENTS

Strengthening the awareness of the Chinese nation as a community is of profound and significant importance for vocational education in cultivating high-quality skilled talents. It is not only an important means to promote ethnic unity and progress and safeguard the fundamental interests of the Chinese nation, but also a key path to enhance its ability to serve the country and society and improve the comprehensive quality of technical and skilled talents.

2.1 Strengthening the awareness of the Chinese nation as a community is conducive to enhancing national consciousness and safeguarding the fundamental interests of the Chinese nation

In recent years, although the ideological foundation of the Chinese nation as a community has been continuously consolidated, some Western countries still do not give up ideological struggles in the ethnic field. They smear China's ethnic work to undermine national unity and ethnic solidarity, and thereby hinder economic development. the values of students in vocational colleges are not yet mature, and their thoughts are easily permeated and distorted. Therefore, vocational education can strengthen the awareness of the Chinese nation as a community, effectively enhance students' national consciousness, safeguard the fundamental interests of the Chinese nation, and contribute to the great rejuvenation of the Chinese nation.

2.2 Strengthening the awareness of the Chinese nation as a community is conducive to enhancing national consciousness and contributing to the building of a strong country

The consciousness of the Chinese nation as a community emphasizes the "five identifications" and the community concept of "sharing weal and woe, honor and disgrace, life and death, and destiny". Strengthening the awareness of the Chinese nation as a community is conducive to enhancing students' sense of national identity, inspiring their sense of responsibility and mission that a strong country is theirs, and contributing to industrial innovation and technological upgrading in our country. It also helps them integrate their "small goals" for career development into the "big blueprint" of building a strong country.

2.3 Strengthening the awareness of the Chinese nation as a community is conducive to enhancing civic consciousness and serving social development

Strengthening the awareness of the Chinese nation as a community can enable students to deeply understand the concept of a community where "all ethnic groups embrace each other closely like pomegranate seeds", which is conducive to enhancing their sense of social responsibility. It can also stimulate students' initiative in participating in social services,

and enable them to practice their sense of responsibility and commitment in community governance, cultural inheritance, and ethnic unity. It can gather the consciousness of individual citizens into a synergy for social development. Provide a lasting spiritual impetus for the common prosperity of the Chinese nation.

Therefore, vocational education should fully recognize this mission of the Times, organically integrate the cultivation of the consciousness of the Chinese nation as a community into the entire process of talent cultivation, and cultivate more high-quality skilled talents with both moral integrity and professional competence for the great rejuvenation of the Chinese nation.

3. THE PATH OF INTEGRATING THE EDUCATION OF THE AWARENESS OF THE CHINESE NATION COMMUNITY INTO THE CULTIVATION OF HIGH-QUALITY SKILLED TALENTS IN VOCATIONAL EDUCATION

To effectively consolidate the awareness of the Chinese nation as a community and cultivate high-quality skilled talents for the new era in vocational education, it is necessary to establish a systematic and all-round educational path. These paths support each other and work in synergy, jointly forming a complete system for vocational education to consolidate the awareness of the Chinese nation as a community, providing a strong guarantee for cultivating high-quality talents with both professional skills and a sense of patriotism.

3.1 Strengthen curriculum-based education and build a dual-track curriculum-based education system

The vocational education curriculum system should revolve around the awareness of the Chinese nation as a community and create an all-round education pattern. Vocational colleges can establish a dual-track curriculum system for the education of the awareness of the Chinese nation as a community, with ideological and political courses as the main focus and "ideological and political courses"+"ideological and political education in courses". On the one hand, in the main field of ideological and political courses, ideological and political teachers should deeply tell the story of the Chinese nation community in ideological and political classes, enabling students to profoundly understand the historical evolution, theoretical connotation and contemporary value of the Chinese nation community. On the other hand, in the field of "ideological and political education in courses", elements of ethnic unity in professional courses should be explored. Integrate the education on the awareness of the Chinese nation as a community into professional courses, and deeply analyze its theoretical connotation, historical context and practical significance from a multi-disciplinary perspective. [2] For instance, integrating advanced ethnic craftsmanship techniques into professional courses can not only broaden students' professional horizons but also showcase the contributions of various ethnic groups to Chinese civilization, thereby fostering a strong sense of community among the Chinese nation in professional studies.

Furthermore, to achieve the best educational effect through courses, it is necessary to strengthen the construction of the teaching staff and enhance the comprehensive quality of teachers in vocational colleges, providing a solid and powerful backing for the education of consolidating the awareness of the Chinese nation as a community.

3.2 Strengthen cultural education and create a campus atmosphere of ethnic unity

By creating a strong cultural atmosphere of ethnic unity, students can enhance their identification with Chinese culture imperceptibly. Build cultural landscapes with ethnic characteristics such as the "Ethnic Unity" cultural corridor on campus to create an atmosphere of ethnic unity culture, so that students can be constantly influenced by ethnic culture in their daily campus life. Hold a three-in-one cultural and art festival integrating "red culture+ethnic culture+craftsmanship culture", and make it a regular event. Let students experience the charm of ethnic culture in the activities, thereby stimulating their love and pride for Chinese ethnic culture and strengthening their cultural confidence.

In addition, vocational colleges should make full use of digital and intelligent technologies to build a network education platform for the awareness of the Chinese nation as a community on campus and form an

educational all-media matrix. For instance, by means of short videos and text and images, we can innovate the ways of educating on the awareness of the Chinese nation as a community. With the in-depth empowerment of digital and intelligent technologies, we can promote the education on the awareness of the Chinese nation as a community from abstract theories to reality, providing strong support for the cultivation of the awareness of the Chinese nation as a community among college students.

3.3 Expand practical education and deepen the experience and recognition of the consciousness of the Chinese nation as a community

Practical education can truly enable the education of community consciousness to "go" on the way and "touch" the hearts of students. By carrying out special activities, promoting interactive exchanges on ethnic relations and guiding teachers and students to recognize the differences among ethnic relations is conducive to ethnic unity and mutual understanding. [3] On campus, vocational colleges can build VR experience rooms for the education of the awareness of the Chinese nation as a community, develop activity venues integrating "artificial intelligence+ethnic culture", empower the education of the awareness of the Chinese nation as a community with modern technology, popularize the history and current situation of ethnic development, and cultivate fertile ground for ethnic unity and integration. Outside of school, vocational colleges can organize students to visit red cultural education bases, allowing them to learn about the revolutionary history of the common struggle of all ethnic groups during the visit, and enhance their patriotic feelings and national pride. It is also possible to cooperate with local universities, communities, enterprises, etc., to achieve inter-school linkage, school-local linkage and school-enterprise linkage in the education of community consciousness, and thereby achieve the best effect of win-win education. For instance, organizing e-commerce major students to carry out live-streaming activities such as "Promoting the Sales of Ethnic Products" in communities can cultivate a sense of responsibility for serving the development of ethnic regions.

Vocational education shoulders the significant responsibility of cultivating high-quality technical and skilled talents. By organically integrating the education of the awareness of the Chinese nation as a community into the talent cultivation path and through multi-dimensional measures such as curriculum-based education, cultural education, and practical education, it can cultivate a group of high-quality skilled talents with the awareness of the Chinese nation as a community and contributing to the great rejuvenation of the Chinese nation in the new era. Promote the high-quality development of vocational education and the continuous progress of the cause of ethnic unity and progress.

References

[1] Xi Jinping emphasized at the Central Ethnic Work Conference:Take consolidating the awareness of the Chinese nation as a community as the main thread to promote the high-quality development of the Party's ethnic work in the new era [N]. People's Daily, 2021-08-29(1).

[2] Shi Shengli, Li Xuejie. The value implications, practical predicaments and practical paths of integrating the awareness of the Chinese nation as a community into ideological and political course teaching in colleges and universities [J]. Research on Ethnic Higher Education, 2024, (6):54-62.

[3] Zhou Ting. The value implications and practical paths of conducting education to strengthen the awareness of the Chinese nation as a community in ethnic colleges and universities [J]. Journal of Nanning Demonstration University(Philosophy and Social Sciences Edition), 2024(11):96.

Research on Cultural Adaptation and Cultural Conflict in the Process of International Education in Universities: A Case Study of Russian Students at Huanggang Normal University

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Abstract: China, as the world's second-largest economy with a gradually internationalizing education system, has attracted a large number of international students to study here. the challenging international environment has fostered a strong back-to-back partnership between China and Russia. An increasing number of Russian students are coming to China to pursue their studies. Their learning experiences in Chinese universities are both a manifestation of cultural exchange and a process of cultural adaptation. However, factors such as language barriers, differences in educational philosophies, and varied living habits pose certain cultural conflicts for Russian students. This paper takes Russian students at Huanggang Normal University as a case study to explore issues of cultural adaptation, the specific manifestations and impacts of cultural conflict, and proposes corresponding coping strategies.

Keywords: Internationalization of Higher Education; Cultural Adaptation and Cultural Conflict; Russian International Students

1. INTRODUCTION

Research on cultural conflict began in the mid-20th century, with early theories primarily focusing on direct opposition between cultures. Kluckhohn and Strodtbeck (1961) proposed the theory of cultural value differences, emphasizing that distinct fundamental values exist across different cultures, and conflicts in these values can lead to friction in social behavior. Hofstede (1980) introduced the cultural dimensions theory, analyzing differences in individualism vs. collectivism, power distance, uncertainty avoidance, and other aspects, which profoundly impact interpersonal communication and organizational behavior.

With the development of cross-cultural communication studies, Berry's (1997) acculturation model further deepened the theoretical framework for cultural conflict. He argued that cultural conflict is not merely a manifestation of cultural differences but also part of the acculturation process. Cultural adaptation is not instantaneous; it is a multi-stage process involving continuous adjustment and adaptation between the individual and the new cultural environment. Building on this, Ward (2001) further refined the concept of cultural conflict, proposing that it can be categorized into three types: cognitive conflict, affective conflict, and behavioral conflict, corresponding to the cultural maladjustment individuals experience at different levels. This paper will use Russian exchange students at Huanggang Normal University as an example to explore the specific manifestations and impacts of cultural conflict this group encounters during their educational process and propose corresponding coping strategies. Research indicates that the cultural conflicts faced by Russian students at our university mainly concentrate on the following aspects: educational philosophy, learning styles,

language barriers, living habits, and social culture.

2. EDUCATIONAL PHILOSOPHY AND CLASSROOM PARTICIPATION

Significant differences exist between the Chinese and Russian education systems. the Chinese education system emphasizes collectivism, exam results, and the authoritative status of teachers, whereas Russian education focuses on student independence and critical thinking (Wang Haiyun & Zhao Xiaotong, 2018). These differences cause difficulties for Russian students adapting to Chinese classrooms, particularly regarding classroom interaction and participation levels. Many Russian students are accustomed to actively raising questions and engaging in in-depth discussions with teachers during class. However, in the Chinese educational environment, students are often expected to follow more rules and discipline, making them feel uncomfortable in the classroom.

3. LEARNING STYLES

Notable differences exist in teaching methods between the Russian and Chinese education systems. Chinese university students are typically accustomed to more teacher-led instruction. In class, the teacher imparts knowledge, students speak less, and classroom interaction is relatively limited. Students' tasks mainly involve listening, taking notes, completing assignments, and taking exams. Classroom discussions tend to be formal, and there is a greater sense of distance between students and teachers. In contrast, Russian university students are usually encouraged to participate more in discussions and interactions during class, with teachers favoring a more debate-style exchange. Within the Russian education system, greater emphasis is placed on critical thinking and autonomous learning, interaction between teachers and students is more egalitarian, and the classroom atmosphere is relatively open. Consequently, during teaching sessions for Russian students at our university, teachers commonly report that Russian students create a very lively classroom atmosphere, demonstrating significantly higher learning initiative than domestic students. They enjoy constantly asking questions and answering the teacher's questions. This difference leads to Russian students potentially struggling to adapt to the teaching styles of Chinese instructors in the classroom, feeling confused or dissatisfied.

4. LANGUAGE BARRIERS AND COMMUNICATION STYLES

Language is a key factor in cultural adaptation. Although many Russian students have acquired some proficiency in Chinese before entering Chinese universities, they still face language barriers, especially in academic writing, classroom discussions, and daily communication (Kasyanov, 2016). the significant differences in grammar structure and vocabulary between Chinese and Russian can easily lead to misunderstandings for Russian students during learning. For instance, the Russian student Vasily directly wrote "Hello, I have a question to ask”in an email to a Chinese professor, which was perceived as overly direct and lacking politeness. Chinese possesses a complex system of honorifics and polite expressions (e. g. “excuse my interruption”, “pardon my bluntness”), particularly in teacher-student relationships. While Russian also has honorific forms (e. g., the formal "Вы"-you), its overall honorific structure is relatively simpler. This difference led to the Russian student's expression being misinterpreted within Chinese culture as lacking propriety. Furthermore, nonverbal behaviors in cross-cultural communication can also cause confusion for Russian students, especially when confronted with the indirect expression styles and implicit culture of Chinese students. For example, Russian students might perceive Chinese students as insufficiently honest, while Chinese students might consider Russian students too blunt or even rude. When the Russian student Ivan stated“I think this issue is unimportant”during a class presentation, it immediately caused discomfort and awkwardness among Chinese classmates and the teacher.

5. DIETARY HABITS AND LIVING HABITS

Dietary cultures in Russia and China differ greatly. With long, cold winters, Russians prefer high-fat, high-calorie foods for warmth. Staples often include bread, pancakes, pies, and other flour-based foods. In contrast, the local diet in Huanggang tends to be spicy and strong-flavored, with rice as the staple,

making dietary issues a significant challenge for them in China. Additionally, Russian students may feel uncomfortable with the hygiene standards and dining habits associated with Chinese cuisine.

Differences also exist in living habits. Russian students are accustomed to a more liberal lifestyle, whereas the strict management and disciplinary requirements of Chinese universities may cause them discomfort. For example, dormitory curfews and campus security checks can feel like constraints to students accustomed to greater freedom.

6. SOCIAL CULTURE AND CULTURAL IDENTITY

Significant differences also exist in social styles between Russian students and Chinese students. Chinese social culture emphasizes collectivism, and social activities often occur in group settings, whereas Russian social culture is more individualistic (Wang Yinghao & Liu Liping, 2021). This cultural conflict can create substantial psychological pressure for Russian students when interacting with Chinese peers, leading to feelings of loneliness, anxiety, and exclusion, especially upon first arriving in China. Prolonged cultural conflict can impact their academic performance and quality of life, and may even lead some students to abandon their studies midway. Furthermore, due to differences in learning styles, Russian students may struggle to adapt to the teaching models of Chinese universities in a short period, affecting their learning outcomes. Especially in courses requiring teamwork, cultural differences can lead to internal conflicts within teams and reduced collaboration efficiency. Additionally, issues of cultural identity pose a challenge for many Russian students. During the adaptation process, they may experience conflict regarding their cultural identity, needing to integrate into Chinese society while preserving their own cultural characteristics.

In response to the various impacts arising from cultural conflicts among Russian students at our university, teachers need to consider countermeasures to mitigate the negative effects of cultural differences on international students. Research shows that international students typically overcome cultural conflict through the following methods:

Strengthening Cultural Exchange: Provide training courses on Chinese culture, campus life, and social customs for international students during the initial enrollment period. Enhance cultural exchange activities with Russian students, such as organizing cultural festivals, lectures, and exchange meetings, to help them better understand Chinese culture. Simultaneously, encourage Chinese students to interact more with Russian students to foster mutual understanding and friendship.

Language Learning and Cultural Immersion: Language is the foundation for adapting to a new culture. Most Russian students overcome language barriers by improving their Chinese proficiency and enhancing their language skills through active participation in extracurricular activities and interaction with Chinese students (Liu Lijuan, 2019). Some students also participate in cultural exchange activities organized by the school to gain a deeper understanding of Chinese social customs and lifestyles, thereby narrowing the cultural gap. Additionally, offer tiered Chinese language courses based on students' proficiency levels, with tailored teaching plans for different levels.

Emotional Support and Psychological Counseling: During cultural adaptation, international students often experience emotional problems like loneliness and anxiety. Universities should establish comprehensive psychological counseling and support systems to help Russian students cope with the psychological pressure caused by cultural conflict. This can be achieved through mental health courses and one-on-one counseling to assist them in adapting better to the new environment. Professional psychological counseling can help students better understand and regulate their emotional responses, reducing the stress caused by cultural conflict (Wu Chunmei, 2022).

Adjusting Teaching Methods: Teachers should appropriately adjust teaching methods in class, respecting students from different cultural backgrounds. For example, encourage students to express diverse viewpoints and opinions, cultivate their critical thinking, while also respecting the learning habits of Chinese students, finding a balance.

Cultural Exchange and Mutual Understanding: Some scholars argue that

cross-cultural exchange is not only a means to resolve cultural conflict but also helps promote cultural integration. Chinese universities can organize Sino-Russian cultural exchange activities, such as language exchanges and festival celebrations, to help students better understand each other's cultural backgrounds and lifestyles (Zheng Wenjie, 2020). Such exchanges not only enhance the sense of belonging among international students but also foster mutual respect and understanding between different cultures.

Providing Dietary and Living Support: Universities should strive to offer diverse dining options to meet the needs of students from different cultural backgrounds. Simultaneously, allow some flexibility in life management, respecting students' personal habits and freedom.

7. CONCLUSION AND OUTLOOK

Existing research indicates that the cultural adaptation process for Russian students in Chinese universities is challenging, involving multiple aspects such as educational philosophy, language, and living habits. Nevertheless, through effective adaptation strategies and support systems, Russian students can gradually overcome cultural conflict and achieve cultural adaptation. Future research could further explore the cultural adaptation issues of international students from other countries in China or conduct in-depth analysis of the long-term impacts of cross-cultural education.

References

[1] Berry, J. W. (1997). Immigration, acculturation, and adaptation. [J]. Applied Psychology, 46(1), 5-34.

[2] Kasyanov, A. (2016). Cultural adaptation of Russian students in China: Challenges and strategies. [J]. Journal of International Education, 42(5), 95-104.

[3] Liu, L. J. (2019). Research on cultural adaptation issues of international students in the context of globalization. [J]. Education and Culture, 35(3), 45-51.

[4] Wang, H. Y., & Zhao, X. T. (2018). Cultural adaptation issues and countermeasures for Russian students in Chinese universities. [J]. Modern Education Management, 32(2), 67-74.

Statistical Analysis of the Influence of Entertainment Video on College Students

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Abstract: This paper collected 217 data by means of online questionnaire and offline survey, and discussed the influence differences between different genders and different grade backgrounds on the behaviors, emotions, learning, social interaction and values of college students, and explored whether there is a significant linear relationship between the influence of entertainment videos on the above five dimensions of college students and their self-regulation fatigue.

Key words: Entertainment Video; College Students; One-Way Anova; Welch's T-Test; Multiple Linear Regressio

1. Research Design

1.1 Research contents

This study recruited college students as subjects and collected data through online questionnaires and offline surveys. A total of 217 questionnaires were collected, including 177 online responses and 40 offline responses. the sample included 117 female participants, 100 male participants, 58 first-year students, 53 second-year students, 56 third-year students, and 50 fourth-year students. the research primarily investigates college students 'preferences for entertainment videos, their viewing duration, purposes, and motivations. It also examines how watching entertainment videos affects students' behavioral patterns, emotional states, academic performance, social interactions, and value systems. the study further analyzes gender and grade-level differences in these behavioral, emotional, academic, social, and value-related dimensions. Additionally, regression analysis was conducted to evaluate the impact of entertainment videos on cognitive fatigue, emotional fatigue, and behavioral fatigue.

1.2 Research method

To examine whether there are significant differences in entertainment video influence across dimensions (behavioral, emotional, academic, social, and value) among male and female college students, Welch's t-test [1] was employed. Primarily used to compare mean values between two independent samples, this test is widely adopted in practical research, particularly demonstrating its universal applicability in handling questionnaire survey data.

The formula for calculating the statistic of Welch's t-test is as follows [2]:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where $\bar{X}_1$, $\bar{X}_2$ are the means of two independent samples; s_1^2, s_2^2 are the variances of two samples; n_1, n_2 are the sample sizes of two samples.

To examine differences among university students across academic levels in various dimensions, this study employs one-way ANOVA [3]. This method investigates the impact of a categorical independent variable on a numerical dependent variable. When testing factors with $A_1, A_2, ..., A_r$ levels, each level represents an observation unit (i. e., k units), with the following assumptions]:

①Each population is normally distributed, denoted as

$N\left(\mu_i, \sigma_i^2\right), i = 1, 2, ...k$;

② the total variance is the same, denoted as

$\sigma_1^2 = \sigma_2^2 = ... = \sigma_k^2 = \sigma^2$;

③All test results are independent.

To compare whether the means are the same at different levels, the following hypothesis

needs to be tested:

$$H_0 : \mu_1 = \mu_2 = \cdots = \mu$$

If H_0 is true, then factor A is significant; otherwise, if H_0 is not true, then factor A is not significant.

The mathematical model of one-way ANOVA can be expressed as:

$$Y_{ij} = \mu + a_i + \varepsilon_{ij}$$

Where Y_{ij} is the i-th group, the j-th observation; μ is the mean of the population; a_i is the effect of the i-th group, i. e. the difference between groups; ε_{ij} is the error term.

Taking the three dimensions of self-regulated fatigue (cognitive fatigue, emotional fatigue and behavioral fatigue) as the dependent variables, this study constructed three multiple linear regression models [4] to explore the predictive effects of five types of influencing factors (behavioral influence, emotional influence, learning influence, social influence and value influence) in entertainment videos on self-regulated fatigue of college students.

The linear regression model between the dependent variable y and each independent variable is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon$$

And the model satisfies the assumptions:

$$\begin{cases} \varepsilon_i \sim N(0, \sigma^2), & i = 1, 2, \ldots, n \\ Cov(\varepsilon_i, \varepsilon_j) = \begin{cases} \sigma^2, & i = j \\ 0, & i \neq j \end{cases} & i, j = 1, 2, \ldots, n \end{cases}$$

2. An Empirical Analysis Of The Influence Of Entertainment Video On College Students

Since the influence of entertainment videos on college students is different in gender, in order to explore the differences of gender in the five dimensions (behavior, emotion, learning, social interaction and values) of the influence of entertainment videos, this paper uses Welch's t-test to compare the average scores of each dimension between male and female. the results are shown in Table 1 below.

Table 1 shows the t-test results of the scores of different genders in each dimension

dimension	Male average	Female average	t value	free degree	P value
behavior	3.87	4.16	-2.43	185.65	0.016
emotion	3.89	4.04	-1.21	186.14	0.228
learning	3.83	3.99	-1.21	197.66	0.227
Social	3.87	4.06	-1.44	188.43	0.152
value	3.84	4.01	-1.39	188.48	0.167

As shown in Table 1, only the behavioral impact dimension showed significant gender differences, indicating that female students were more likely to have behavioral responses after watching entertainment videos, while the gender differences were not obvious in the other four dimensions. This indicates that the influence of entertainment videos on college students is more universal in these aspects.

Then, by using single-factor analysis of variance and other methods [5], the mediating and moderating effects between different background variables and the influence of each dimension are verified, so as to systematically reveal the mechanism of entertainment video on college students' behavior and psychology.

Taking grade as the independent variable and the average score of each dimension as the dependent variable, the results of single factor analysis are shown in Table 2 below:

Table 2. One-way ANOVA results of influence scores in each dimension by grade

dimension	free degree	quadratic sum	mean square	F value	P value
behavioral	3213	11.17/155.33	3.724/0.729	5.106	0.00197
emotion	3213	7.40/168.80	2.467/0.793	3.113	0.0272
learning	3213	9.88/175.77	3.293/0.825	3.990	0.00859
Social	3213	19.71/170.26	6.569/0.799	8.218	0.000034
value	3213	8.03/168.74	2.676/0.792	3.378	0.0192

This indicates that there are some differences in the emotional responses of students of

different grades after watching entertainment videos, which may be related to psychological maturity, content preference changes and other factors.

In the learning influence dimension, ANOVA results also revealed significant differences ($F = 3.99$, $p = 0.00859 < 0.01$). This finding indicates that grade level is a crucial factor influencing changes in learning attitudes. the difference between grade levels and social influence dimensions was highly significant ($F = 8.218$, $p < 0.001$), suggesting that entertainment videos 'impact on shaping college students' social behaviors is significantly moderated by grade stage. Significant grade-level differences were also observed in the values dimension ($F = 3.378$, $p = 0.0192 < 0.05$). This suggests that students at different grade levels may exhibit notable differences in value construction, moral judgment, and content acceptance after watching entertainment videos.

To investigate the relationship between the effects of entertainment video consumption on college students' behavior, emotions, learning, social interactions, and values, as well as their self-regulation fatigue levels, this study employed correlation coefficients to analyze two types of variables. the impact of entertainment videos encompasses five dimensions (behavioral effects, emotional effects, academic performance, social engagement, and value orientation), while the self-regulation fatigue scale includes three dimensions (cognitive fatigue, emotional fatigue, and behavioral fatigue). the correlation analysis results are presented in Table 3:

Table 3 Correlation coefficient matrix between the influence of entertainment video and self-regulated fatigue

	Cognitive fatigue	Emotional fatigue	Behave tired
behavior	0.311	0.731	0.773
emotion	0.278	0.793	0.809
learning	0.241	0.790	0.786
social	0.324	0.822	0.800
value	0.280	0.785	0.823

As shown in Table 3, the correlation coefficients between the five dimensions of entertainment video and the first dimension of self-regulation fatigue (cognitive fatigue) are all relatively low ($r = 0.241$-0.324), indicating weak positive correlations. However, significant correlations are observed with the second (emotional fatigue) and third (behavioral fatigue) dimensions of fatigue. Notably, the correlations between social influence and emotional fatigue ($r = 0.822$) as well as value influence and behavioral fatigue ($r = 0.823$) demonstrate particularly strong positive correlations.

These findings demonstrate that college students' social interactions and value judgments following entertainment video consumption are strongly correlated with the fatigue experienced during emotional regulation and behavioral adjustment. Conversely, the weaker relationship with the first dimension suggests limited impact from entertainment videos in this aspect. Further analysis reveals correlations between emotional influence, learning influence, and value influence dimensions with both second and third fatigue dimensions at approximately 0.78, indicating consistent associations with behavioral regulation of self-regulated fatigue and emotional exhaustion. There are consistent manifestations with behavioral regulation of self-regulated fatigue and emotional exhaustion.

To sum up, the influence of entertainment videos on college students, especially in the social and value aspects, may aggravate their fatigue experience in the process of emotional and behavioral regulation, which deserves attention in educational intervention and psychological adjustment.

In order to further explore the influence of entertainment videos on different dimensions of self-regulation fatigue of college students, this paper takes "behavior(x_1)" "emotion(x_2)" "learning(x_3)" "social(x_4)" and "value(x_5)" five dimensions are used as independent variables, take "cognition(y_1)" "sentiment(y_2)" and "conduct(y_3)" three

dimensions are used as dependent variables, Three multiple linear regression models were constructed respectively. The results are shown in Table 4, Table 5 and Table below:

Table 4 Regression analysis results of the influence of entertainment videos on cognitive fatigue dimensions

variable	coefficient of regression	standard error	t value	P value
(Intercept)	2.268	0.165	13.729	<0.001***
behavior	0.132	0.082	1.610	0.109
emotion	0.009	0.090	0.097	0.923
learning	-0.126	0.082	-1.544	0.124
social	0.167	0.071	2.337	0.020*
value	0.018	0.083	0.223	0.824

The linear regression equation is:

$$\hat{y}_1 = 2.351 + 0.183x_4$$

The results show that only one dimension is significant, so it is believed that there is no significant linear relationship between the five dimensions of entertainment video and cognitive fatigue. It may also be due to the small sample data, which has some limitations.

Table 5 Regression analysis results of the influence of entertainment videos on emotional fatigue dimensions

variable	coefficient of regression	standard error	t value	P value
(Intercept)	0.890	0.117	7.588	<0.001***
behavior	-0.061	0.058	-1.045	0.297
emotion	0.141	0.064	2.216	0.028*
learning	0.126	0.058	2.182	0.030*
social	0.307	0.051	6.066	<0.001***
value	0.169	0.059	2.884	0.004*

The linear regression equation is:

$$\hat{y}_2 = 0.861 + 0.124x_2 + 0.115x_3 + 0.298x_4 + 0.151x_5$$

The "social influence" coefficient ranks highest, demonstrating its most significant predictive role in emotional fatigue. This indicates that social content can trigger emotional resource consumption in individuals. For instance, when college students engage in video comment interactions or share discussions on social platforms, they may experience psychological states such as comparison, anxiety, and being evaluated, which intensify emotional fluctuations and increase regulatory burden.

Emotional influence, as an indicator of emotional tone in video content, demonstrates a significant impact. Videos with high emotional intensity (such as sad plots, hilarious content, or sentimental materials) tend to cause emotional exhaustion among viewers. Additionally, value influence positively predicts emotional fatigue, suggesting that individuals may develop emotional identification or conflict when encountering the values conveyed in entertainment content, thereby affecting their emotional regulation capabilities.

In general, entertainment videos not only affect college students' emotional fatigue through the emotional tension of their content, but also aggravate their emotional resource consumption through implicit paths such as sociality and value orientation.

Table 6 Regression analysis results of the influence of entertainment video on behavioral fatigue dimensions

variable	coefficient of regression	standard error	t value	P value
(Intercept)	0.845	0.112	7.527	<0.001***
behavior	0.041	0.056	0.737	0.462
emotion	0.137	0.061	2.245	0.026*
learning	0.064	0.055	1.152	0.251
social	0.196	0.048	4.047	<0.001***

value	0.248	0.056	4.413	<0.001***

The linear regression equation is:

$$\hat{y}_3 = 0.930 + 0.205x_2 + 0.155x_3 + 0.308x_5$$

The regression coefficient for "value influence" shows the highest magnitude, indicating that lifestyle values, consumption patterns, and social perceptions conveyed in entertainment videos profoundly shape students' behavioral habits. For instance, influenced by the lifestyles or goals portrayed in these videos, students may fall into blind imitation or excessive comparison, leading to time management imbalances, procrastination, and other issues that exacerbate behavioral adjustment fatigue. Additionally, "emotional influence" significantly contributes to behavioral fatigue, likely due to its impact on the motivational system. When emotionally exhausted, individuals experience diminished action willingness and reduced behavioral control capabilities.

In conclusion, the emotional color and value guidance in entertainment video content will affect the fatigue of behavioral regulation, which indicates that we should pay attention to guide students to maintain good behavioral rhythm and self-control consciousness when designing entertainment content.

3. Conclusion

While entertainment videos provide college students with relaxation and entertainment, they exert significant negative impacts on cognitive functions, emotional regulation, and behavioral self-regulation mechanisms. Particularly in emotional and behavioral adjustment, the high-stimulation, high-frequency nature of these videos disrupts students' established circadian rhythms and psychological equilibrium, potentially triggering emotional burnout and behavioral laxity.

References

[1] Kong Lingyao. the Impact of Short Video Entertainmentization on College Students 'Values and Educational Strategies [D]. Northeast Normal University, 2021. DOI:10.27011/d. cnki. gdbsu. 2021.001096.

[2] Liu Xumei. Research on the Impact of Short Video Entertainmentization on College Students' Values [D]. LudongUniversity, 2023.2023.000093.

[3] Zhang Shuo. College Students 'Use and Satisfaction with Entertainment Videos [D]. Zhejiang University of Media and Communications, 2015.

[4] Liu Yuan & Xu Fenfei. Challenges and Countermeasures of Short Video Entertainmentization in College Students' Ideological and Political Education [J]. Public Relations World, 2025(03):21-23.

[5] Ling Jiyi. Negative Impacts of Short Video Entertainmentization on College Students' Values and Countermeasures [D]. Southwest University, 2023. DOI:10.27684/d. cnki. gxndx. 2023.000807.

Study on the Image Elements and Attention Degree of Tourism and Cultural Landscapes in Qinhuangdao Zushan Scenic Area from a Cross-Cultural Perspective

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Abstract: Taking Qinhuangdao Zushan Scenic Area as the research object, this paper, from a cross-cultural perspective and combined with visual representation analysis, social media data mining, the IPA model and deep learning technology, carries out the extraction of image elements of tourism and cultural landscapes, the analysis of attention degree characteristics, and the exploration of international development paths. The study aims to clarify the composition system of landscape image elements in this scenic area and provide theoretical and practical support for the scenic area to optimize landscape presentation, meet the needs of the international market, and formulate scientific internationalization strategies.

Key Words: Zushan Scenic Area; tourism and cultural landscape; image element; attention degree; cross - culture

1. RESEARCH BACKGROUN

Under the current tide of globalization, tourism, as an important bridge for international cultural exchange and economic cooperation, its international development has become an inevitable trend. China is rich in tourism resources, and many scenic areas are committed to exploring the international market to enhance their international influence and competitiveness.

Qinhuangdao Zushan Scenic Area is located in Qinhuangdao City, Hebei Province. It integrates natural scenery with cultural heritage and has unique tourism and cultural landscapes. However, in the process of internationalization, Zushan Scenic Area is faced with many challenges, such as how to accurately grasp the needs of tourists from different cultural backgrounds and optimize landscape presentation to attract international tourists. Groups with different cultural backgrounds have significant differences in values, aesthetic preferences, consumption habits, etc., and these differences will directly affect their cognition and evaluation of tourism and cultural landscapes. Therefore, in - depth research on the tourism and cultural landscapes of Zushan Scenic Area from a cross - cultural perspective is of great practical significance.

2. ANALYIS OF THE COMPOSITION SYSTEM OF IMAGE ELEMENTS OF TOUTISM AND CULTURAL LANDSCAPES IN ZUSHAN SCENIC AREA

2.1 Natural landscape elements

Through visual representation analysis and social media data mining, we have extracted the following main natural landscape elements.

Mountains are one of the most prominent natural landscape elements in Zushan Scenic Area. The mountains in Zushan have various forms, some are towering and straight, while others are precipitous and steep, giving people a strong visual impact. On social media, many tourists share the magnificent scenery of the mountains and express their admiration for their grand momentum.

Rivers and waterfalls are also the focus of tourists' attention. Clear rivers meander through the valleys, and waterfalls pour down from high places, forming a spectacular scene. These water landscapes not only add a flexible beauty to the scenic area but also provide

places for tourists' leisure and entertainment, such as playing in the water and fishing.

Vegetation coverage is the basis of the natural landscape of Zushan Scenic Area. The scenic area has a variety of vegetation types, including forests, shrubs, and herbs, with different sceneries in four seasons. In spring, hundreds of flowers bloom; in summer, the area is lush and green; in autumn, the mountains are covered with colorful leaves; in winter, everything is wrapped in silver. All these attract a large number of tourists to come for sightseeing.

2.2 Humanistic landscape elements

Zushan Scenic Area not only has beautiful natural landscapes but also contains profound cultural heritage, with a variety of humanistic landscape elements.

Ancient buildings are important representatives of the humanistic landscapes in Zushan Scenic Area, such as ancient temples and ancient Great Wall ruins. These ancient buildings have witnessed the changes of history and have high historical and cultural values. On social media, tourists often share photos of these ancient buildings and discuss their architectural styles and historical backgrounds.

Folk activities are also important factors attracting tourists. Residents around Zushan Scenic Area have preserved many traditional folk cultures, such as temple fairs and folk art performances. These folk activities show the local customs and allow tourists to have an in - depth understanding of the local cultural characteristics.

Historical relics are another important part of the humanistic landscapes in Zushan Scenic Area, such as ancient battlefield ruins and former residences of celebrities. These historical relics carry rich historical stories and cultural connotations, which can arouse tourists' historical feelings and desire for exploration.

2.3 Service facility elements

In addition to natural and humanistic landscape elements, service facility elements are also important factors affecting tourists' travel experience and constitute a part of the image of the tourism and cultural landscapes in Zushan Scenic Area.

Transportation facilities are the basis for tourists to enter the scenic area and travel within it, including parking lots, sightseeing cars in the scenic area, and walking paths. Convenient transportation facilities can improve the efficiency and comfort of tourists' travel, while the opposite will affect tourists' experience.

Catering and accommodation facilities are also the focus of tourists' attention. The food quality, service level, and environmental hygiene of restaurants and hotels inside and around the scenic area will all affect tourists' evaluation.

Tourism information service facilities, such as scenic area guide maps, signboards, and tourist centers, can provide tourists with necessary information and help, facilitating tourists to have a better understanding of the scenic area.

3. INTERANTIONL DEVELOPMENT PATHS OF ZUSHAN SCENIC AREA

3.1 Optimize landscape presentation

According to the differences in attention degree of groups with different cultural backgrounds towards landscape elements, optimize the landscape presentation of Zushan Scenic Area.

For natural landscapes, on the basis of maintaining their original style, develop some challenging hiking routes and adventure projects to meet the needs of Western tourists, and set up clear signboards and safety reminders in the scenic area. At the same time, pay attention to creating the overall artistic conception of natural landscapes and add some areas and viewing platforms for Eastern tourists to take a leisurely walk.

For humanistic landscapes, strengthen the protection and restoration of ancient buildings and historical relics, deeply explore their historical and cultural connotations, and produce detailed explanatory materials to meet the needs of Eastern tourists for history and culture. At the same time, hold more interactive and participatory folk activities and invite Western tourists to participate in them to enhance their sense of experience.

In terms of service facilities, improve transportation facilities to enhance their convenience and safety, add multi - language signboards and guide information to facilitate Western tourists' self - guided tours. Improve the service quality of catering and accommodation, launch local characteristic

dishes and personalized services to meet the needs of Eastern tourists.

3.2 Accurately meet the needs of the international market

Through the investigation and analysis of the international market, accurately grasp the needs of tourists from different cultural backgrounds and formulate targeted marketing strategies.

For the Western market, use internationally renowned tourism websites, social media platforms, etc. for promotion, highlight the natural landscape characteristics and adventure projects of Zushan Scenic Area, and attract tourists who like hiking and adventure. Cooperate with international travel agencies to launch customized tourism products to meet the personalized needs of Western tourists.

For the Eastern market, use traditional promotion channels and social media to emphasize the historical and cultural connotations and leisure vacation atmosphere of Zushan Scenic Area, and attract family tourists and cultural lovers. Participate in international tourism exhibitions to display the characteristics and charm of Zushan Scenic Area and improve the visibility of the scenic area.

3.3 Strengthen cultural exchange and cooperation

Strengthen exchanges and cooperation with international tourism institutions and cultural organizations, and hold cross - border cultural exchange activities, such as cultural festivals and art exhibitions, to enhance the understanding and recognition of Zushan Scenic Area among groups with different cultural backgrounds. Through cultural exchanges, promote the dissemination and integration of the tourism culture of the scenic area and enhance the international influence of the scenic area.

3.4 Improve service quality and management level

Strengthen the training of scenic area staff, improve their foreign language proficiency and service awareness, and provide high - quality services for international tourists. Establish and improve the management system of the scenic area, strengthen the management of the scenic area's environment, safety, etc., and create a good tourism environment. At the same time, use information technology to improve the intelligent management level of the scenic area and provide more convenient services for tourists.

4. Conclusion

Looking forward to the future, with the continuous advancement of the internationalization process of Zushan Scenic Area, it is necessary to continuously pay attention to the changes in the international tourism market and the evolution of tourists' needs, and constantly optimize the development strategy of the scenic area. At the same time, strengthen exchanges and cooperation with other scenic areas, learn from successful international experience, and jointly promote the international development of China's tourism industry. It is believed that the results of this study can provide useful references for the international development of Zushan Scenic Area and help Zushan Scenic Area achieve better development in the international tourism market.

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A Study on the Extraction of Landscape Image Elements and Attention Degree in the Context of Internationalization - A Case Study of the Tourism and Cultural Landscapes in Qinhuangdao Zushan Scenic Area

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References

[1] Bao Jigang, Chu Yifang. Tourism Geography [M]. Beijing: Higher Education Press, 2018.

[2] Baloglu, S., & McCleary, K. W. A model of destination image formation[J]. Annals of Tourism Research, 1999, 26(4): 868 - 897.

[3] Li Tianyuan. Tourism Destination Marketing [M]. Tianjin: Nankai University Press, 2007.

[4] Pearce, D. G. Tourist Destination Management [M]. Harlow: Longman, 1992.

[5] Qinhuangdao Municipal People's Government. Zushan [EB/OL]. 2022.

[6] http://www.qhd.gov.cn/front_pcthi.do?LMCL=EUmo0z&LMCL=vOdRz&uuid=A1430893D45F33485268AD3F45535DD3

[7] 8035.html https://www.chinaqinglong.gov.cn/single/6/2

Practice and Exploration of Effective Scenarios in Financial Management Classroom Teaching

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Abstract: The financial management course is a professional course with strong theoretical and practical aspects. the traditional teaching mode based on lectures is difficult to stimulate students' learning interest, thinking ability, and innovation ability. This article focuses on the teaching reform of financial management courses. Based on the theoretical foundation of situational teaching method, it explores the design, implementation and evaluation of effective situations in financial management classroom teaching, explores the innovative application of situational teaching method, and provides reference for the reform of financial management teaching.

Keywords: Situational teaching; reform in education; Practical teaching; Classroom interaction

1. INTRODUCTION

Financial management is a core course in economic management majors, involving important content such as fundraising management, investment decision-making, working capital management, profit management, and financial analysis. It has strong practicality and applicability. With the advent of the digital economy era, the traditional classroom teaching model that focuses on professors and students passively receive knowledge is difficult to apply theory to practical financial problems and meet the needs of cultivating "business finance integration" composite talents. Therefore, innovative teaching methods, strengthening practical teaching links, and exploring the application of situational teaching methods in financial management courses are of great practical significance.

The key to situational teaching method lies in the "context". Effective context "refers to a simulated teaching environment that is characterized by authenticity, interactivity, and development, and can effectively promote students' knowledge construction and ability development. Effective situational teaching method refers to the creation of real or simulated financial scenarios, allowing students to actively learn through role-playing, case analysis, decision simulation and other activities, and using real or virtual scenarios for practical application, effectively achieving the integration of theory and practice, thereby helping students understand and analyze practical problems in financial management, and effectively enhancing their participation and practical abilities. This situational teaching method can directly experience the significance of theory and practice, providing a replicable implementation path for the reform of financial management practice teaching.

2. THEORETICAL BASIS FOR EFFECTIVE SITUATIONAL CREATION IN CLASSROOM TEACHING OF FINANCIAL MANAGEMENT

The situational teaching method originates from the constructivist learning theory, emphasizing the creation of real or simulated environments in teaching, highlighting the student's subjectivity in the teaching process, encouraging learners to actively construct knowledge, participate in practical activities, and use simulated situations to broaden students' thinking, achieving good teaching results. Its core viewpoints include:

Situational cognitive theory: Knowledge is formed in specific contexts, and learning should be combined with practical applications, emphasizing the initiative and

practicality of learning.

Experiential learning: based on the concept of experiential teaching, emphasizing the principle of participation. Students learn and apply knowledge in practical operations, deepen their understanding and mastery of knowledge through personal experience and reflection.

Collaborative learning: the situational teaching method emphasizes communication and cooperation among students. Students cannot solve problems in a work environment without cooperation among team members. Through cooperative learning, cultivate communication and decision-making skills, and improve students' comprehensive abilities.

In financial management teaching, situational teaching method creates virtual company scenes that are close to reality to help students better learn financial knowledge, understand financial concepts, and improve their ability to analyze and solve problems.

3. EFFECTIVE SITUATIONAL DESIGN IN CLASSROOM TEACHING OF FINANCIAL MANAGEMENT

The situational teaching method selects suitable content and projects based on teaching objectives and student characteristics, and creates realistic situations. the situation can be a daily life scenario or a simulated situation in a professional environment. the setting of the situation should be in line with students' interests and actual background.

By creating and applying effective classroom contexts, teaching content is vividly presented to students, allowing them to actively engage in effective contexts and improve learning efficiency. This teaching method achieves the unity of teaching context and teaching content.

3.1 Principles of situational design

Authenticity: the design context should be close to the actual scene and environment of the enterprise, and close to the actual financial issues of the enterprise, such as budget preparation, fundraising and investment decisions, financial statement analysis, etc. Realistic situations can enhance students' ability to solve practical problems.

Interactivity: In teaching practice, teachers design situational teaching based on teaching content, create situations based on problems, integrate teaching content into situations, encourage students to actively participate in discussions, role-playing, and decision-making simulations, and enhance classroom interactivity.

Challenging: the scenario design should meet the learning requirements and have a certain level of difficulty, in order to stimulate students to think deeply and explore.

Operability: Situational design should conform to teaching objectives and students' cognitive levels, be in line with the teaching environment, have practical operability, and facilitate classroom implementation.

Development: Situational design should have a certain level to support the step-by-step improvement of practical abilities.

3.2 Typical cases of situational design

A situation can be a simulation of practice, a reproduction of real cases, or a hypothetical situation. When designing scenarios, teachers need to play the role of creators and create management activities related to financial management.

3.2.1Budget preparation and management context

Scenario setting: Simulate the annual budget preparation process of a company and set up budget preparation and management scenarios, with students playing roles such as department heads and financial managers.

Implementation method: Role playing and negotiation simulation methods are adopted, with students serving as department heads, actively seeking budget resources, and ultimately forming a balanced budget plan.

3.2.2Investment decision simulation scenario

Scenario setting: the enterprise has multiple alternative investment projects, and students act as management to make decisions using methods such as net present value and internal rate of return.

Implementation method: Discuss in groups, calculate and compare investment decision indicators of different schemes, and finally make investment scheme choices and explain the reasons.

3.2.3Context of Corporate Financial Analysis

Scenario setting: Set up a financial statement analysis for a listed company, where students act as financial analysts to evaluate the company's financial situation and provide recommendations.

Implementation method: Group discussion, through real report data analysis, write a

financial analysis report and provide opinions.

3.2.4Financial risk control scenario

Scenario setting: the enterprise is facing the risk of capital shortage, and students act as financial managers to develop response plans. Implementation method: Adopting case analysis method, decision simulation method, group discussion, and solving the current crisis through fundraising, cash flow management, cost control and other solutions.

3.3 Problems and improvement suggestions in situational practice

Students have different levels of acceptance, and some students have insufficient participation. It is possible to design progressively difficult tasks for students with different foundations by designing scenarios in a layered manner.

The situation design is too simple or complex, which affects the teaching effectiveness. Information technology can be combined with financial software or simulation platforms (such as virtual simulation experiments) to enhance the realism and conformity of the situation.

Classroom time is limited, making it difficult to fully explore complex situations. Teacher guidance can be strengthened by providing prompts in key areas to avoid discussions deviating from the main topic.

4. EFFECTIVE SITUATIONAL IMPLEMENTATION IN CLASSROOM TEACHING OF FINANCIAL MANAGEMENT

4.1 Establish a situational case library for school enterprise cooperation

Currently, financial management teachers usually need high-quality teaching cases that are operable and easy to simulate as references when applying situational teaching methods. This requires selecting high-quality cases through multiple channels and methods, gradually improving and supplementing relevant school enterprise cooperation cases in teaching practice, and enriching the situational case library of the curriculum. For example, in the case of Changyu Co. Ltd. 's consecutive high cash payouts for many years, students are guided to set up a hypothetical work scenario, analyze the abnormal cash payouts that occur in Changyu Company's dividend distribution, guide students to analyze from various perspectives such as creditors, investors, managers, and internal employees, and make financial evaluations.

4.2 Conduct training on teachers' situational teaching ability

The situational teaching method has certain requirements for teachers' theoretical knowledge reserves, professional abilities, and experience storage. Influenced by traditional teaching methods, many "financial management" teachers focus more on theoretical teaching and academic research, lacking practical experience in financial management. They are unable to integrate relevant theoretical knowledge and corresponding simulation scenarios in their teaching, which affects the teaching effectiveness. In addition, due to the insufficient situational teaching ability of teachers, the created situations may be simple or complex, or not suitable for the current financial management situation, which will also affect the application of situational teaching methods. Therefore, it is necessary to improve teachers' situational setting and teaching level through various means, actively carry out training on teachers' situational teaching ability, regularly organize discussions on the application of situational teaching methods, increase opportunities for teachers to work in enterprises for training, which will help teachers accumulate more financial management practical experience and better carry out situational teaching.

4.3 Develop an intelligent situational teaching platform

The implementation of situational teaching method requires extremely high requirements for the teaching hard environment. In addition to the necessary network simulation studio and multimedia equipment, there must also be necessary teaching software. In the knowledge economy, information technologies such as multimedia, network, and big data are important teaching methods in modern education, with characteristics such as imagery, vividness, and efficiency. Their superiority is increasingly highlighted in helping to create and implement situational teaching. In financial management teaching, the development of an intelligent situational teaching platform, through virtual reality technology, creates a realistic and vivid financial environment for students, allowing

them to experience the entire process of financial management activities in enterprises by role and position, which is of great help to students entering the workplace in the future.

4.4 Building a research and development community in the context of "school enterprise"

Creating effective scenarios for financial management can start from industry and enterprise applications. Through teacher to enterprise research or inviting enterprise experts to schools for guidance, a "school enterprise" scenario research and development community can be established. In course teaching, knowledge points can be integrated into task points, skill points, and project points to jointly design realistic teaching scenarios, enabling students to cultivate their professional skills and comprehensive literacy through job experience.

5. EFFECTIVE SITUATIONAL EVALUATION IN CLASSROOM TEACHING OF FINANCIAL MANAGEMENT

The situational teaching method places more emphasis on students' practical and comprehensive abilities, and it is difficult to evaluate them using traditional examination methods. Therefore, it is necessary to improve the existing curriculum evaluation system and methods.

Adopting a diversified evaluation approach: Evaluation is a key factor in determining the effectiveness of implementing situational simulation teaching methods. Diversified evaluation subjects, such as teachers, students, and enterprise guidance teachers, all participate in the evaluation; Diversified evaluation methods, such as project evaluation, questionnaire evaluation, observation evaluation, etc., use various forms to comprehensively evaluate students' learning outcomes and future career abilities.

Emphasize process evaluation: the situational teaching method emphasizes timely summary and evaluation of the simulated practice process. Teachers' comments on students' practical processes can enhance their enthusiasm and initiative in participating in situational simulations, enabling students to gain a sense of achievement and satisfaction through teachers' evaluation and encouragement. When evaluating the process, teachers should be reasonable and moderate, focusing on students' thinking, analysis methods, and problem-solving approaches. They should leave room for students to think, so that students can have a deeper understanding and grasp of the application of theoretical knowledge and practical operations in situational learning.

Emphasize effectiveness evaluation: the situational teaching method should pay attention to comprehensive feedback on the final simulation effect, including student feedback, classroom observation, and performance comparison.

Student feedback: Through questionnaire surveys or communication, understand students' acceptance and learning experience of situational teaching.

Classroom observation: During classroom teaching, record students' participation, discussion depth, and problem-solving ability.

Comparison of grades: Compare the assessment scores and application abilities of students under situational teaching and traditional teaching modes, and demonstrate the advantages of creating and practicing effective scenarios in financial management course teaching through comparison.

Teaching evaluation is the final stage of teaching activities and should run through the entire process of teaching activities. Only by establishing a comprehensive course evaluation system can the teaching quality of financial management courses be better improved.

In summary, financial management is a professional course that integrates theory and practice. Its practicality requires students to master both theoretical knowledge and relevant practical skills. the situational teaching method enables students to simulate and practice through specific cases and events, achieving efficient classroom teaching, improving teaching quality, and enhancing students' practical application abilities.

Situational teaching method is a teaching approach based on context, which has significant importance in modern education. Currently, by exploring the design, implementation, and evaluation of effective scenarios in financial management classroom teaching, the practicality and interactivity of financial management classrooms can be

effectively enhanced, achieving an organic unity of knowledge imparting, ability cultivation, and value guidance. Future research can further explore the deep integration of information technology and situational teaching, and promote the innovative development of financial management curriculum reform.

References

[1] Zhao Zhiying. The application of situational teaching method in the teaching of "financial management" in higher vocational education. Chinese and foreign entrepreneurs, 2020-01-10

[2] Wu Jing. Teaching Financial Management in the Knowledge Economy Era. New Technologies and Products in China, 2008-11-25

[3] Feng Yinbo. Reform of Financial Management Teaching Mode - Situational Teaching Method. Business Situation (Financial Research), 2007-10-15

[4] Han Zhili. The application of behavior oriented situational teaching method in financial management teaching. Friends of Accounting (Mid Month Journal), 2006-07-15

Demand Characteristics and Cultivation Countermeasures of New Energy Vehicle Professionals under Horizontal Division of Labor

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Abstract: With the acceleration of the global energy transition process, the new energy automobile industry is experiencing unprecedented rapid development. In this process, the industrial chain organization presents a significant horizontal division of labor, which has a profound impact on the demand structure of professionals. Against this background, this paper explores the demand characteristics of new energy automobile professionals and their cultivation path under the horizontal division of labor mode. It is found that the continuous refinement of the industrial division of labor not only gives rise to deeply specialized technical positions, but also puts forward higher requirements for the cross-field collaboration ability of talents. the current talent cultivation system has problems such as lagging behind in specialties and curricula, insufficient teachers, and lack of in-depth cooperation between schools and enterprises. Based on this, this paper puts forward countermeasures from the optimization of professional curriculum, strengthening the construction of faculty, and in-depth school-enterprise cooperation, which provides a reference for the construction of talent cultivation adapted to the development needs of new energy automobile industry.

Keywords: Horizontal Division Of Labor; New Energy Vehicle Professionals

1. INTRODUCTION

1.1 Research Background

The global new energy automobile industry is in the stage of rapid development, the industry scale continues to expand, and technological innovation is changing day by day. According to EVTank statistics, the global new energy vehicle sales in 2024 exceeded 18.23 million units, and China contributed 70.5% of the global sales with 12.866 million units. Compared with the traditional automobile industry, the new energy vehicle industry chain presents obvious horizontal division of labor characteristics, and each specialized link is completed independently by different enterprises. For example, core components such as batteries, motors and electronic control are independently developed and produced by specialized enterprises, while vehicle manufacturers focus on system integration and brand operation. This mode of division of labor, while enhancing industrial efficiency, also puts forward new requirements for the knowledge structure and ability quality of professionals. It is of great theoretical and practical significance to deeply analyze the characteristics of talent demand under the horizontal division of labor and explore effective talent training paths to promote the high-quality development of new energy automobile industry.

1.2 Research significance

The talent demand of new energy automobile industry is undergoing structural change. the knowledge system of traditional automobile engineers can no longer meet the needs of emerging technology fields, and the talent training in colleges and universities is lagging behind. Studying the characteristics of talent demand under the horizontal division of labor is of great value for optimizing the education

system, guiding the human resource management of enterprises and perfecting industrial policies.

2 THE INFLUENCE MECHANISM OF HORIZONTAL DIVISION OF LABOR ON TALENT DEMAND

2.1 Characteristics of horizontal division of labor

Horizontal division of labor refers to the stage of producing final products or services, where different units are responsible for different sectors, industries or products. Horizontal division of labor in the new energy automobile industry is mainly reflected in three dimensions: technology dimension: core technology is decomposed into multiple specialized R&D directions; production dimension: the manufacturing process is subdivided into multiple specialized links; service dimension: after-market services form an independent professional system. Under the horizontal division of labor mode, the new energy vehicle industry chain is decomposed into multiple specialized links. Take power battery as an example, positive electrode materials, negative electrode materials, diaphragm, electrolyte, etc. are specialized by different enterprises, and finally handed over to battery enterprises for integration. This division of labor significantly improves the technical depth and production efficiency of each link, but also increases the difficulty of synergy.

2.2 Core performance of demand change

The demand for professional talents presents two significant features: on the one hand, the degree of specialization has deepened, such as the subdivision of battery R&D positions into solid-state battery experts, thermal management engineers and other directions; on the other hand, the demand for cross-field collaboration has been enhanced: for example, the development of intelligent driving systems requires software engineers to understand the automotive functional safety standards.

2.3 New Energy Vehicle Talent Demand

The rapid development of new energy vehicles based on the horizontal division of labor mode has led to an increase in the industry's demand for technical personnel, especially professional talents with theoretical knowledge of the latest technology and the ability to operate it in practice. At present, the core technology of new energy vehicles is mainly concentrated in the field of three electric technologies, motor, battery and electronic control. These three core technologies are the key to new energy vehicles and put forward higher requirements for the professional level of technicians, such as the development of energy management strategies, battery thermal management, fault diagnosis and the development of energy recovery strategies. Table 1 demonstrates the emerging job requirements under the horizontal division of labor.

Table 1 Emerging job requirements

Division of Labor	Typical Positions	Competency Requirements
Power Battery	Solid State Battery R&D Engineer	Material Science, Electrochemistry, Mass Production Process
Intelligent Network	Vehicle-Circuit Collaboration Algorithm Engineer	Communication Protocol, Edge Computing, Traffic Engineering
Electric Drive System	Silicon Carbide Power Device Engineer	Semiconductor physics, thermal design, reliability verification

3. HIGHER EDUCATION NEW ENERGY VEHICLE PERSONNEL TRAINING STATUS QUO

3.1 status quo of professional opening

In recent years, some higher vocational colleges and universities in accordance with the development trend of new energy vehicles, have opened new energy vehicles, intelligent networked vehicles and other emerging professions, but compared with the rapid development of the new energy vehicle industry, these professions have been opened at a slower pace, and the coverage is not extensive, still limited to the general structure of the new energy vehicle, and has not been refined. And there are still some higher vocational colleges and universities do not offer courses in the direction of new energy vehicles. Most of the higher vocational colleges and universities of the automotive industry is still based on the traditional automotive testing and maintenance technology, automotive manufacturing and assembly technology, new energy vehicles

related courses are set less, resulting in a disconnect between the professional knowledge structure of the students and the market demand.

3.2 Status quo of curriculum system

The main content of the courses in the curriculum system is still focused on the traditional vehicle mechanical structure and electrical system, involving new energy vehicles accounted for a relatively small number of courses, and the content of the course is seriously lagging behind the current development of the industry, so that students are unable to understand the latest development of the industry technology.

The proportion of practical courses is small. New energy vehicles emphasize the hands-on ability, need to combine theory and practice, but the proportion of practical courses in the current higher vocational curriculum is still low, is still mainly theoretical lectures, practical hours are small, resulting in the lack of students' practical operation ability after graduation. At the same time, the curriculum system of many higher vocational colleges and universities is relatively fixed, and lack of personalized training mode for different students' characteristics. the single course content, lack of elective courses and interdisciplinary courses, it is difficult to meet the diversified demand for talents in the field of new energy vehicles.

3.3 Status of Teachers' Strength

The rapid development of new energy vehicles has put forward higher requirements for the professional level and professional ability of teachers, most of the automotive teachers have traditional automotive engineering, mechanical engineering and other backgrounds, and they do not have a thorough understanding of the core technology of new energy vehicles, such as the three electric technologies, and the teachers have a limited grasp of the new technologies and new developments in the industry, which affects the quality of the teaching content, and the practicality and applicability of the new energy vehicle technology requires the teachers to have the ability to teach new energy vehicles. the practicality and applicability of new energy vehicle technology require teachers to have a certain amount of practical experience in the industry, but many teachers do not have enough practical work experience, especially less practical experience in new energy vehicle manufacturing, maintenance and application of intelligent network technology.

3.4 Status of school-enterprise cooperation

School-enterprise cooperation is an important part of higher vocational education, through school-enterprise cooperation can better realize the docking of talent cultivation and market demand, but at present there are many problems. Single form of cooperation, most of the current school-enterprise cooperation is limited to the basic level, such as equipment donations, student internships, and so on, and did not carry out closer cooperation, such as curriculum co-construction, faculty sharing and so on. School-enterprise cooperation is mostly temporary or project-based, and lacks a continuous cooperation mechanism and benefit-sharing mechanism. Enterprises often participate in the enthusiasm is not high, the cooperation cycle is short, the frequency of interaction is low, and it is difficult to realize the deep integration of school and enterprise resources.

4. COUNTERMEASURES TO OPTIMIZE TALENT CULTIVATION

4.1 Optimize professional settings

In order to better adapt to the development of new energy vehicles, higher vocational colleges and universities should start from the optimization of professional settings and curriculum system, so that students have the professional skills required for the development of new energy automobile industry, and improve the core competitiveness of students. Higher vocational colleges and universities need to be aligned with the current trend of industry development, real-time new or adjust the existing professional direction, such as new energy vehicles, intelligent networked vehicles, new energy vehicle fault detection and repair and other general direction of the profession, but also need to refine these directions, divided into more detailed specialties, such as battery management, vehicle control, electronic control and so on.

4.2 Improve the curriculum system

On the one hand, adjust the structure of traditional specialized courses. Adjust the existing automotive professional courses,

incorporate the new energy vehicle technology related professional courses into the core curriculum, such as new energy vehicle technology, three electric technology, intelligent networked vehicle technology and other courses, appropriately increase the number of hours, gradually reduce the internal combustion engine technology related courses, increase the electrification and intelligent content, while the core curriculum can be modularized design, so that the students can learn a certain field in depth according to the direction of their own interest, and at the same time, students can learn a certain field in depth according to the direction of their own interest. At the same time, the core courses can be designed modularly so that students can study a certain field in depth according to their own interests, which not only improves the relevance of learning but also facilitates the timely adjustment of course contents to adapt to the technological updates. On the other hand, the course content and teaching materials should be updated, and the course content should be adjusted according to the latest development of the new energy automobile industry (new technology, new standards, new norms) to ensure the real-time and practicality of the course. Meanwhile, for the selection of teaching materials, it is necessary to organize the professional and industry representatives to evaluate the course materials to ensure the accuracy of the teaching materials and to avoid that the teaching materials are too old to meet the current needs of the industry. the content of teaching materials should focus on practicality and operability, increase case studies and practical guidance to help students master core skills.

4.3 Strengthen the construction of professional teaching staff

In the cultivation of talents in the new energy automobile industry chain, the strengthening of the dual-teacher team at the teacher level is crucial. Teachers as the core force of talent training, its quality directly affects the quality of talent training. Vocational colleges and universities should vigorously introduce teachers with rich practical experience, and at the same time build training and exchange platforms for in-service teachers to improve their practical teaching ability. Teachers themselves need to actively update the concept of education, adhere to the student-centered, focus on cultivating students' innovative spirit and practical ability. In terms of teaching content, they should keep pace with the development of the new energy automobile field, and timely integrate new knowledge, new technology and new techniques into the classroom. Teaching methods should also keep pace with the times, and flexibly utilize case-based and project-based teaching methods to enhance the teaching effect. Teachers should strengthen the practical guidance for students in key teaching links such as single column practice, engineering alternation and graduation design. In addition, teachers should actively guide students to engage in innovation and entrepreneurship practice, stimulate students' innovation and entrepreneurship awareness, effectively improve students' innovation and entrepreneurship ability, and cultivate the required talents for new energy automobile industry chain in an all-round way.

4.4 Deepen school-enterprise cooperation

Higher vocational colleges and universities need to strengthen school-enterprise cooperation based on the in-depth integration of industry and education, and realize the effective docking between talent training and industrial demand through systematic mechanism innovation. Colleges and universities should take the initiative to build a two-way flow mechanism of talents between schools and enterprises, promote the mutual employment of teachers and technical backbones of enterprises, introduce industry experts to participate in teaching practice through the establishment of "industrial professors, enterprise mentors" and other positions, and at the same time, send teachers to the front line of enterprises to improve the practical ability to enhance the practical teaching level of the teaching force. Colleges and universities can jointly with leading enterprises to implement order-based talent training mode, based on the actual job requirements of enterprises to customize the training program, to achieve enrollment, training, employment of the whole chain through, for the precise delivery of high-quality technology and skills for the enterprise. In terms of the construction of practical

training platforms, schools and enterprises should jointly build productive training bases and industrial colleges, introduce real production projects to carry out practical training, and promote the seamless integration of teaching content and production processes. Institutions also need to actively attract enterprises to participate in teaching reform, collaborate in the development of teaching materials and teaching resources, and integrate cutting-edge technology and management experience into the curriculum system, so as to enhance the timeliness and foresight of teaching.

5. CONCLUSION

The rapid development of the new energy automobile industry and the deepening of the horizontal division of labor have put forward higher and more detailed requirements for the demand of professional talents. By analyzing the characteristics of talent demand of new energy automobile industry under horizontal division of labor, this paper reveals the deficiencies of current higher vocational colleges and universities in terms of professional setting, curriculum system, teacher strength and school-enterprise cooperation, and puts forward corresponding optimization countermeasures. In the future, higher vocational colleges and universities should further break the traditional educational barriers, promote interdisciplinary integration, strengthen the synergy with enterprises and industries, and form a dynamically adjusted talent training mechanism. At the same time, teachers and students also need to actively embrace technological innovation, improve practical ability and cross-field collaboration, and provide solid talent support for the high-quality development of the new energy automobile industry. Only through the joint efforts of many parties can we realize the deep integration of education and industry and inject lasting power for the sustainable development of the industry.

References

[1] Lin Qiuchen. Exploration on the Innovative Development of New Energy Vehicle Power Batteries and Related Industries - Taking Ningde City as an Example [J]. China Electronic Business, 2025, 31(14):130-132

[2] Wang Longlong, Du Yangyang. Research on the Construction of Application-oriented Talent Cultivation Mode for New Energy Vehicle Specialty under the Background of Industry-education Integration [J]. Automobile Testing Report, 2025, (05):121-123

[3] Song Dandan. Practical Research on the Integrated Talent Cultivation Model of Production, Teaching, Research, and Innovation in Higher Vocational New Energy Vehicle Technology Major [J]. Automobile Maintenance Technician, 2024, (24):84-85

[4] Li Yalong. Integration and Energy Efficiency Improvement of the New Energy Vehicle Industry Chain in the Context of the New Economy [J]. Special Purpose Vehicles, 2024, (12):109-111

Cultivation of High School Students' Interest in Physical Education

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Abstract: **This paper primarily investigates the cultivation of high school students' interest in physical education, analyzes the reasons for their lack of interest, and proposes targeted recommendations to promote the development of their sports interest, thereby laying a solid theoretical foundation for high school physical education.**

Keywords: **High school students; Sports interest; Cultivation**

1. INTRODUCTION

Physical education is a highly complex systematic project, involving multiple aspects such as the setting of teaching objectives, the selection of teaching content, the application of teaching methods, and the implementation of teaching evaluations. During the teaching process, it is essential to closely integrate the psychological characteristics of students to achieve the desired teaching outcomes. Especially for high school students, their psychological traits are undergoing rapid and significant changes, making it particularly important to tailor teaching based on their psychological characteristics.

Teachers' understanding of students' learning motivations and interests is a crucial prerequisite for effective physical education. Learning motivations and interests, as internal psychological driving forces for students, play a decisive role in their acquisition of sports knowledge and skills and the formation of long-term exercise habits. Therefore, a thorough analysis of high school students' motivations and interests in physical education, and the exploration of suitable teaching models and methods for this age group, are the core objectives of this study.

2. REASONS FOR HIGH SCHOOL STUDENTS' LACK OF INTEREST IN PHYSICAL EDUCATION

When analyzing the reasons why students are not interested in sports activities, apart from a few students who are unable to actively participate due to physical illness or poor physical condition, the influence of teachers' levels and behaviors on students' interest in sports activities cannot be underestimated. Teachers' professional levels directly determine the quality of teaching content and the effectiveness of teaching methods, while their behaviors can have a subtle impact on students' psychology and emotions, thereby affecting their attitudes towards sports activities.

According to statistical data, the majority of students are interested in sports activities, while only a minority are not. However, it is concerning that the phenomenon of students being disinterested in physical education is still quite prominent. So, what exactly causes students to develop a negative attitude towards physical education?

To explore the root cause of this issue, we conducted in-depth and comprehensive exchanges with some middle school students who showed signs of disinterest in physical education through various means such as face-to-face interviews and home visits. During the exchanges, most students attributed their disinterest to numerous objective factors, such as inadequate teaching facilities and boring teaching content. However, after a detailed analysis, we found that the reasons for students' disinterest in physical education include both subjective and objective factors. Among them, the most critical factors are students' cognitive levels and educational factors. Students' cognitive levels affect their understanding of the value and significance of physical education. If they cannot correctly recognize the importance of physical education, they are prone to develop a negative attitude. Educational factors, such as

teaching concepts, teaching methods, and evaluation systems, also directly or indirectly influence students' attitudes towards physical education and their interest in it.

2.1 Physical and Psychological Characteristics of High School Students

Disinterest in physical education refers to a psychological state where students feel reluctant and uninterested when it comes to physical education classes and learning sports knowledge. High school students are generally between 16 and 18 years old. Physically and psychologically, they are like young saplings that are about to grow into big trees but are not yet fully mature. Physically speaking, as girls and boys of the same age grow up, there is a gradual gap in their physical indicators. Take the motor organs for example. Girls' long bones are thinner than those of boys, and their ability to withstand pressure and tension is inferior to that of boys. Moreover, girls' muscle strength, lung capacity, and the volume of blood pumped by the heart with each beat are all inferior to those of boys at the same stage. However, girls also have their own strengths. Their pelvises are softer and more flexible, and they have a stronger perception of music. Therefore, in sports such as gymnastics, rhythmic gymnastics, and dance, girls have more advantages.

2.2 Students' Cognitive Level

When they are faced with simple sports equipment and limited sports fields, due to the lack of a deep understanding of the value of sports and the ability to cope with poor teaching conditions, students are prone to develop a dislike for physical education classes and pay less and less attention to them. Learning motivation is the internal driving force that promotes students to engage in learning activities and is the core source of learning enthusiasm. When students lack the motivation to learn physical education, it means they lack the internal drive to actively participate in sports activities, which will inevitably lead to a rebellious attitude towards physical education classes and affect the effectiveness of physical education teaching.

2.3 Educational Factors

In the current educational field, some educational administrators do not attach enough importance to physical education courses, and the phenomenon of excessive academic burden on students and the one-sided pursuit of college admission rates is particularly prominent. From a social perspective, the traditional concept of "hoping one's child becomes successful" is deeply rooted, and the majority of parents have a tendency to focus solely on grades. This social perception directly leads to the neglect of basic requirements for children's physical exercise at the family level. A double squeeze is formed in the educational field: schools reduce physical education class hours and occupy sports field resources; families lack rigid constraints on physical exercise. This exam-oriented education tendency reaches its peak in the senior year of high school, where students' entire energy is forced to be concentrated on college entrance examination preparation. Excessive practice and frequent mock exams subject teenagers to academic pressure far beyond their physical and mental capacity.

3. STRATEGIES FOR CULTIVATING HIGH SCHOOL STUDENTS' INTEREST IN PHYSICAL EDUCATION CLASSES

Surveys show that although most high school students initially like physical education classes, there are many problems in actual teaching. Many physical education teachers follow the same routine every year, with little change in content and no new teaching methods, which makes students lose interest in physical education classes over time.

To change this situation, we need to address the root cause. It is suggested to take three steps: First, change the teaching concept and not treat physical education classes as a chore; second, enrich the teaching content and add more sports that students are interested in; finally, reform the assessment method and not only focus on exam scores but also pay more attention to students' performance and progress in class.

3.1 Changing High School Students' Attitudes towards Physical Education. Schools only focus on the college admission rate, and parents are more concerned about their children's academic performance. As a result, students' understanding of sports has gone astray. Many students think that as long as they do well in cultural studies, it is enough to just pass physical education. This kind of

negative attitude is even more obvious among high school students. To change this situation, physical education teachers need to make efforts in three aspects: First, they should help students change their mindset. Second, they should stimulate students' intrinsic motivation. Finally, they should cultivate students' exercise habits. Through these methods, students can truly fall in love with sports, changing from "I have to exercise" to "I want to exercise".

3.2 Create scenarios to stimulate high school students' interest

Physical education teachers need to carefully create teaching scenarios to meet students' psychological needs for earning corresponding status due to their own competence. During the physical education teaching process, teachers should provide students with opportunities to showcase themselves, such as having students lead exercises, give demonstrations, and take turns serving as group leaders, allowing students to enhance their abilities and confidence through these roles. At the same time, for students who perform outstandingly in certain aspects or achieve excellent grades in exams, teachers should promptly offer affirmation and praise to satisfy their self-esteem and let them experience a sense of self-worth, thereby stimulating their enthusiasm and initiative in learning physical education.

3.3 Reasonably select teaching content and vary teaching methods

3.3.1 Organize game-based teaching to stimulate high school students' interest

According to educational psychology theory, game scenarios can effectively activate the dopamine reward circuit and enhance the intrinsic motivation of participants through immediate feedback mechanisms. For students with insufficient participation in sports, structured game design can break through the linear model of traditional physical education teaching and create a "catfish effect" field, transforming passive participants into active actors.

In terms of skill acquisition, game-based teaching follows the "situated cognition theory", embedding basic movement skills such as running, jumping, and throwing into simulated combat scenarios. This immersive learning environment not only optimizes movement patterns but also enhances skill transfer ability through variant training. From the perspective of physical development, game-based intervention can precisely control the intensity of exercise. Competitive games naturally increase maximal oxygen uptake, strategy games promote intermittent aerobic metabolism, and cooperative games strengthen muscle endurance and proprioception. Notably, cognitive participation in games (such as rule interpretation and strategy formulation) can simultaneously develop executive functions, achieving dual stimulation of "body and mind coordination".

3.3.2 Innovate teaching methods to improve teaching quality

Students have a strong curiosity and desire for novelty, which is particularly evident in physical education classes. In the teaching process, students expect the teaching content to be constantly updated, hoping to encounter new knowledge and participate in new activities in each class and gain new insights.

As the organizer and guide of teaching activities, physical education teachers should, on the basis of strictly adhering to the content requirements of the teaching syllabus, focus on the "new" aspect. Taking long-distance running as an example, this project is often one of the least favored by students due to its relatively monotonous content and high intensity. Teachers can adapt it into a running and jumping exercise accompanied by music. This innovative teaching method not only ensures that students reach a certain level of exercise intensity but also adds fun and novelty to the practice, thereby increasing students' participation enthusiasm.

In the application of teaching methods and means, teachers should also pay attention to variety. For instance, in the aspect of giving commands, the traditional way is mostly done by the teacher shouting or blowing a whistle. Teachers can innovate by having students participate in giving commands, forming a form where teachers and students take turns to shout commands. Commands can also be practiced with music accompaniment to enrich the teaching form. Queue practice can also be innovated. Besides the conventional four-row horizontal formation, various formations such as four-column vertical, circular, and arc

formations can be adopted to increase the fun and challenge of queue practice.

3.4 Update educational concepts and enhance teachers' own qualities

Firstly, physical education teachers should possess profound cultural background and a reasonable knowledge structure. In an era of rapid knowledge updates and information explosion, teachers should not be complacent but embrace the concept of lifelong learning, master scientific learning methods, and continuously acquire new knowledge from various channels. They should not only deeply understand and digest the newly acquired knowledge but also possess the ability to innovate knowledge, be courageous in exploring unknown knowledge areas, and timely adjust and optimize their own knowledge structure to meet the expectations of the times for the professional qualities of physical education teachers.

Secondly, an innovative way of thinking is the key for physical education teachers to achieve teaching breakthroughs. Innovative physical education teachers should pursue novelty and uniqueness in their thinking, have a pioneering spirit, be good at closely integrating scientific theories with teaching practice, and put forward forward-looking and innovative viewpoints and theories. At the same time, they should be able to use novel methods and ideas to analyze and solve practical problems encountered in school physical education, dare to break the traditional thinking patterns, and inject new vitality into physical education teaching.

References

[1] Lu Aihua. On Stimulating the Interest of Senior High School Students in Physical Education. Journal of Hebei Institute of Physical Education, 2003, 17(1):12-13.

[2] Tian Xiaofang. Research on the Learning Motivation and Interest of Senior High School Students in Physical Education and Teaching Strategies. Journal of Changzhou Teachers College, 2003, 21(4):89-90.

[3] Lu Qiaoxian. A Brief Discussion on How to Enhance the Interest of Senior High School Students in Physical Education Classes. Secondary Vocational Education, 2005, 12(4):32-33.

Risk Factors of Delirium in Hospice Patients: A Meta-analysis

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Abstract: Objective: To determine the risk factors of delirium in hospice patients by Meta-analysis. Methods: Studies regarding risk factors of delirium in hospice patients were retrieved and collected from various databases including PubMed, Web of Science, Cochrane Library, Embase, CNKI, WanFang Database, VIP and CBM from inception to April 18, 2022. Two staff were appointed to do the work independently of literature screening, data extracting and quality evaluation in accordance with the criteria. Meta-analysis was performed by Revman 5.3 software. Results: A total of fourteen studies were included. Meta-analysis showed factors related to delirium includes age(OR=1.02), gender(OR=2.41), tumor disease (OR=2.02),, dehydration (OR=2.38), sedatives and hypnotics (OR=6.51). Conclusion: Current evidence indicates that age >65 years, male, tumor disease, dehydration, sedatives and hypnotics are risk factors of delirium in hospice patients.

Keywords: Hospice; Delirium; Risk factors; Meta-analysis

1. INTRODUCTION

Delirium is an acute neurological disorder characterized by altered consciousness, disorganized thinking, and disrupted sleep-wake cycles. Statistics indicate that the incidence of delirium in hospice patients ranges from 6% to 74% [1]. Not only does delirium increase risks of falls and accidental intubation in hospice patients, but it also shortens their life expectancy and reduces quality of life. Therefore, preventing delirium is crucial for hospice patients, with identifying and clarifying its risk factors being the primary preventive measure. Current research identifies infections, sleep disorders, and opioid use as major risk factors for delirium in hospice patients, though findings vary across studies. This meta-analysis aims to further clarify the risk factors for delirium in hospice patients, providing clinical references for early identification and effective prevention.

2. DATA AND METHODS

2.1 Literature retrieval strategy

The literature search was conducted through databases including Pub Med, Web of Science, Cochrane Library, Embase, China National Knowledge Infrastructure (CNKI), Wanfang Database, VIP Database, and China Biology Medical Literature Database (CBM) to collect studies on risk factors for delirium in hospice care patients. the search period covered from database establishment to July 2022. A combination of subject headings and free keywords was employed, supplemented by literature tracing and manual searches. English search strategy:("Palliative" OR "hospice" OR "life end") AND ("delirium" OR "delirious") AND ("factors"). Chinese retrieval strategy: (Palliative care OR hospice care OR end-of-life care OR palliative medicine) AND ("delirium") AND ("risk factors" OR "influencing factors").

2.2 Literature inclusion and exclusion criteria

Inclusion criteria: (1) Participants must be end-stage patients with less than 6 months of life expectancy who are not receiving survival-extending treatments but instead undergoing palliative care; (2) Study designs must include cohort studies, case-control studies, or cross-sectional studies; (3) Diagnostic tools must be used to identify delirium cases; (4) Outcomes should measure risk factors for delirium. Exclusion criteria: (1) Repetitive publications; (2) Incomplete or unavailable full-text data; (3) Non-Chinese/English literature.

2.3 Literature screening and data extraction

Import the retrieved literature into NoteExpress software for screening and removal of duplicates. Two researchers independently conducted preliminary screening by reading titles and abstracts sequentially, followed by secondary screening through full-text review. For included studies, information extraction was performed covering: author, publication year, country, study type, total sample size, control group numbers, delirium incidence rate, delirium assessment tools, frequency of evaluation, and associated risk factors, with subsequent meta-analysis conducted.

2.4 Literature quality evaluation

For cohort studies and case-control studies, the Newcastle-Ottawa Scale (NOS) [2] was used, comprising 8 items across three sections: study selection, intergroup comparability, and outcomes evaluation. the scale has a maximum score of 9 points, with 0-3 indicating low quality, 4-6 moderate quality, and 7-9 high quality. Two researchers independently conducted literature quality evaluations.

2.5 Statistical methods

Data analysis was conducted using Rev Man 5.3 software. Heterogeneity testing was performed first: if $P \geq 0.1$ and $I^2 \leq 50\%$, the heterogeneity among studies was deemed acceptable, and a fixed-effects model was employed for Meta-analysis; if $P < 0.1$ and $I^2 > 50\%$, significant heterogeneity was observed, requiring sensitivity analysis or subgroup analysis to address sources of heterogeneity. If heterogeneity persisted, a random-effects model was used. Count data were presented as odds ratios (OR) with 95% CI, while quantitative data were expressed as standardized mean differences (SMD) with 95% CI.

3. Results

3.1 Results of literature retrieval

The initial screening yielded 1, 029 articles in total, comprising 857 English papers and 172 Chinese papers. After deduplication, 620 articles were obtained. Following preliminary screening through title and abstract review, 535 articles were excluded. Subsequent full-text examination led to further exclusion of 71 articles, with 14 articles ultimately selected for inclusion. the detailed screening process is illustrated in Figure 1.

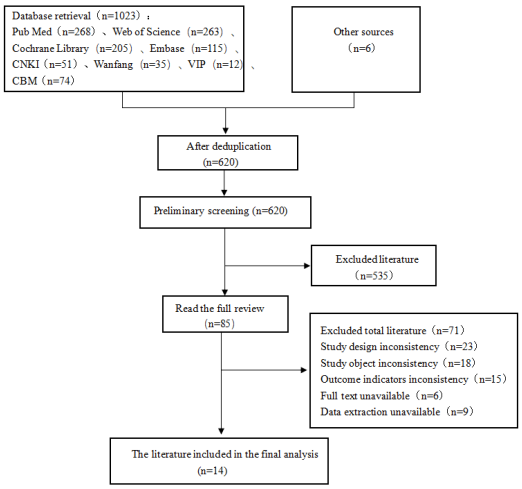

Figure1 Literature screening process

3.2 Basic characteristics and quality evaluation of included literature

This study included 14 articles, comprising 8 cohort studies, 6 case-control studies, with a total sample size of 6, 285 cases. the cumulative case group comprised 1, 730 patients, while the control group included 4, 555 participants. the incidence of delirium ranged from 6.9% to 68.3%, as shown in Table 1. All 14 articles were classified as medium-to-high quality. 14 cohort and case-control studies scored between 5-8 points, including 9 high-quality articles. Detailed quality evaluation results are presented in Table 2.

Table1 Basic features of the study included

Investigator	Country	Type of study	Number of total cases	Number of cases	Number of control group cases	Delirium rate (%)	Delirium assessment tool	Frequency of delirium assessment (hours/times)	Risk factors
Lawlor 2000[5]	Canada	Cohort study	104	71	33	68.2	DSM-IV	12	②①④⑤
Morita 2003[4]	Japan	Case-control study	284	57	227	20.1	MDAS	24	②⑧
Kanbayashi 2013[6]	Japan	Case-control study	182	80	102	43.9	MDAS	-	①⑤
Zimmerman 2014[6]	America	Case-control study	217	67	150	30.9	DSM-IV	-	④⑧
Matsuoka 2015[7]	Japan	Case-control study	166	58	108	34.9	DSM-IV	-	③⑥
De la Cruz 2015[8]	America	Case-control study	556	323	233	58.1	MDAS	24	④⑪
Plaschke 2016[9]	Germany	Cohort study	100	29	71	29.0	NU-DESC	24	⑥⑫
Matsuo 2017[10]	Japan	Cohort study	207	35	172	16.9	CAM	24	②⑦⑧
Mercadante 2018[11]	Italy	Cohort study	263	110	153	41.8	MDAS	24	⑦⑨⑩⑪
Kang 2019[12]	Korea	Cohort study	102	24	78	23.5	CAM	24	①⑩⑫
Kates 2020[13]	America	Cohort study	154	82	72	53.2	DSM-V	-	②⑩
Seiler 2020[14]	Switzerland	Cohort study	410	229	181	55.9	DOS	8	⑨⑩⑫
Hamano 2021[15]	Japan	Cohort study	2829	194	2635	6.9	DSM-V	24	⑨⑫
Klankluang 2021[16]	Thailand	Case-control study	350	154	196	44.0	DSM-V	-	①⑤⑫

Note: DSM-V: Diagnostic and Statistical Manual of Mental Disorders, 5th edition; DOS: Delirium Observation and Assessment Scale; MDAS: Memory Delirium Assessment Scale; CAM: Confusion Assessment Method; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders, 4th edition; NU-DESC: Nursing Delirium Screening Scale. Risk factors include: ① ECOG score; ② Opioid use; ③ Metabolic disorders; ④ Tumorous diseases; ⑤ Infections; ⑥Gender, ⑦ Dyspnea; ⑧ Jaundice, ⑨ NSAIDs; ⑩ Age, ⑪ Hypoxic encephalopathy; ⑫ Sedatives, ⑬ Sleep disturbances, ⑭ Place of death, ⑮ Dehydration。

Table2 Quality assessment of studies included

Studies included	Crowd selection	Inter-group comparability	Outcome evaluation	Total points
Lawlor[5]	4	2	2	8
Morita[4]	4	1	2	7
Kanbayashi[6]	3	2	1	6
Zimmerman[6]	3	1	1	5
Matsuoka[7]	4	1	2	7
De la Cruz[8]	4	1	2	7
Plaschke[9]	3	2	1	6
Matsuo[10]	4	2	2	8
Mercadante[11]	4	2	1	7
Kang[12]	3	1	2	6
Kates[13]	3	2	2	7
Seiler[14]	4	2	1	7
Hamano[15]	4	1	2	7
Klankluang[16]	4	1	1	6

3.3 Meta analysis results

3.3.1 Age

Four studies [6, 11, 12, 16] reported the relationship between age and delirium in hospice patients, with statistically significant

heterogeneity observed across the studies (P=0.0007, I²=82%). Sensitivity analysis revealed that Klankluang [18] study was the primary source of heterogeneity. After excluding this study, the remaining three studies showed no significant heterogeneity (P=0.14, I²=49%), and a fixed-effects model was employed for analysis. the results demonstrated that age was a risk factor for delirium in hospice patients [OR=1.02, 95%CI (1.01, 1.04), P=0.009], as shown in Figure 2.

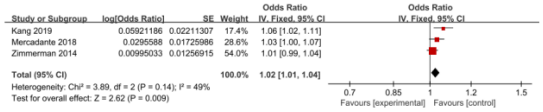

Figure2 Forest map of the relationship between age and delirium

3.3.2 Gender

Six studies [4, 5, 9, 12, 14, 15] reported the relationship between gender and delirium in hospice patients, with no statistically significant heterogeneity among the studies (P=0.97, I²=0%). A fixed-effects model was used for meta-analysis. the results showed that gender was a risk factor for delirium in hospice patients [OR=2.41, 95%CI (1.86, 3.13), P<0.001], as shown in Figure 3.

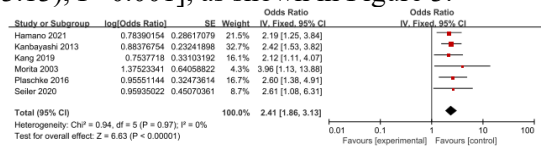

Figure3 Forest map of the relationship between gender and delirium

3.3.3 Tumor diseases

Six studies [5, 6, 8, 14, 15, 16] reported the association between cancer-related conditions and delirium in hospice patients. No statistically significant heterogeneity was observed among these studies (P=0.14, I²=39%), and a fixed-effects model was employed for meta-analysis. the results demonstrated that cancer-related conditions were a risk factor for developing delirium in hospice patients [OR=2.02, 95% CI(1.55, 2.63), P<0.001], as shown in Figure 4.

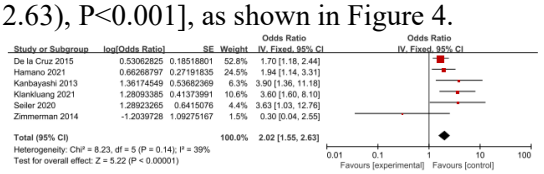

Figure4 Forest map of the relationship between tumor diseases and delirium

3.3.4 Dehydration

Three studies [3, 7, 11] reported the relationship between dehydration and
delirium in hospice patients, with no statistically significant heterogeneity among the studies (P=0.17, I²=44%). A fixed-effects model was used for meta-analysis. the results showed that dehydration was a risk factor for delirium inhospice patients [OR=2.38, 95%CI (1.48, 3.84), P<0.001], as shown in Figure 5.

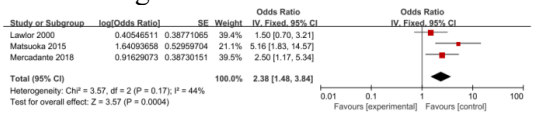

Figure5 Forest map of the relationship between dehydration and delirium

3.3.5 Sedatives and hypnotics

Three studies [3, 9, 12] investigated the association between sedative-hypnotic medications and delirium in hospice care patients. No statistically significant heterogeneity was observed across these studies (P=0.99, I²=0%), and a fixed-effects model was employed for meta-analysis. the results demonstrated that sedative-hypnotic agents were a risk factor for developing delirium in hospice patients [OR=6.51, 95% CI(2.67, 15.86), P<0.001], as shown in Figure 6.

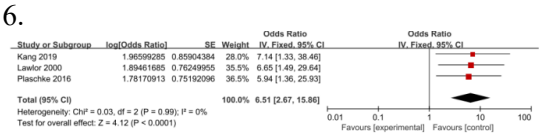

Figure6 Forest map of the relationship between sedative hypnotics and delirium

3.4 Publication bias analysis

Because the number of literature included in each single influencing factor in this study was less than 10, the funnel diagram was not drawn.

4. DISCUSSION

The overall quality of the included studies was high and the results were relatively reliable

This study included 14 peer-reviewed articles, all of which clearly defined inclusion/exclusion criteria and diagnostic evaluation tools for delirium. All 14 articles were classified as medium-to-high quality with reliable findings.

4.1 Risk factors for delirium in hospice patients

4.1.1 Patient characteristics

4.1.1.1Age

Advanced age is a significant risk factor for delirium in hospice care patients. the higher risk of delirium in elderly patients primarily stems from age-related irreversible degenerative changes in brain tissue and increased neuronal apoptosis. This ultimately leads to an imbalance between dopaminergic and cholinergic neurotransmitters, triggering delirium. Therefore, nursing staff should

prioritize elderly hospice care patients by regularly assessing cognitive functions and implementing measures such as adjusting ward environments and providing time-specific reminders to improve cognitive status.

4.1.1.2Gender

This study reveals that male hospice patients exhibit a higher risk of delirium compared to females, which may be associated with inflammatory mechanisms underlying delirium. Peripheral inflammatory responses act on brain cells through multiple pathways, inducing the production of inflammatory mediators. These mediators further disrupt normal synaptic transmission and neuronal function [17]. However, estrogen serves as an effective anti-inflammatory agent, inhibiting the production of central and peripheral pro-inflammatory factors. Although the mechanisms by which gender influences delirium development require further exploration, current research suggests that nursing staff should prioritize male hospice patients to minimize their delirium risk.

4.2.2Disease factors

4.2.2.1 Tumor diseases

Multiple studies have confirmed that neurological malignancies are significant risk factors for delirium. Further studies demonstrated that patients with brain tumors or metastatic brain lesions face a 53% higher risk of developing delirium compared to others, likely due to tumor compression and invasion of normal brain tissue [18]. Therefore, clinical staff should closely monitor psychiatric status in palliative care patients with brain tumors or metastases, regularly assess cognitive impairment, and implement effective pain management strategies to prevent delirium.

4.2.2.2 Dehydration

Research findings indicate that hospice patients with dehydration face elevated risks of delirium. This stems from hypernatremia caused by dehydration, which not only elevates plasma osmotic pressure but also triggers rapid fluid loss from central nervous cells. Such severe dehydration and excessive cellular contraction lead to abnormal membrane potential changes in contracted nerve cells, ultimately causing delirium. This underscores the need for clinical staff to promptly identify dehydration risk factors, optimize hydration status, and dynamically monitor vital signs including plasma osmotic pressure, urine specific gravity, and blood urea nitrogen levels when administering dehydrating agents.

4.2.3Sedatives and hypnotics

The findings of this study demonstrate that the use of sedative-hypnotic drugs remains a significant risk factor for delirium in hospice care patients. These medications disrupt cholinergic transmission by enhancing central nervous system inhibition, ultimately causing neurotransmitter imbalances that induce delirium. Therefore, healthcare providers should dynamically monitor patients' sedation levels and adjust medication dosages accordingly. While ensuring patient comfort, clinicians should avoid excessive sedation by maintaining patients in a state of easy arousal and cooperation, thereby reducing the incidence of delirium.

5. CONCLUSION

This study identified several risk factors for delirium in hospice patients,
including age>65 years, male gender, cancer-related conditions, dehydration, and use of sedatives. Healthcare providers should enhance clinical assessments to identify high-risk groups prone to delirium, while implementing preventive measures and management strategies targeting these risk factors.

Reference

[1] Watt CL, Momoli F, Ansari MT, et al. the incidence and prevalence of delirium across palliative care settings: A systematic review [J]. Palliat Med, 2019, 33(8):865-877. DOI:10.1177/0269216319854944.

[2] Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses [J]. Eur J Epidemiol, 2010, 25(9):603-605. DOI: 10.1007/s10654-010-9491-z.

[3] Lawlor PG, Gagnon B, Mancini IL, et al. Occurrence, causes, and outcome of delirium in patients with advanced cancer: a prospective study [J]. Arch
Intern Med, 2000, 160(6):786-794. DOI: 10.1001/archinte. 160.6. 786.

[4] Morita T, Tei Y, Inoue S. Impaired communication capacity and agitated delirium

in the final week of terminally ill cancer patients: prevalence and
identification of research focus [J]. J Pain Symptom Manage, 2003, 26(3):827-834. DOI:10.1016/s0885-3924(03)00287-2.
[5] Kanbayashi Y, Hatano Y, Hata Y, et al. Predictive factors for agitation severity of hyperactive delirium in terminally ill cancer patients in a general hospital using ordered logistic regression analysis [J]. J Palliat Med, 2013, 16(9):1020-1025. DOI: 10.1089/jpm. 2013.0100.
[6] Zimmerman KM, Salow M, Skarf LM, et al. Increasing anticholinergic burden and delirium in palliative care inpatients [J]. Palliat Med, 2014, 28(4):335-341. DOI:10.1177/0269216314522105.
[7] Matsuoka H, Yoshiuchi K, Koyama A, et al. Chemotherapeutic drugs that penetrate the blood-brain barrier affect the development of hyperactive delirium in cancer patients [J]. Palliat Support Care, 2015, 13(4):859-864. DOI: 10.1017/S1478951514000765.
[8] De la Cruz M, Ransing V, Yennu S, et al. the Frequency, Characteristics, and Outcomes Among Cancer Patients With Delirium Admitted to an Acute Palliative Care Unit [J]. Oncologist, 2015, 20(12):1425-1431. DOI: 10.1634/theoncologist. 2015-0115.
[9] Plaschke K, Petersen KA, Frankenhauser S, et al. the Impact of Plasma Cholinergic Enzyme Activity and Other Risk Factors for the Development of Delirium in Patients Receiving Palliative Care [J]. J Pain Symptom Manage, 2016, 52(4):525-532. DOI: 10.1016/j. jpainsymman.
[10] Matsuo N, Morita T, Matsuda Y, et al. Predictors of Delirium in Corticosteroid-Treated Patients with Advanced Cancer: An Exploratory, Multicenter, Prospective, Observational Study [J]. J Palliat Med, 2017, 20(4):352-359. DOI: 10.1089/jpm. 2016.0323.
[11] Mercadante S, Masedu F, Balzani I, et al. Prevalence of delirium in advanced cancer patients in home care and hospice and outcomes after 1 week of palliative care [J]. Support Care Cancer, 2018, 26(3):913-919. DOI: 10.1007/s00520-017-3910-6.
[12] Kang B, Kim YJ, Suh SW, et al. Delirium and its consequences in the specialized palliative care unit: Validation of the Korean version of Memorial Delirium Assessment Scale [J]. Psychooncology, 2019, 28(1):160-166. DOI:10.1002/pon. 4926.
[13] Kates J. Hyperactive Terminal Delirium in Hospice Patients: A Retrospective Cohort Study [J]. J Hosp Palliat Nurs, 2020, 22(2):95-100. DOI:10.1097/NJH. 0000000000000631.
[14] Seiler A, Schubert M, Hertler C, et al. Predisposing and precipitating risk factors for delirium in palliative care patients [J]. Palliat Support Care, 2020, 18(4):437-446.
[15] Hamano J, Mori M, Ozawa T, et al. Comparison of the prevalence and associated factors of hyperactive delirium in advanced cancer patients between inpatient palliative care and palliative home care [J]. Cancer Med, 2021, 10(3):1166-1179. DOI:10.1002/cam4.3661.
[16] Klankluang W, Tongsai S, Sriphirom C, et al. the prevalence, associated factors, clinical impact, and state of diagnosis of delirium in palliative care patients [J]. Support Care Cancer, 2021, 29(12):7949-7956. DOI:10.1007/s00520-021-06367-7.
[17] Wang Chunjie and Qiu Yi. Research progress on the pathogenesis of postoperative delirium [J]. Journal of Chengde Medical College, 2018, 35(06):512-515.
[18] Tsuruta R, Oda Y. A clinical perspective of sepsis-associated delirium [J]. J Intensive Care, 2016, 4:18. DOI:10.1186/s40560-016-0145-4.

The Importance of Verbal Communication Skills in Nurse-Patient Communication

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Abstract: Effective communication between nurses and patients is a cornerstone of quality healthcare. Verbal communication skills play a crucial role in establishing trust, ensuring accurate information exchange, and improving patient satisfaction and outcomes. This paper explores the significance of verbal communication in nurse-patient interactions, discussing key techniques such as active listening, empathy, clarity, and cultural sensitivity. Additionally, it examines barriers to effective communication and strategies to overcome them. By enhancing verbal communication skills, nurses can foster better therapeutic relationships, reduce medical errors, and promote patient-centered care.

Keywords: Nurse-patient communication, Verbal Communication Skills, Active Listening, Empathy, Healthcare Outcomes

1. INTRODUCTION

Communication is a fundamental aspect of nursing practice, influencing patient safety, satisfaction, and clinical outcomes. Among various communication forms, verbal communication is particularly vital as it allows nurses to convey information, assess patient needs, and build rapport. Poor communication can lead to misunderstandings, non-compliance with treatment, and increased patient anxiety. Therefore, developing strong verbal communication skills is essential for nurses to provide high-quality care.

This paper discusses the importance of verbal communication in nurse-patient interactions, highlighting key techniques, barriers, and strategies for improvement.

2. THE ROLE OF VERBAL COMMUNICATION IN NURSING

2.1 Building Trust and Rapport

Trust is the foundation of any therapeutic relationship. Patients are more likely to share critical health information and adhere to treatment plans when they trust their healthcare providers (Fakhr-Movahedi et al., 2018). Nurses who use clear, respectful, and empathetic language can foster trust, making patients feel valued and understood.

2.2 Ensuring Accurate Information Exchange

Miscommunication in healthcare can lead to medical errors, misdiagnoses, and adverse events. Effective verbal communication ensures that patients comprehend their conditions, treatment options, and medication instructions (Street et al., 2009). Nurses must use simple, jargon-free language and confirm understanding through techniques like teach-back.

2.3 Enhancing Patient Satisfaction

Patients who perceive their nurses as good communicators report higher satisfaction levels (Norouzinia et al., 2016). Positive verbal interactions may reduce anxiety, improve cooperation, and contribute to a better overall healthcare experience.

3. KEY VERBAL COMMUNICATION TECHNIQUES IN NURSING

3.1 Active Listening

Active listening is a fundamental component of effective nurse-patient communication, requiring nurses to fully concentrate on the patient's words, emotions, and underlying concerns. Unlike passive hearing, active listening involves intentional engagement, where the nurse demonstrates genuine interest through verbal and nonverbal cues. Key verbal techniques include paraphrasing ("What I hear you saying is…") and summarizing ("So, your main concern is…"), which help clarify the patient's message and confirm understanding (Kourkouta & Papathanasiou, 2014). Nonverbal cues, such as maintaining eye contact, nodding, and leaning slightly forward,

further reinforce attentiveness and empathy.

Additionally, active listening involves withholding judgment and avoiding interruptions, allowing patients to express themselves fully. Reflective responses, such as "It sounds like you're feeling anxious about the procedure, " validate the patient's emotions and encourage further disclosure. Research indicates that patients who perceive their nurses as active listeners report higher satisfaction and are more likely to adhere to medical advice (Bramhall, 2014). Moreover, this technique reduces misunderstandings, as nurses can detect subtle cues—such as hesitation or uncertainty—that may indicate unmet needs or concerns. By mastering active listening, nurses not only enhance therapeutic relationships but also contribute to more accurate assessments and personalized care plans.

3.2 Empathy and Compassionate Language

Empathy in nursing goes beyond mere sympathy; it requires nurses to genuinely understand and share in patients' emotional experiences while maintaining professional boundaries. Compassionate language serves as a powerful tool to convey this empathy, helping to alleviate patient distress and build therapeutic connections. Yet, simple impactful phrases like "I can see this is really a challenging for you" or "It's completely normal to feel in this way" validate patients' emotions and create a safe space for open dialogue (Bramhall, 2014). Research demonstrates that when nurses express empathy, patients experience reduced anxiety, greater emotional relief, and improved cooperation with treatment plans (Hojat et al., 2011).

Empathetic communication also involves recognizing nonverbal distress signals, such as facial expressions or body language, and responding appropriately. For instance, a patient who appears tearful may need reassurance: "I'm here to support you through this. " Additionally, tailoring language to individual needs—such as using softer tones with anxious patients or more direct explanations with those who prefer factual information—enhances the effectiveness of empathetic interactions. Studies in oncology nursing, for example, show that empathic communication significantly improves patients' psychological adjustment to illness (Fujimori et al., 2014). By consistently incorporating empathy into verbal exchanges, nurses not only foster trust but also contribute to better emotional and clinical outcomes.

3.3 Clarity and Simplicity

Clear and simple communication is essential in healthcare to ensure patients fully comprehend their conditions, treatments, and self-care instructions. Medical jargon, while efficient among professionals, often creates barriers for patients, leading to confusion and non-adherence. Nurses should prioritize plain language—for example, replacing "myocardial infarction" with "heart attack" or "antihypertensive" with "medication to lower blood pressure" (Kessels, 2003). Breaking down complex information into manageable steps also enhances understanding. Instead of saying, "You need to monitor your glucose levels daily, " a nurse might explain, "We'll show you how to check your blood sugar every morning using this simple device. "

The "teach-back" method is particularly effective for verifying comprehension. After explaining a concept, nurses can ask patients to repeat it in their own words: "Can you tell me how you'll take this medicine at home?" This approach identifies gaps in understanding and allows for immediate clarification (Schillinger et al., 2003). Visual aids, such as diagrams or models, can further reinforce verbal explanations, especially for patients with low health literacy. Studies indicate that clear communication reduces hospital readmission and improves chronic disease management (DeWalt et al., 2010). By consistently prioritizing clarity, nurses empower patients to take an active role in their care, ultimately leading to safer and more effective health outcomes.

These expanded sections now provide deeper insights into the practical application and evidence-based benefits of empathy and clarity in nurse-patient communication. Let me know if you'd like any adjustments!

3.4 Empathy and Compassionate Language

Empathy involves understanding and sharing patients' emotions. Phrases like "I understand this must be difficult for you" can alleviate distress. Studies show that empathetic communication improves patient coping and adherence to treatment (Bramhall, 2014).

3.5 Clarity and Simplicity

Medical jargon sometimes may make patients confused. Nurses should use plain language, break down complex information, and check for understanding. For example, they can say "high blood pressure" instead of saying "hypertension. "

Patients from diverse backgrounds may have different communication preferences. Nurses should be aware of cultural norms, use interpreters when needed, and avoid assumptions (Jirwe et al., 2010).

4. BARRIERS TO EFFECTIVE NURSE-PATIENT VERBAL COMMUNICATION

4.1 Language Differences

Non-native speakers may struggle to express symptoms or understand instructions. Professional interpreters, rather than family members, should be used to ensure accuracy (Hadziabdic et al., 2014).

4.2 Emotional Distress

Patients in pain or anxiety may have difficulty communicating. Nurses should remain patient, use calming tones, and allow time for responses.

4.3 Time Constraints

Heavy workloads may lead to rushed conversations. Prioritizing communication and using structured approaches (e. g., SBAR—Situation, Background, Assessment, Recommendation) can improve efficiency without sacrificing quality.

5. STRATEGIES TO IMPROVE VERBAL COMMUNICATION SKILLS

5.1 Communication Training Programs

Healthcare institutions should provide regular training on active listening, empathy, and cultural competence (Berman & Chutka, 2016). Role-playing and simulation exercises can enhance nurses' skills.

5.2 Patient-Centered Communication Models

Frameworks like the LEARN model (Listen, Explain, Acknowledge, Recommend, Negotiate) encourage collaborative dialogue (Berlin & Fowkes, 1983).

5.3 Feedback Mechanisms

Hospitals can implement patient feedback systems to assess communication effectiveness and identify areas for improvement.

6. CONCLUSION

Verbal communication is indispensable in nurse-patient interactions, influencing trust, accuracy of care, and patient satisfaction. By mastering techniques such as active listening, empathy, and clarity, nurses can overcome communication barriers and enhance healthcare outcomes. Continuous training and patient-centered approaches are essential for fostering effective communication in clinical settings.

References

[1] Berman, A. C., & Chutka, D. S. (2016). "Assessing effective physician-patient communication skills: Are we listening?" Journal of Graduate Medical Education, 8(2), 242-244.

[2] Bramhall, E. (2014). "Effective communication skills in nursing practice. " Nursing Standard, 29(14), 53-59.

[3] Hojat, M., et al. (2011). Physicians' empathy and clinical outcomes for diabetic patients. Academic Medicine, 86(3), 359-364.

[4] Fujimori, M., et al. (2014). Effect of communication skills training program for oncologists based on patient preferences for communication when receiving bad news. Journal of Clinical Oncology, 32(20), 2166-2172.

[5] Kessels, R. P. (2003). Patients' memory for medical information. Journal of the Royal Society of Medicine, 96(5), 219-222.

[6] Schillinger, D., et al. (2003). Closing the loop: Physician communication with diabetic patients who have low health literacy. Archives of Internal Medicine, 163(1), 83-90.

[7] DeWalt, D. A., et al. (2010). Health literacy and health outcomes: Systematic review. Annals of Internal Medicine, 155(2), 97-107.

[8] Fakhr-Movahedi, A., et al. (2018). "Exploring nurse's communicative role in nurse-patient relations: A qualitative study. " Journal of Caring Sciences, 7(2), 105-112.

[9] Hadziabdic, E., et al. (2014). "Healthcare professionals' perceptions of cultural competence in intercultural communication. " Journal of Intercultural Communication, 35, 1-12.

[10] Kourkouta, L., & Papathanasiou, I. V. (2014). "Communication in nursing practice. " Materia Socio-Medica, 26(1), 65-67.

[11] Norouzinia, R., et al. (2016). "Communication barriers perceived by nurses and patients. " Global Journal of Health

Science, 8(6), 65-74.
[12] Street, R. L., et al. (2009). "How does communication heal?" Patient Education and Counseling, 74(3), 295-301.

Transformation of the Automotive Industry and Talent Training Models

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Abstract: As the global automotive industry enters the "CASE" era—Connected, Autonomous, Shared, and Electric— the new energy vehicle (NEV) sector is undergoing profound technological and structural transformations. Talent requirements vary significantly under different enterprise division models: vertically integrated enterprises emphasize in-depth technical capabilities, while horizontally specialized enterprises prioritize interdisciplinary system integration skills. Consequently, talent cultivation in automotive engineering is shifting from a traditional mechanical-oriented approach to a new model that balances vertical and horizontal development, emphasizes interdisciplinary integration, and is driven by practical experience. This transformation aims to meet the demands of industrial upgrading and support the sustainable development of the NEV sector.

Keywords: New Energy Vehicles(NEVs), Automotive Engineering Education, Vertical Integration Model, Horizontal Division Model

1. BACKGROUND OF THE GLOBAL AUTOMOTIVE INDUSTRY'S "CASE" TRANSFORMATION

In recent years, the global automotive industry has been undergoing a profound transformation known as "CASE, " which stands for Connected, Autonomous, Shared, and Electric. These four trends are not only reshaping vehicle forms and usage patterns but also redefining industry boundaries. the automotive sector is increasingly integrating with emerging industries such as information technology, artificial intelligence, energy, and mobility services, while its core technological pathways are shifting. According to data from the International Energy Agency (IEA) and the China Association of Automobile Manufacturers, global sales of new energy vehicles (NEVs) exceeded 10 million units in 2024, with pure electric vehicles accounting for over 70% of the total, and China contributing roughly half. This indicates that the global automotive industry is accelerating its transition from traditional mechanical-driven vehicles to electrification and intelligent mobility.

Currently, global vehicles are primarily classified into three types: conventional internal combustion engine vehicles, hybrid vehicles, and pure electric vehicles. In China, NEVs—especially pure electric vehicles—have become the development focus driven by both policy and market demand. This electrification-centered industrial transformation has fundamentally altered vehicle structures and component systems: the number of traditional engines and related components has significantly decreased, while batteries, electric motors, and electronic control systems have become core technological components. This shift has fueled the rapid rise of companies such as CATL and BYD while placing pressure on traditional internal combustion engine component manufacturers to transform.

At the same time, the NEV sector has attracted numerous cross-industry entrants. For example, IT companies such as Xiaomi and Huawei Seres have entered the NEV market, leveraging intelligence and digital technology as their core competitive advantages, emerging as new forces in vehicle innovation. In contrast, traditional automakers like SAIC, Changan, and BYD continue to rely on vertical integration but are gradually incorporating intelligent and digital technologies to maintain competitiveness. Therefore, the NEV industry is not only

changing vehicle forms but also reshaping enterprise competition and industry chain structures.

2. EVOLUTION OF DIVISION OF LABOR: FROM VERTICAL INTEGRATION TO HORIZONTAL SPECIALIZATION

The evolution of the automotive industry chain has led to the coexistence of two main division-of-labor models: vertical integration and horizontal specialization.

The vertical integration model, represented by companies such as BYD, involves controlling most stages internally, from research and development, manufacturing, and assembly to sales, with a particular emphasis on self-developing and producing core components. This model helps ensure supply chain security and product differentiation but requires extremely high capabilities in R&D, manufacturing, and management. It also entails long investment cycles and relatively slower innovation and iteration.

The horizontal specialization model, exemplified by Tesla, Xiaomi, and Huawei Seres, relies more heavily on external suppliers for components, positioning the automaker more as a system integrator. Its advantages lie in achieving rapid iteration and cost optimization through supply chain collaboration, following a "modular assembly" logic similar to the consumer electronics industry. However, this model depends on supply chain stability, and ensuring vehicle quality and component compatibility requires strong system integration capabilities.

During the era of internal combustion vehicles, the vertical integration model dominated because the complexity and proprietary nature of engines and core components required companies to control the entire process themselves. In the era of new energy vehicles, however, the reduced complexity of components and increased modularity have facilitated the rise of the horizontal specialization model, creating opportunities for cross-industry entrants to enter the market.

3. TALENT DEMAND DIFFERENCES UNDER DIFFERENT DIVISION-OF-LABOR MODELS

Automotive companies exhibit significant differences in talent demand under different industry division-of-labor models.

Table. Recruitment situations of various automakers

Company	*Recruitment Characteristics*	*Talent Focus Areas*
BYD	*Extensive campus recruitment, covering R&D to manufacturing chain*	*Core manufacturing technologies, R&D, batteries, electronic control*
Xiaomi Auto	*High demand for frontline factory positions (operators) and R&D talents*	*Automated operations, design, autonomous driving*
Tesla	*Strict campus recruitment; many Robotaxi/Autopilot positions*	*Autonomous driving, data operations, manufacturing engineering, AI*

Vertical integration model companies, exemplified by BYD, typically complete the majority of processes—research and development, manufacturing, assembly, and sales—internally, with core components largely relying on in-house research and production. This organizational model shapes their talent demand, placing strong emphasis on capabilities across the entire R&D and manufacturing chain. Specifically, these companies tend to prioritize recruiting professionals who can master the development of core components such as batteries, motors, and electronic control systems, as well as engineers with experience in full-vehicle manufacturing processes, quality control, and automated production line management. In other words, talent in vertically integrated firms is expected to possess a multi-faceted skill set that combines design, manufacturing, and quality management competencies, enabling the company to maintain comprehensive control over all processes.

For automotive engineering programs, such enterprises' talent requirements lean toward traditional automotive engineering expertise, but with an added emphasis on mastery of the new energy vehicle (NEV) "three-electric" technologies (battery, motor, and electronic control). Consequently, the focus is on cultivating "deeply specialized" engineers who possess both traditional and emerging technology skills, creating a hybrid professional capable of supporting the full technical chain in NEV development.

In contrast, companies following a horizontal division model, such as Xiaomi Automotive and Tesla, primarily rely on external suppliers for components, with the automaker itself

acting mainly as a system integrator. As a result, the talent demand in these companies is more diversified and emphasizes cross-disciplinary collaboration. On one hand, there is a high demand for professionals with expertise in supply chain management and collaborative operations, enhancing the company's ability to coordinate across enterprises, integrate components, and control costs. On the other hand, high-level R&D talent remains a critical focus, particularly in emerging technology areas such as autonomous driving, intelligent cockpits, artificial intelligence, and big data analytics.

Specifically, Tesla recruits extensively for roles related to testing and data acquisition, such as Robotaxi and Autopilot testing and validation positions, to support the rapid iteration of autonomous driving technology. Meanwhile, Xiaomi, which is in a fast production ramp-up phase, has substantial demand for manufacturing and frontline positions, particularly factory operators and personnel skilled in automation production and maintenance. Under these conditions, Xiaomi emphasizes that automotive engineering graduates should serve as "system integration engineers, " playing a key role in coordinating vehicle design, testing, and production processes, and often requiring cross-disciplinary knowledge spanning electronics and computer science. In comparison, Tesla's talent demand for automotive engineering graduates is broader, encompassing not only traditional full-vehicle engineering but also extensive integration with autonomous driving testing and data collection, reflecting a high demand for cross-domain, hybrid talent.

In summary, vertically integrated enterprises place greater emphasis on "deeply specialized" talent capable of covering the full technical chain from R&D to manufacturing. By contrast, graduates in horizontally divided enterprises are expected to function as "system integration engineers, " combining mechanical engineering knowledge with electronics, computer science, and AI capabilities to support cross-disciplinary vehicle development, testing, and optimization. This distinction highlights how different industry structures directly shape the skill profiles and multidisciplinary requirements of automotive engineering graduates.

4. TRANSFORMATION OF TALENT TRAINING SYSTEMS: INSIGHTS FROM THE MINISTRY OF EDUCATION'S TEACHING STANDARDS

During the internal combustion engine (ICE) era, the automotive industry was dominated by the vertical integration model, with vehicle manufacturers generally controlling the full R&D–manufacturing–sales chain. Correspondingly, automotive engineering education was centered on mechanical disciplines, with courses focusing on engine principles, chassis design, thermodynamics and fluid mechanics, and materials science. the training model emphasized a combination of theory and laboratory practice, with application scenarios concentrated on internal combustion engines and vehicle manufacturing.

However, with the advancement of electrification and intelligence, the horizontal division of labor model has emerged, and vehicle manufacturers are gradually transforming into system integrators. This shift imposes new demands on automotive engineering education: more complex knowledge structures, broader skill requirements, and stronger emphasis on practical training. the "Teaching Standards for the New Energy Vehicle Technology Major (Higher Vocational Education)" issued by the Ministry of Education of the People's Republic of China exemplifies this transformation.

According to these standards, the core reforms of the talent training system are reflected in three aspects:

First, the core curriculum system specifies that students majoring in new energy vehicles must master the "Three Electric" technologies, including courses on power batteries and management, drive motors and control, vehicle control systems, and other automotive electrical technologies. At the same time, courses on vehicle manufacturing processes and experimental testing are included as core content to ensure that students not only grasp the key electrification technologies but also understand the overall vehicle production process and experimental validation methods.

This curriculum emphasizes a complete chain from theoretical knowledge to engineering application, laying the foundation for cultivating in-depth talents proficient in critical new energy vehicle technologies.

Second, the extended curriculum system strengthens the cultivation of interdisciplinary and digital capabilities. Course content includes intelligent connected vehicle technologies, shared mobility, artificial intelligence, Python programming, CAD/CAE virtual design, virtual simulation, and automotive quality management. These courses aim to broaden students' knowledge boundaries and develop versatile talents capable of conducting innovative practices in an intelligent, digital, and networked automotive environment. At the same time, this reflects the new energy vehicle industry's strong reliance on data analysis, software development, system integration, and cross-domain collaboration skills.

Third, the practical teaching system has been significantly enhanced. In addition to traditional vehicle assembly, performance testing, and fault diagnosis, the standard emphasizes leveraging cutting-edge technologies such as big data analysis, cloud computing, artificial intelligence, and virtual simulation to improve the quality and depth of experiments and practical training. This digitalized practical education not only enhances students' engineering operational skills but also fosters their innovation abilities in the design, testing, and optimization of intelligent vehicle systems.

The Ministry of Education's teaching standards for the New Energy Vehicle (NEV) major reflect the transformation of China's automotive engineering education from a single mechanical orientation to a "mechanical+electrical+intelligent+data" integrated approach. the new talent training model emphasizes the combination of interdisciplinary knowledge, digitalized practical teaching, and industry-academia collaboration, providing a systematic framework for universities to cultivate high-quality engineering professionals who can meet the demands of industrial upgrading and technological innovation.

5. A NEW TALENT TRAINING MODEL: BALANCING DEPTH-ORIENTED AND BROAD-ORIENTED APPROACHES

With the development of the new energy vehicle (NEV) industry and the diversification of industrial division patterns, the talent training model for automotive engineering majors is also undergoing profound changes. Based on industry practices and the Ministry of Education's Teaching Standards for New Energy Vehicle Technology, future talent cultivation should address both depth-oriented and broad-oriented talent needs to meet the distinct characteristics of vertically integrated and horizontally divided enterprises.

Firstly, depth-oriented talent cultivation primarily targets vertically integrated enterprises, such as BYD, which independently control full-vehicle R&D, core component production, and manufacturing processes. These enterprises emphasize the integrity of the technology chain, so graduates are expected not only to possess R&D capabilities for power batteries, motors, and electronic control systems but also to have full-process competencies in vehicle manufacturing, assembly processes, quality control, and automated production line management. the goal of depth-oriented talent cultivation is to develop technical backbones capable of supporting the full R&D-to-manufacturing chain within the enterprise, ensuring autonomy and competitive advantage in core technologies. Accordingly, the curriculum must balance theoretical depth with practical training, strengthen professional modules on the "three electrics" (power battery, motor, and electronic control), and cultivate comprehensive engineering skills through vehicle design, process simulation, and laboratory practice.

Secondly, broad-oriented talent cultivation targets horizontally divided enterprises, such as Tesla, Xiaomi Automobile, and Huawei Seres. These companies rely more on external suppliers for vehicle production, while their primary roles are system integration and overall vehicle optimization. Therefore, graduates are expected to excel in interdisciplinary collaboration and systems thinking, including smart technology applications, supply chain management, system integration, testing and validation, and data collection and analysis. Broad-oriented talents need to understand mechanical,

electrical, and electronic control principles while also possessing cross-domain knowledge in computer science, artificial intelligence, virtual simulation, and information technology, to meet the diverse demands of innovation and rapid iteration in the emerging intelligent vehicle industry.

In this context, future talent training programs in automotive engineering should emphasize interdisciplinary integration, enterprise-oriented customization, and differentiated training. By promoting co-developed courses and collaborative teaching across mechanical, electronic, computer, and information technology disciplines, a composite talent training model can be formed. Students should acquire knowledge of mechanical design and dynamics while applying software programming, data analysis, and intelligent control technologies, achieving an organic integration of engineering and digital capabilities. Meanwhile, differentiated training paths can be established to meet the specific needs of vertically integrated and horizontally divided enterprises. For depth-oriented talents, the focus is on training across R&D and manufacturing chains; for broad-oriented talents, emphasis is placed on interdisciplinary system integration, intelligent applications, and supply chain collaboration.

The training of automotive engineering professionals is shifting from a single mechanical focus to a new model that balances depth-oriented and broad-oriented approaches, is interdisciplinary, practice-driven, and industry-collaborative. This model not only satisfies the diverse talent needs of enterprises under different industrial division patterns but also provides students with broader development opportunities, equipping them with sustainable competitiveness and innovation capacity in the NEV and intelligent vehicle sectors. Consequently, it effectively supports the high-quality development and technological upgrading of China's automotive industry.

The "CASE" transformation in the NEV industry has not only reshaped the automotive industry chain but also imposed entirely new requirements on talent cultivation in automotive engineering. Vertically integrated enterprises require depth-oriented technical talents, while horizontally divided enterprises need broad, collaborative, interdisciplinary talents. the education system must keep pace with industrial upgrading, comprehensively improving talent quality in automotive engineering through curriculum reform, interdisciplinary integration, and practical teaching innovation, thereby providing robust talent support for the sustainable development of China's NEV industry.

References

[1] Wang, X., Yang, Z. Exploration of Talent Training Model for Intelligent Vehicle Majors Oriented to Emerging Industry Development and Needs [J]. Creative Education Studies, 2023, 11:559.

[2] Huang, Y. Research on Intelligent Transformation Strategies of Automobile Enterprises in the Context of Digitalization: A Case Study of BYD [J]. E-Commerce Letters, 2024, 14:2613.

[3] Ministry of Education of the People's Republic of China. Teaching Standards for New Energy Vehicle Technology (Higher Vocational Education, Specialist Level). URL: http://www. moe. gov. cn/s78/A07/zcs_ztzl/2017_zt06/17zt06_bznr/bznr_zyjyzyjxbz/gdzyjy_zk/zk_zbzzdl/zbzzdl_qczzl/202502/P020250207528684826334.pdf

A PM2.5 Detection System Based on Filtering Algorithm

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Abstract: This project primarily uses the STM32F103 series microcontroller, power supply, dust sensor, ink screen display module, alarm circuit, SHT20 temperature and humidity sensor, and BMP180 atmospheric pressure module to design an air quality monitoring system for PM2.5 concentration. In this system, the STM32 microprocessor serves as the control core. the dust concentration sampling system consists of a buzzer, PM2.5 dust sensor, ink screen, and analog-to-digital converter (ADC). the PM2.5 dust sensor measures the PM2.5 concentration by monitoring the air quality around it. After the microprocessor and its peripheral circuits process the data, the analog-to-digital conversion circuit converts the analog output from the detection circuit into a digital signal. the PM2.5 concentration is then displayed on the ink screen. If the PM2.5 dust concentration is too high, the system alerts users with an LED warning light and a buzzer. This allows users to monitor real-time environmental and atmospheric pollution levels. the SHT20 temperature and humidity sensor monitors the external air's temperature and humidity, while the BMP180 atmospheric pressure module and the HC05 Bluetooth module facilitate communication with mobile phones and other electronic devices. This design is user-friendly, cost-effective, and multifunctional, making it suitable for widespread application in daily life and industrial production.

Key words: STM32 PM2.5 filtering algorithm, ink screen, temperature and humidity

1. INTRODUCTION

The World Health Organization (WHO) believes that PM2.5 has a significant impact on human health. When the annual average concentration of PM2.5 reaches 35 micrograms per cubic meter, the risk of death increases by about 15% compared to when it is 10 micrograms per cubic meter. Numerous studies have been conducted both domestically and internationally to monitor PM2.5 concentrations. As awareness of the dangers of smog grows, there is an urgent need for a portable, real-time, and cost-effective PM2.5 air quality detector. Therefore, this paper aims to design and develop a PM2.5 detection device based on STM32.

2. RESEARCH CONTENT

2.1 STM32 minimum system

The main control chip is the STM32F103C8T6, featuring a high-performance ARM Cortex-M3 core with a clock frequency of 72MHz. It has a program memory capacity of 64KB, operates at 2V~3.6V voltage, and can function in temperatures ranging from-40℃ to 85℃. the STM32's minimal system includes a power supply circuit, a clock crystal, a reset circuit, a decoupling circuit, and communication interfaces

The system utilizes the ADC sampling function of the STM32. the STM32 chip features 1 to 3 independent ADCs that can operate in dual modes. the STM32 has 18 channels, capable of measuring 16 external and 2 internal signal sources. Each channel can switch between different modes for analog-to-digital conversion. the STM32's maximum analog-to-digital conversion rate is 1 MHz, and it is essential to keep the ADC clock below 14 MHz to ensure the accuracy of the conversion results. the STM32 divides the ADC conversion into two groups: the regular channel group and the injection channel group. the conversion in the injection channel group can interrupt the conversion in the regular channel group, and only after the injection

channel group successfully completes its conversion can the regular channel group proceed [1]. the STM32's analog-to-digital conversion can be initiated using either the ADON bit in the ADC-CR2 register or an external trigger, with the CONT bit set to 0. For the regular channel, once the conversion is complete, the result is stored in the ADC-DR register, and the conversion completion flag is set. If the EO-CIE was previously configured, an interrupt will occur. the ADC then stops until the next start-up.

2.2 PM2.5 sensor module

The PM2.5 data collection is conducted using the GP2Y1010AU0F sensor, developed by Sharp Corporation in Japan. This sensor measures the PM2.5 index [2] in the air. Due to the low density of dust, the data collection results are intermittent, necessitating the use of filtering algorithms. the software design employs mean filtering and limit filtering algorithms to achieve effective filtering.

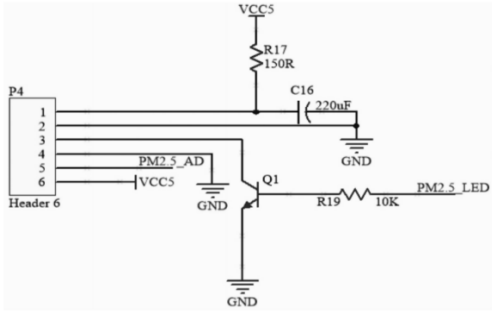

Figure 1 PM2.5 acquisition circuit

The power supply voltage for the GP2Y1010AU0F sensor is 3.3V. Its output pin A is connected to the AD converter pin inside the STM32 processor, and the ILED pin is connected to the GPIO pin of the STM32 chip. the sensor outputs a voltage value through an internal infrared diode, which changes based on dust concentration [3] [4]. the STM32 chip can estimate the dust concentration in the air by analyzing this voltage level.

The GP2Y1010AU0F sensor is an optical dust concentration detection device designed to detect extremely fine particles, such as cigarette smoke and fine dust, including PM2.5 levels in the air, with a precision of ±5pμ g/m. This sensor uses LEDs based on the photoelectric principle, with infrared LEDs and phototransistors arranged in pairs. Typically, when LEDs are continuously powered, their output decreases, leading to a reduction in the dust-free output voltage and detection sensitivity.

The GP2Y1010AU0F sensor is characterized by high sensitivity and accuracy; its specifications are relatively small (size: (46.0×30×17.6mm)) and easy to install; it can achieve air circulation, greatly enhancing the external atmospheric circulation; it is easy to protect and care for.

There are pores on the sensor, and air can flow through the pores. At this time, directional LED light is emitted. the sensor can judge the dust concentration by sensing the light condition of the air dust after refraction [5].

Figure 2 Physical diagram of GP2Y1010AU0F sensor

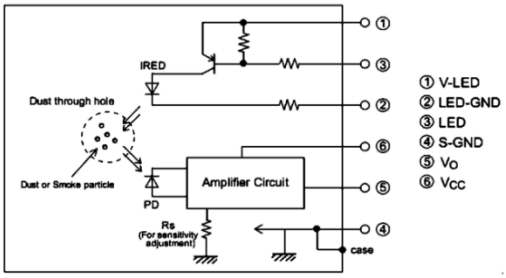

Figure 3 Working principle diagram of GP2Y1010AU0F sensor

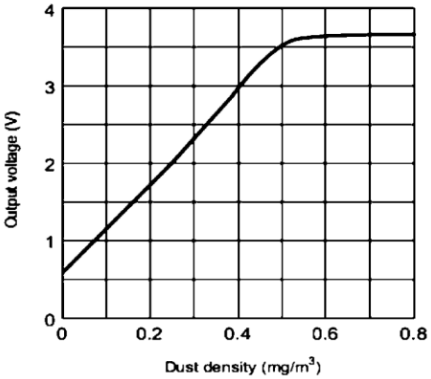

Figure 4. Relationship between sensor output voltage and particle concentration

Based on the observed image, the curve shows a linear growth trend in its early stages. However, around 0.5mg/m3, the growth rate

slows down, and the output voltage stabilizes at approximately 3.5V. Observations of the curve's early phase indicate that the relationship between voltage and dust concentration is given by Dustdentity=0.17 * OutputVoltae.

GP2Y1010AU0F determines the particle concentration by relying on the height of the output pulse. the dust-free output voltage and sensitivity correction algorithm are added to ensure the accuracy of PM2.5 collection. If the output voltage standard does not change within a specified time during the operation of the air purifier, the dust-free output voltage will be automatically updated.

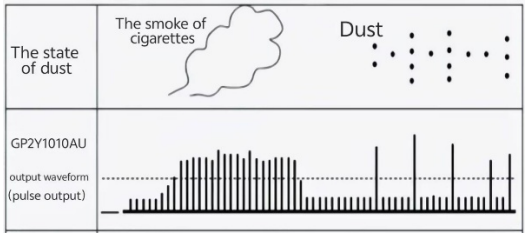

Figure 5 The concentration of PM2.5 particles is determined by pulse height

2.3 Light-emitting alarm module

The core component of the alarm circuit is a buzzer, which is connected to the S8050 transistor and the microcontroller's IO pin. When the IO pin is at a high level, the buzzer does not sound an alarm. However, when it turns to a low level, the LED diode lights up, and the buzzer sounds an alarm. the system also allows users to manually adjust the PM2.5 threshold. If the PM2.5 concentration exceeds the set maximum value, the buzzer will sound an alarm [6].

2.4 Ink screen display module

The display module is used to display the current PM2.5 value for users to know. In the whole detection system, a piece of ink screen is selected, and the display screen is connected with the microprocessor through SPI interface.

2.5 Temperature and humidity detection

This design utilizes the SHT20 chip, a new generation of digital temperature and humidity sensors. It features a DFN package suitable for reflow soldering, with a base size of 3x3 mm and a height of 1.1 mm. the SHT20 employs a novel CMOSens chip and standard bandgap temperature sensing elements, complemented by an improved capacitive humidity sensing element, offering high precision, low power consumption, and cost-effectiveness. Its moisture range is approximately ±3% RH, with a humidity range of 0 to 100% RH and a temperature range of 40℃ to 125℃. the SHT20 operates on a minimum voltage of 2.1V and a maximum of 3.6V, with a relatively low power consumption of [7].

2.6 BMP180 atmospheric pressure circuit

The BMP180 features a powerful 8-pin ceramic leadless chip carrier (LCC) ultra-thin package, offering outstanding performance. It includes built-in calibration and correction, achieving an absolute accuracy of 0.03 HPa (0.25 m), with electrode consumption of only 3 μA. the pressure measurement range is approximately 300 HPa to 1, 100 HPa, making it suitable for most daily use scenarios. the BMP180 operates within a voltage range of 1.8 V to 3.6 V, with a typical operating voltage of 2.5 V.

2.7 Internet of things

The Internet of Things mainly uses cloud computing, pattern recognition and other intelligent technologies to combine sensors and intelligent technologies to expand the application field. the PM2.5 detection design based on the Internet of Things is mainly composed of data acquisition end, execution control end, information transmission between different systems, so that the system interaction is stronger.

Data acquisition end: including STM32 microcontroller, PM2.5 sensor, temperature and humidity sensor, and pressure sensor. When the PM2.5 value is too high and the temperature and humidity are abnormal, the central controller will receive the signal and transmit it for processing [8].

Execution control end: including air purifier, humidifier and air conditioner. the execution end is controlled by the Internet of Things to make the environment where users are in a healthy environment.

3. INNOVATION POINTS AND PROJECT CHARACTERISTICS

Compared with the traditional large PM2.5 detection instrument, this instrument has the characteristics of small size and easy to carry

The circuit structure of this system is simple, the research and development cost is low, the price advantage is obvious, the use threshold is low, and the application population is wide.

Compared with traditional instruments, this instrument is based on STM32 microprocessor,

which has stable performance, high accuracy and sensitivity, and can carry out real-time monitoring.

This product can be connected to smart home appliances based on the Internet of Things, so that users can get rid of their hands to the greatest extent, combined with air purifiers, so that users are in a healthy environment.

4. CONCLUSION

The PM2.5 detection system, based on filtering algorithms, integrates multiple technologies to achieve precise real-time monitoring and multifunctional integration. It is innovative, compact, cost-effective, and intelligent, addressing the shortcomings of traditional instruments. However, it also has limitations, such as needing to improve its ability to resist interference in complex electromagnetic environments and ensure the long-term stability of some sensors. In the future, the system will continue to optimize its performance, expand its functions, integrate more pollutant monitoring capabilities, and enhance its applicability across various scenarios, providing stronger technical support for air quality monitoring and pollution control, thus promoting the development of related fields.

Reference

[1] Chen Yu. Design of a PM2.5 Detection System Based on STM32 [J]. Computer Programming Skills and Maintenance, 2023, (05):46-48+76. DOI:10.16184/j. cnki. comprg. 2023.05.007.

[2] He T. He T. PM2.5 environmental detection and air pollution control based on improved and upgraded network [J]. Arabian Journal of Geosciences, 2021, 14(13):

[3] Xinwei Z, Longqing Z, Shu G, Xinwei Z, Longqing Z, Shu G, et al. Design of PM2.5 Air Quality Detection System based on Median Value Average Filtering Algorithm and OLED Screen [J]. IOP Conference Series: Earth and Environmental Science, 2020, 450012013-012013.

[4] Sun Chang, Zhu Haohua, and Gao Kai. Design of a PM2.5 Monitoring Device Based on STM32 [J]. Science and Technology Innovation and Application, 2019, (18):38-39.

[5] Nie Lijuan, Hang Li, Fang Zhiwei, et al. Design and Implementation of a PM2.5 Monitoring System Based on STM32 [J]. New Industrialization, 2019, 9(01):91-95. DOI:10.19335/j. cnki. 2095-6649.2019.01.017.

[6] Zhou Wenping. Design of Indoor PM2.5 Monitor Based on STM32 [D]. Anhui University, 2016.

[7] Gu Honghua, Wang Kunpeng, Wang Chunfeng, et al. Home PM2.5 detector [J]. Silicon Valley, 2015, 8(02):11+8.

[8] Wang Xiaodong. Design of a new type of PM2.5 detector [J]. Electric Age, 2014, (04):82-84.

Thoughts on Integrating the Great Anti-Japanese War Spirit into College Ideological and Political Theory Courses

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Abstract: The great anti-Japanese war spirit is a precious spiritual wealth formed by the Chinese nation in the grand process of resisting Japanese militarist aggression and is an important part of the spiritual spectrum of the Communist Party of China. Integrating it into college ideological and political theory courses is of extremely important contemporary value and practical significance for guiding the new generation of young people to remember history, honor the martyrs, cherish peace, and create the future. This article aims to explore the profound connotation of the great anti-Japanese war spirit, analyze its intrinsic value in ideological and political theory courses, and attempt to propose specific practical paths, with the expectation of enhancing the ideological, theoretical, and affinity and pertinence of ideological and political theory courses.

Keywords: Anti-Japanese War Spirit; Ideological and Political Theory Courses; Value Guidance; Teaching Path; Patriotism

1. The Profound Connotations And Contemporary Value Of the Great Spirit Of the War Of Resistance Against Japanese Aggression

The great spirit of the War of Resistance originated from the arduous struggle waged by the Chinese people of all ethnic groups against Japanese aggression from 1931 to 1945. Its core connotation is highly condensed as: "the patriotic feeling that 'every man is responsible for the rise and fall of the nation', the national integrity of facing death unflinchingly and preferring death to humiliation, the heroic spirit of defying brute force and fighting to the end, and the unyielding belief in victory with perseverance and fortitude". This spirit has rich connotations and a clear hierarchical structure:Patriotic feeling is the spiritual cornerstone. It transcends the boundaries of region, class and political party, closely connects the destinies of all Chinese people, forms an unprecedented sense of a united national community, and represents the sublimation of the Chinese nation's tradition of patriotism; National integrity is the spiritual backbone. In the face of the invaders' cruelty and inducements to surrender, countless heroic sons and daughters upheld their integrity, preferring to "break like jade rather than remain intact as tiles" (meaning to preserve dignity even at the cost of life, demonstrating the unyielding resolve and noble character of the Chinese nation; Heroic spirit is the spiritual power. Under the extremely difficult condition where the enemy was stronger and we were weaker, the Chinese people fought tenaciously with their flesh and blood, showing the great courage to overwhelm all enemies and never yield to them; Belief in victory is the spiritual pillar. It was precisely by virtue of the firm belief that the just cause would surely triumph that the Chinese people were able to overcome hardships and obstacles, persist in the War of Resistance until the end, and finally win the great victory. [1]

On the new journey to realize the great rejuvenation of the Chinese nation, the challenges we face remain complex and severe. the core of patriotism, the quality of uniting to resist aggression, the style of hard work, and the will of self-improvement embodied in the great spirit of the War of Resistance are precisely the indispensable "calcium" and "soul" for us to address risks and challenges, pool national strength, and consolidate cultural confidence today. It tells

us that no matter how times change, the theme of patriotism will never become outdated, the tradition of unity and struggle must never be abandoned, and national integrity and heroic spirit must always be carried forward. In the new era, carrying forward and promoting the great spirit of the War of Resistance Against Japanese Aggression is of irreplaceable contemporary value in inspiring young students to integrate their personal ideals into the Chinese Dream, to be courageous in overcoming all difficulties and obstacles on the way forward, to unswervingly follow the path of socialism with Chinese characteristics, and to realize the Chinese Dream of the great rejuvenation of the Chinese nation.

2. The Significant Value Of Integrating the Great Spirit Of the Anti-Japanese War Into Ideological And Political Theory Courses Teaching

Ideological and political courses are the key courses for implementing the fundamental task of fostering virtue through education, and the core platform for conducting education on socialist core values. Currently, the once-in-a-century changes in the world are evolving at an accelerated pace, and exchanges and collisions between various ideologies and cultures have become more frequent. Young students'values have not yet been truly formed, making them highly vulnerable to environmental influences. Standing at the forefront of teaching and educating people, teachers of ideological and political courses shoulder the important responsibility of guiding young people to establish correct outlooks on history, ethnicity, the nation, and culture.

To deeply explore the great spirit of the War of Resistance—a vivid "mine of spiritual wealth"—and effectively integrate it into the entire process of education and teaching is a strategic necessity. It serves to strengthen confidence in history, enhance spiritual strength, resist historical nihilism, and cultivate new talents for the times. Moreover, it is our bounden duty.

This means that we must not merely teach the history of the War of Resistance as a set of cold, detached knowledge points. Instead, we should dig deeper into the spiritual values behind it. By using vivid, profound, and moving methods, we need to help young students truly feel the solemn heroism and glory of that historical period, understand the choices and sacrifices made by martyrs, and thereby foster in their hearts a sense of awe for history, respect for heroes, and a sense of responsibility toward the nation.

Integrating the great spirit of the War of Resistance into the teaching of ideological and political courses is by no means a simple (superposition) of content; instead, it is an in-depth integration aimed at achieving value guidance, emotional resonance, and capacity enhancement. By narrating detailed historical facts and vivid heroic stories, we help students deeply understand the pivotal role of the Communist Party of China in the War of Resistance, powerfully refute a series of wrong viewpoints such as historical nihilism, and establish a correct view of history.

College students possess a strong sense of patriotism. By integrating the spirit of the War of Resistance into classroom teaching, we can enhance students' national identity and sense of belonging, deepen their understanding of the Chinese nation's thousands of years of cultural heritage and socialist revolutionary culture, strengthen their cultural confidence, and accumulate strength for building a strong socialist cultural country.

The history of the War of Resistance is magnificent, and the stories of the War of Resistance are moving and inspiring—they are in themselves extremely attractive and inspiring teaching resources. Making good use of these resources can enhance the appeal and persuasiveness of ideological and political classrooms, make the teaching content more vivid, vivid and emotional, and significantly increase students engagement in class and the effectiveness of moral education. [2]

3. Practical Approaches To Integrating the Great Spirit Of the War Of Resistance Into Ideological And Political Course Teaching

How to make the great spirit of the War of Resistance move from history to reality and from books to the hearts of students is a practical question that every teacher of ideological and political courses must reflect on. To achieve its effective integration [into teaching], I believe it is necessary to explore diverse and multi-dimensional approaches.

First of all, efforts should be made to organically incorporate the spirit into teaching

content. This is not a mechanical transplantation; instead, it requires precise and effective integration based on the characteristics of each ideological and political course. For instance, when teaching courses such as History of the Communist Party of China and Ideology, Morality and Rule of Law, it is essential not only to vividly and thoroughly narrate major historical battles but also to conduct in-depth analysis of the historical logic, theoretical logic, and practical logic behind them. Through vivid historical details and touching heroic stories, the profound connotations of patriotism, ideals and beliefs, revolutionary ethics, and other values are vividly interpreted.

Secondly, innovate teaching methods and make full use of modern information technology tools to arouse students' emotional resonance. For example, AI software like DeepSeek can be used to innovate the design of teaching PPTs, create an immersive restoration of historical scenes, and enhance the intuitiveness and sense of engagement in teaching. In addition, students can be guided to visit online memorial halls and AI experience halls, as well as conduct on-site visits to practical bases such as War of Resistance memorial halls and martyrs' cemeteries, allowing them to receive spiritual enlightenment in real scenarios.

Thirdly, we should emphasize teachers' self-cultivation and inspire students with the charm of personality. "Let those who have faith teach faith. " First and foremost, we ourselves must truly learn, truly understand, truly believe in, and truly apply the great spirit of the War of Resistance. We need to continuously improve our historical literacy and theoretical proficiency, and teach with deep emotion—only then can we infect and move students. We should take our own patriotic feelings, professional dedication, and noble character as examples for students to carry forward and practice the great spirit of the War of Resistance.

Finally, strengthen practical teaching to promote the unity of knowledge and practice. Organize students to carry out social practice and social surveys themed on the spirit of the War of Resistance. Specific activities may include: visiting veterans of the War of Resistance and their descendants to compile oral history; conducting study trips to important memorial sites of the War of Resistance; and conducting research on the inheritance of the War of Resistance spirit in the new era and forming research reports. Through these initiatives, theoretical learning is transformed into practical actions, and students internalize the spiritual qualities in practice. [3] [4]

4. Conclusion

The great spirit of the War of Resistance is a treasure of the Chinese nation and a powerful driving force inspiring us to move forward. the in-depth, effective, and innovative integration of this spirit into the teaching of ideological and political courses in colleges and universities is a systematic project of far-reaching significance. We must adhere to the principles of "content as the core, methods as the key, practice as the focus, and teachers as the foundation", continuously explore new paths and methods for integration, and enable the great spirit of the War of Resistance to radiate new vitality in ideological and political classrooms, truly reaching students' ears, minds, and hearts. In this way, we can better guide the majority of young students to carry forward the red heritage, draw strength for forging ahead, aspire to become new-era talents who shoulder the responsibility of national rejuvenation, and contribute their youthful wisdom and strength to the realization of the great rejuvenation of the Chinese nation.

References

[1] Liu Guangming. Viewing the Monument of the Spirit of the War of Resistance from the "Will Index" [J]. China Discipline Inspection and Supervision, 2020-09-01.

[2] Ma Xiaoying. Traditional Aesthetic Education and the Construction of College Students' Socialist Core Values [J]. Grade & Classic, 2020-08-25.

[3] Wang Jianbo. Contemporary Review on Integrating the Spirit of the War of Resistance into Ideological and Political Work in Colleges and Universities [J]. Industrial Science and Technology Forum, 2019-11-01.

[4] Wang Meiduo. Theoretical Reflection and Practical Approach of Integrating Excellent Traditional Chinese Culture into the Teaching of Ideological and Political Courses in

Colleges and Universities [J]. Journal of Changsha Aeronautical Vocational and Technical College, 2024-12-15.

A Comparative Study of the Musical Characteristics of Miao Wicca and Mongolian Shamanism

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Abstract: This article explores the similarities and differences in their religious background, musical characteristics, functions and socio-cultural significance through a comparative study of Miao Wiccan music and Mongolian shamanistic music. the article combines the research methods of ethnomusicology, cultural anthropology and religion to reveal the roles of the two musical traditions in different cultural ecologies. the study reveals that although both are centered on religious rituals with strong functionality and mysticism, their expressions and cultural significance reflect their unique ethnic history and cultural values.

Keywords: Miao Wiccan Music, Mongolian Shamanism Music, Comparative Study

1. INTRODUCTION

As two ethnic groups with unique cultural charms in the Chinese family, the music cultures of the Miao and the Mongolian are like bright stars, each shining with brilliant light. Miao music, with its melodious and delicate style, tells the poetic life and tough emotion of the Miao people in the mountains and waters; Mongolian music, with its majestic and bold quality, shows the nomadic and open-mindedness of the Mongolian people in the vast grassland. Although there are significant differences between the two in terms of region and lifestyle, music, as an important carrier of national culture, deeply reflects the historical lineage, social outlook and spiritual world of the nation. In this paper, a systematic comparative study of Miao and Mongolian music from the perspective of musicology helps us to more precisely grasp the essential characteristics of different ethnic music, understand the close connection between music and culture, and explore the deep value of ethnic music, and at the same time, it can also provide useful ideas and directions for the cross-ethnic music exchange and integration, as well as for the modern inheritance and innovation of ethnic music.

2. RELIGIOUS BACKGROUND AND CULTURAL FOUNDATION

Miao Wicca and Mongolian Shamanism both have their origins in polytheistic beliefs, but the former emphasises ancestry and bloodlines, while the latter reveres the gods of heaven and nature. the Miao believe in the immortality of the soul, and in funerals, the ‘Soul Homecoming Song’ guides the deceased back to their ancestral homes; and in exorcisms, the ‘Compulsion Mantra’ begs the mountain gods to get rid of evil spirits. Mongolian shamans beat their drums and huomai during the heavenly rituals, imitating the eagle's song with the Song of Calling the Eagle to communicate with the Everlasting Sky and symbolise the ascension of the soul. Agricultural settlement makes Miao music narrative and repetitive, such as the ‘Invocation of Souls’ melodic simplicity, to maintain the clan; nomadic mobility makes Mongolian music improvisation, openness, and rhythm with the dance, to serve the tribal collective rituals. the former is inward-looking and regular, while the latter is outward-looking and dynamic.

3. COMPARISON OF MUSICAL CHARACTERISTICS

Miao Wiccan music and Mongolian shamanic music show distinctive ethnic characteristics and religious functions in terms of the use of musical instruments, singing styles, melodies

and rhythms, etc. Through an in-depth comparison of their musical characteristics, we can understand the interaction between religion and culture. Through an in-depth comparison of their musical characteristics, it can be found that they have similarities, but also show unique artistic styles due to their different cultural backgrounds. the following is a discussion of musical instruments, singing styles, melodies and rhythms, supported by concrete examples and relevant literature.

3.1 Use of Musical Instruments

The use of musical instruments in religious ceremonies is not only an artistic expression, but also carries religious symbols and cultural memories.

In Miao Wiccan music, the lusheng, as an iconic instrument, is widely used in funeral ceremonies and rituals. For example, in the funeral rituals of the Miao in Taijiang County, Guizhou Province, the lusheng song "Soul-inducing Tune" is believed to be able to guide the souls of the deceased to cross the secular world and return to the land of their ancestors [1]. In addition, in the witchcraft exorcism ceremony in the Phoenix region of western Hunan, shamans use special wooden drums with strong drum beats to expel evil spirits, and this use is documented in detail in An Introduction to Miao Folk Music [2]. Mouth-stringed instruments, on the other hand, are commonly used in small family rituals and are considered a medium of communication with spirits because of their delicate tone.

The shaman's drum is the most symbolic instrument in Mongolian shamanistic ceremonies. According to Research on the Music and Culture of Mongolian Shamanism [3], the surface of the shaman's drum is painted with patterns symbolizing the three worlds of heaven, earth and man, and the shaman enters the "state of the gods" during the ceremony through the rhythm of the drum. For example, in the Hulunbeier grassland rituals, the shaman's drum beats change from slow to rapid, expressing the shaman's soul's journey through the three realms. the mouth chord is also an important Mongolian instrument, for example, in the Ordos shamanic ceremony, the mouth chord imitates the howling of wolves or the sound of the wind, which is used to awaken the spirits of the natural world [4].

Miao Wicca and Mongolian shamanism reflect the needs and belief backgrounds of their respective cultures in their choice of musical instruments. the Miao focus on rice culture and ancestor worship, and the Lusheng tunes convey the continuity of life; while the shamanic drums and mouth strings of Mongolian shamans highlight the worship of heaven and earth and nature in nomadic culture. Specifically, the smooth melody and repetitive rhythm of the Spirit-inducing Tune emphasize the solemnity of the ceremony, while the drums of the Mongolian shaman are flexible and changeable, adapting to the improvisation of the shamanic dance.

3.2 Singing Methods

Miao shamans usually chant ceremonial songs in the form of lead singing, and the content of their lyrics are mostly ancestor legends or prayers. For example, the "Ancient Song of the Miao" is the centerpiece of the Miao rituals in western Hunan, in which the shaman recounts the story of the opening of the heavens and the earth, and the creation of the world by the ancestors in a single-voice chant. the singing style is low and solemn, emphasizing the clarity of speech, and most of the lyrics are in the ancient Miao language to enhance the sense of mystery.

Mongolian shamanistic music is mainly characterized by throat singing and hula. Throat singing forms multiple tones through special vocal techniques. For example, in the Ulanchab region, during the shaman rituals, the shaman uses throat singing to imitate the sound of eagles and the wind in order to show reverence for nature. Hula, on the other hand, resonates with the sounds of nature through the singer's improvisation, especially in the spirit invocation ceremony, where this form of expression symbolizes the shaman's soul's ability to transcend time and space.

The singing style of Miao Wiccan music focuses on the narrative function and expresses the solemnity of the ceremony, for example, the Ode to the Ancestors has straightforward lyrics and a simple melody; while the singing style of Mongolian shamanic music is more expressive, with huomai and guttural singing combining the shaman's personal ability with nature worship, such as the high-pitched tone in the Song of the Spirit Eagle, which expresses the soul's

ascent. Singing style plays an important role in communicating with the spirits in religious music.

3.3 Melody and Rhythm

The melodies of Miao Wiccan music are usually simple and rich in repetition. For example, in the funeral rituals of the Miao in Guizhou, the Lusheng song "The Return of the Soul" is based on a three-note scale, which is played repeatedly to form a stable musical background. In terms of rhythm, the tempo of the wooden drums in "Exorcism Mantra" is synchronized with the pace of the shaman, with a slow tempo to attract the spirit and a fast tempo to exorcise the evil spirits, a design that effectively strengthens the mystical sense of the ceremony.

The melody of Mongolian shamanistic music is varied and has a lot of ups and downs. For example, in the shamanic rituals of the Altai Mountains region, the melody of the Dance of the Flying Eagle imitates the sounds of nature, and the rhythm changes flexibly with the shaman's movements, showing the process from slow to rapid. the beating rhythm of the shaman's drum is mostly progressive to enhance the tension and mystery of the ceremony.

The melody of Miao Wiccan music tends to be more stable, focusing on repetition and regularity, for example, the melody of "The Return of the Soul" reinforces the solemnity of the ceremony through a cycle; whereas Mongolian shamanic music emphasizes improvisation and dynamic changes, and the combination of shamanic drums and mouth strings creates a more open artistic expression. Melody and rhythm are important parts of religious music, directly affecting the atmosphere and effect of the ceremony.

3.4 Comprehensive Analysis

Through the specific analysis of the use of instruments, singing styles and melodic rhythms, we can see the commonalities in religious functions and the differences in cultural backgrounds between Miao Wiccan music and Mongolian shamanic music:

Both the Miao and the Mongolians utilize music as a bridge to supernatural forces. For example, the Miao's "Tune for Guiding Souls" and the Mongolian's "Song of Calling Eagles" both aim to guide souls or deities, reflecting the functionality of music in religious ceremonies.

In terms of the use of musical instruments, Miao Wicca favors the expression of the continuity of life and family, and the lusheng and the mouth string are mostly used in personal and family occasions; Mongolian shamanism emphasizes the interaction between man and nature, and the shaman's drums and the mouth string are mostly used in the large-scale ceremonies of offering to the sky. In terms of melody and rhythm, the Miao focuses on stability and repetition, such as the "Spell for Driving Compulsions", while the Mongolian shaman pays more attention to improvisation and tension, such as the "Dance of the Flying Eagle".

By comparing the religious function and social significance of Miao Wiccan music and Mongolian shamanistic music, we can see the similarities and differences between the two in terms of religious demand, social structure and cultural inheritance. Miao Wiccan music focuses on the maintenance of individual souls and family culture, for example, the "Soul-inducing Tune" carries the significance of family continuity; Mongolian shamanic music pays more attention to the resonance between human and nature and the cohesion of tribes, for example, the "Song of the Calling Eagle" expresses the worship of heaven and earth and nature. Such differences reflect the uniqueness of the two ethnic groups in terms of geography, economic model and social organization.

References

[1] Tian Qing. 2022. The Music of the Chinese People. Beijing: CITIC Publishing Group.

[2] He Maoli. 2006(04). A Cultural Anthropological Study of Miao Oral Literature and Witch Culture. Guizhou Social Science.

[3] Ulanje. 2010. Research on Mongolian Shamanism Music. Beijing: Yuanfang Publishing House.

[4] Meng Huiying. 2000(01). Heavenly Gods and Heavenly Orders in Shamanism. Inner Mongolia Social Science (Chinese edition).

Research Progress of Therapeutic Touch in Cancer Patients

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Abstract: In this paper, the concept, origin and development of touch therapy, the mechanism of action, as well as the implementation methods and effects of touch therapy applied to cancer patients were reviewed, aiming to improve the understanding of touch therapy among nursing staff and provide reference for the subsequent clinical application and related research of touch therapy in cancer patients.
Keywords: Cancer patients; Therapeutic Touch; nursing; Review

1. INTRODUCTION

Cancer is a major public health problem, with 17 million new cases in 2018 and an estimated 27.5 million new cases worldwide by 2040, according to the International Agency for Research on Cancer (IARC)[1]. Most patients diagnosed with cancer experience both physical and psychological stress from the disease and its treatments, leading to a decline in overall quality of life. Complementary and alternative medicine (CAM) refers to therapeutic methods specifically used or added to standard treatments (surgery, radiotherapy, chemotherapy), but not included in standard treatments. Globally, CAM is applied to manage symptoms related to cancer and as an adjunct to mainstream cancer treatments. Touch therapy, as a CAM modality, demonstrates notable clinical efficacy in alleviating or resolving physical and psychological issues caused by cancer. In view of this, this article reviews the concept, origin and development, mechanism of action, as well as the implementation methods and effects of touch therapy in cancer patients, with the aim of providing references for the care of cancer patients in China.

2. OVERVIEW OF TOUCH THERAPY

2.1 The concept of touch therapy

Touch therapy, also known as therapeutic touch, can be defined as an overall, evidence-based practice that involves coordinated hand pressure techniques on the human energy field. the therapist performs gentle touches on the patient with care and compassion, while transmitting energy, warmth, and love to the patient. the aim is to restore the balance of the patient's energy, stimulate the patient's body's self-recovery through touch, enhance the patient's natural healing ability, and promote the coordination and recovery of health in various dimensions of humanity.

2.2 Origin and development of touch therapy

In the 1970s, non-professional therapist Dora Kunz and Dolores Krieger, a nursing professor and certified dietitian at New York University, first introduced Touch Therapy. They considered it an interpretation of ancient therapeutic practices adapted for modern use, establishing it as a unique treatment modality. Over time, Touch Therapy has evolved into a comprehensive evidence-based approach internationally, with applications spanning nursing homes, burn units, rehabilitation wards, hospice facilities, psychiatric and pediatric clinics, and operating rooms. the therapys scope continues to expand globally. the American Cancer Society has even endorsed Touch Therapy as an adjunctive method for alleviating cancer-related symptoms. However, in China, Touch Therapy remains underutilized as a nursing intervention among cancer patients, with clinical research in this field remaining scarce.

3. MECHANISM OF TOUCH THERAPY

The mechanism of touch therapy has not been completely unified, and the current research can be summarized as psychological mechanism and neural mechanism.

3.1 Psychological mechanism

Touch therapy helps individuals achieve comfort and emotional stability. Research

shows that touch stimulates skin receptors, which through the central nervous system prompts the brain to increase prolactin and endorphin secretion while reducing cortisol release. This enhances the bodys stress-relieving and bonding hormones, effectively alleviating anxiety and tension, ultimately leading to a state of relaxation and well-being. Serotonin and dopamine are psychoactive substances that respond to the central nervous system, and touch therapy can also help individuals balance serotonin and dopamine levels in the body to maintain emotional stability.

3.2 Neural mechanism

Touch therapy enhances immune function by modulating the nervous system. Neurophysiological research indicates that touch can affect the autonomic nervous system, causing a decrease in blood pressure, a reduction in respiratory and pulse frequencies, relaxation of the peripheral nervous system, a reduction in stress related to diseases, and an enhancement of immune function. Touch therapy can also increase the number of natural killer cells in the body, alleviate pain and reduce the levels of the neurotransmitter "substance P", which is responsible for inflammation. This, in turn, enhances the body's immune function and helps individuals increase their confidence in life.

4. Implementation of touch therapy for cancer patients

4.1 Implementers of touch therapy

In the 1970s, when Dora Kunz was conducting research on touch therapy, she stated that as long as one is empathetic towards others, willing to help them, and undergoes training in touch therapy, anyone can practice touch therapy. With the evolution of time, most practitioners of touch therapy are nurses who have received formal and professional training and successfully completed courses on the origin, development and practice of touch therapy. Currently, practitioners of touch therapy in western countries include licensed health care providers, general physicians, registered nurses, physical therapists and other health care professionals. the main implementers of touch therapy in China are clinical nursing staff. They need to receive theoretical and technical training in touch therapy, be patient-centered and be able to help patients with sincerity.

4.2 Implementation methods of touch therapy

To restore balance in cancer patients energy systems and enhance therapeutic capacity, the implementation of touch therapy generally follows three distinct phases:(1) Calming Phase:The therapist achieves mental tranquility and focuses attention on the patient. (2) Assessment Phase:The therapist begins with the patients head and gradually moves downward to the feet for evaluation. (3) Treatment Phase:The therapist employs rhythmic and symmetrical hand movements to conduct touch therapy. This gentle, straightforward process requires no strenuous movements, typically lasting 15-20minutes(usually under 25minutes). Through this therapeutic approach, therapists help patients experience the power of nonverbal communication while transmitting spiritual strength such as trust, sincerity, respect, support, recognition, and willingness to assist through tactile means.

5. The implementation effect of touch therapy in cancer patients

5.1 Pain relief

Pain is the most common indicator for cancer patients. the use of touch therapy can reduce the intensity of pain for cancer patients. A review of previous literature and found that interventions such as touch therapy and other complementary and alternative therapies are feasible for cancer patients who are experiencing the disease and for pain related to cancer treatment. They have potential clinical efficacy in improving the pain of cancer patients, and the intensity of pain shows a downward trend. Tabatabaee et al. [2] randomly selected 90 male cancer patients in a hospital. the intervention included seven sessions of touch therapy over a period of four weeks. the results showed that touch therapy could enable cancer patients to have more energy and a sense of calm, be in a greater state of relaxation, improve their sleep quality, and reduce short-term pain, thereby indirectly increasing their tolerance for pain. At the same time, touch therapy was proposed by healthcare providers as a complementary method for managing pain and its parameters. In a 2013 study with 9 children aged 3-18, pediatric cancer patients receiving touch

therapy showed marked reductions in pain scores and intensity. Although the small sample size limited conclusive evidence, the therapy has provided hope for cancer patients undergoing treatment.

5.2 Relieve nausea

Nausea is more common in cancer patients, Matourypour et al. [3] aimed to investigate the degree of reduction in nausea experienced by breast cancer patients undergoing chemotherapy after receiving touch therapy. They randomly divided 108 breast cancer patients receiving chemotherapy into a control group, an experimental group, and a placebo group, and recorded the duration and frequency of nausea respectively. the study found that compared to the control and placebo groups, the touch therapy protocol demonstrated significant efficacy in reducing nausea duration, effectively alleviating chemotherapy-induced acute nausea. A 2016 study targeting female breast cancer patients further confirmed that touch therapy can serve as a complementary alternative method. It significantly influenced the average duration and frequency of acute nausea episodes in breast cancer patients, delaying the onset of nausea, shortening its duration, relieving physical tension, and helping cancer patients maintain a relaxed state. However, Post-White et al. [4] found in their study on the effects of therapeutic massage and touch therapy on cancer patients that the implementation of touch therapy did not show a significant improvement in the nausea of cancer patients. From the researchers' perspective, the type of chemotherapy regimen, the techniques of touch therapy, etc. might be the reasons for this contradiction. Therefore, the long-term efficacy of touch therapy as a complementary intervention to reduce nausea in cancer patients still needs to be supported and further validated.

5.3 Improve negative emotions

The application of touch therapy can reduce the negative psychological stress reactions such as anxiety and depression caused by the disease in cancer patients, and enhance the happiness of cancer patients. Yucel et al. [5] study found that the use of touch therapy in clinical Settings can help cancer patients experience a sense of comfort, provide physical and psychological satisfaction, and alleviate symptoms of anxiety and depression in cancer patients. Senderovich et al. [6] conducted a study by providing touch therapy to elderly cancer patients in the terminal stage twice a week, with each session lasting 5 to 7 minutes. the study found that the most common state after implementing touch therapy was relaxation, followed by gradually falling asleep. This therapy reduced the anxiety and depression levels of elderly cancer patients. Research on 88 gastric cancer patients revealed that combining touch therapy with Progressive Muscle Relaxation Training (PMRT) stimulated oxytocin secretion, improved blood circulation, alleviated tension and stress, while suppressing sympathetic nervous system activity and cortisol production. This approach effectively reduced anxiety and pain perception, helped divert attention from metastatic cancer, and stabilized emotional states. Touch therapy serves as a non-pharmacological complementary treatment that soothes emotions, reduces patient stress, and fosters positive mindset development.

5.4 Improve life satisfaction and quality of life

Touch therapy is a beneficial symptom management that makes cancer patients feel close and secure, which can effectively improve the quality of life of cancer patients. Clinical studies show marked improvements in social interaction skills among pediatric cancer patients following touch therapy and acupressure treatments, including enhanced verbal communication, emotional expression, social engagement, and even verbal self-reporting of comfort levels. Cancer-related fatigue leads to disruptions in various aspects of quality of life and has an adverse impact on their quality of life. Aghabati et al. [7] randomly divided 90 cancer patients into three groups. the cancer patients lay on hospital beds and received touch therapy once a day for 30 minutes each time. the intervention lasted for 5 consecutive days. the results showed that the fatigue intensity recorded by the patients themselves decreased significantly in a linear manner compared to before the touch therapy. the fatigue level and fatigue perception were reduced, the symptom burden was lower, and the quality of life was higher. the findings demonstrate that touch therapy is a feasible,

safe, and well-tolerated approach that effectively enhances cancer patients life satisfaction and quality of life.

6. BRIEF SUMMARY

In conclusion, touch therapy has demonstrated significant benefits for cancer patients by alleviating pain, reducing nausea and other side effects, decreasing anxiety and depression, providing psychological support, and enhancing life satisfaction and quality of life. A large amount of research evidence indicates that touch therapy provides cancer patients with a non-pharmacological intervention for disease management, and it is a promising comprehensive treatment method. While foreign countries have established earlier research foundations and conducted more studies on touch therapy, China currently shows broader research coverage but fewer clinical applications in cancer patients. the lack of standardized guidelines has resulted in insufficient evidence regarding the clinical efficacy of touch therapy for cancer patients. Future research should appropriately draw upon mature international protocols, enhance healthcare professionals understanding of touch therapy, and utilize this approach to deliver more user-friendly, human-centered, sincere, and effective treatments that promote healthy development.

Reference

[1] Zhang C, Xiao J, Yu Z, et al. Cancer pain management and the roles of pharmacists in China [J]. International Journal of Clinical Pharmacy, 2021(9). DOI:10.1007/s11096-021-01230-5

[2] Tabatabaee A, Tafreshi M Z, Rassouli M, et al. Effect of therapeutic touch on pain related parameters in patients with cancer: a randomized clinical trial [J]. Materia socio-medica, 2016, 28(3):220. DOI:10.5455/msm.2016.28.220-223

[3] Matourypour P, Zare Z, Mehrzad V, et al. An investigation of the effects of therapeutic touch plan on acute chemotherapy-induced nausea in women with breast cancer in Isfahan, Iran, 2012–2013[J]. Journal of education and health promotion, 2015, 4. DOI:10.4103/2277-9531.162380

[4] Post-White J, Kinney M E, Savik K, et al. Therapeutic massage and healing touch improve symptoms in cancer [J]. Integrative cancer therapies, 2003, 2(4):332-344. DOI:10.1177/1534735403259064

[5] Yücel Ş Ç, Arslan G G, Bagci H. Effects of hand massage and therapeutic touch on comfort and anxiety living in a nursing home in turkey: A randomized controlled trial [J]. Journal of religion and health, 2020, 59(1):351-364. DOI:10.1007/s10943-019-00813-x

[6] Senderovich H, Ip M L, Berall A, Therapeutic Touch® in a geriatric Palliative Care Unit–A retrospective review [J]. Complementary therapies in clinical practice, 2016, 24:134-138. DOI:10.1016/j. ctcp. 2016.06.002

[7] Aghabati N, Mohammadi E, Pour Esmaiel Z. the effect of therapeutic touch on pain and fatigue of cancer patients undergoing chemotherapy [J]. Evidence-Based Complementary and Alternative Medicine, 2010, 7(3):375-381. DOI:10.1093/ecam/nen006

The optimized design scheme of the intelligent pharmacy based on the improved algorithm of TensorFlow and MobileNetV3

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Abstract: This study is based on the TensorFlow framework and utilizes deep learning to optimize the intelligent pharmacy system. Two major systems, speech recognition and drug recognition, were constructed, significantly improving the level of automation management and operational efficiency. the speech recognition system adopts RNN architecture combined with CTC loss function optimization, which improves the accuracy and robustness of speech instruction recognition. the drug recognition system has improved the accuracy of drug box classification and recognition through the improved MobileNetV3 algorithm and image enhancement technology, and compressed the model using LASSO regression channel pruning technology to further improve operational efficiency. In addition, a multi label recognition system for medication boxes has been designed to provide comprehensive support for intelligent pharmacy automation management. the experimental results show that the improved algorithm and system design effectively enhance the automation management level of intelligent pharmacies, providing new ideas for future development.
Keywords: **Smart pharmacy; TensorFlow; MobileNetV3; Speech recognition; Drug recognition; Model compression**

1. INTRODUCTION

In the context of "Internet plus+Medical", the intelligent pharmacy management system is developing towards informatization and intelligence. In recent years, the number of medical institutions in China has increased year by year, especially affected by the COVID-19, and the number of hospitals has increased. However, the demand for medical services is still in short supply. It is urgent to build, rebuild, and expand hospitals, which brings potential demand for smart pharmacies. The core of an intelligent pharmacy is to improve the accuracy and efficiency of drug dispensing, and its automated system can shorten the waiting time for patients to take medication. Many outpatient pharmacies in domestic hospitals have introduced automation equipment and shifted towards the "automated intelligent pharmacy model", freeing pharmacists from physical labor and focusing on professional pharmaceutical services, thereby improving patient satisfaction and hospital operational efficiency. However, most smart pharmacies still face problems such as complex service processes, low space utilization, long patient queues, and lack of standardized management. To this end, we adopt the TensorFlow deep learning framework, combined with the improved MobileNetV3 algorithm, to optimize the existing intelligent pharmacy system, in order to improve the current situation and promote industry development.

2. RESEARCH CONTENTS

This plan optimizes the intelligent pharmacy, which is divided into two parts: speech recognition and drug recognition:

Speech recognition system: Based on the TensorFlow framework, various data cleaning methods are used to enhance the robustness of the system. In acoustic model training, GRU is used to construct the RNN network architecture, and the CTC loss function is combined to optimize the model, achieving high recognition accuracy while compressing the model size and improving operational efficiency.

Drug recognition system: using an improved MobileNetV3 algorithm combined with image enhancement algorithm, the effectiveness of the improved algorithm is verified through experiments. Compress the model of BCE MobileNetV3 network, prune low size factor channels, and optimize computation speed.

2.1 RESEARCH AND DEVELOPMENT OF SPEECH RECOGNITION MODULE

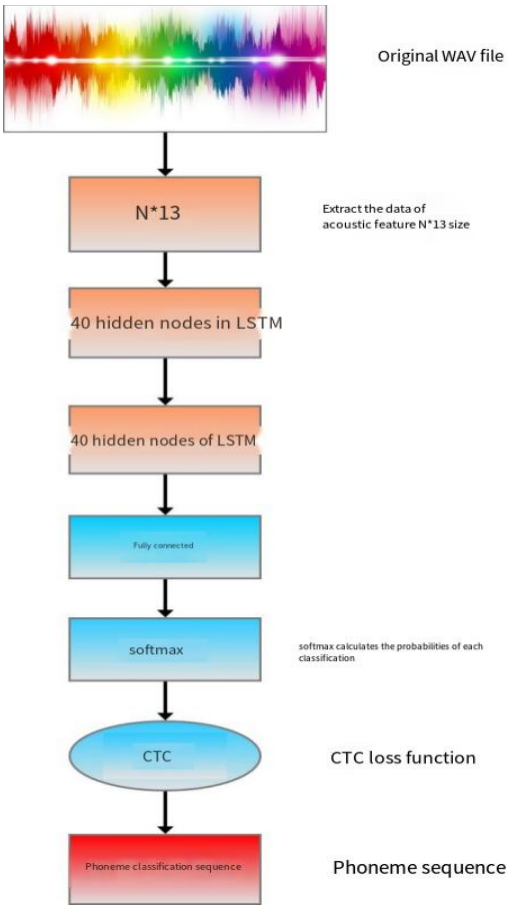

Figure 1 Schematic diagram of calculation process

The speech recognition module utilizes the TensorFlow framework to implement voice interaction functions, improving operational convenience and efficiency.

2.1.1Feature extraction

Extracting acoustic features from sound waveforms, the original audio file stores sound waveform data points, which need to be converted into feature vectors. Using the MFCCs method, waveform frames are converted into multidimensional vectors to extract key features of sound.

2.1.2Acoustic model training

Convert acoustic features into phonemes for pronunciation. Construct an acoustic model using LSTM and CTC. LSTM can process sequence data and capture temporal features of speech, while CTC loss function is suitable for situations where the length of input and output sequences is inconsistent, accurately converting acoustic features into phoneme sequences.

2.1.3Language Modeling and Decoding

Use language models based on N-grams or neural networks to calculate the probability of text sequences corresponding to phoneme sequences. The decoding process scores the hypothetical word sequence, selects the highest score as the final result, completes the conversion from phoneme to text, and achieves speech recognition.

Figure 1 shows the calculation process of a simple example, demonstrating how to use TensorFlow's LSTM+CTC to complete end-to-end speech recognition.

2.2 research And Improvement Of Image Recognition Module

The image recognition module achieves efficient drug recognition and classification through the improved MobileNetV3 algorithm, improving automation level and management efficiency.

2.2.1Classification recognition neural network algorithm

The core advantage of using MobileNetV3 as the infrastructure is its depthwise separable convolution structure, which decomposes standard convolution into depthwise convolution and pointwise convolution through depthwise separable convolution, significantly reducing computational complexity and parameter count. It is superior to traditional convolutional networks and more suitable for running on resource constrained devices.

Equation *(1.1)* shows the ratio of the computational cost of a regular convolution to that of a depthwise separable convolution. Among them, *M, N,* $D_K D_F$ and respectively represent the depth of the input feature matrix, the depth of the output feature matrix, the size of the convolution kernel, and the height and width of the output feature matrix in the network.

$$\frac{D_K \times D_K \times M \times D_F \times D_F + M \times N \times}{D_K \times D_K \times M \times N \times D_F \times D_F} = \frac{1}{N} + \frac{1}{D_K^2} \quad (1.1)$$

2.2. 2Principles and Improvements of MobileNetV3

MobileNetV3 introduces a more efficient Block structure and NAS technology to optimize the network structure based on MobileNetV2, and redesigns the time-consuming layer structure.

By adjusting the hyperparameters in the network, the performance of the model is optimized. Equation *(1.2)* includes hyperparameters α and β, where α is the multiplier of the convolution kernel, which controls the number of convolution kernels used during the convolution process, and β is the parameter for the resolution during the convolution process.

$$D_K \times D_K \times \alpha M \times \beta D_F \times \beta D_F + \alpha M \times \alpha N \times \beta D_F \times \beta D_F \quad (1.2)$$

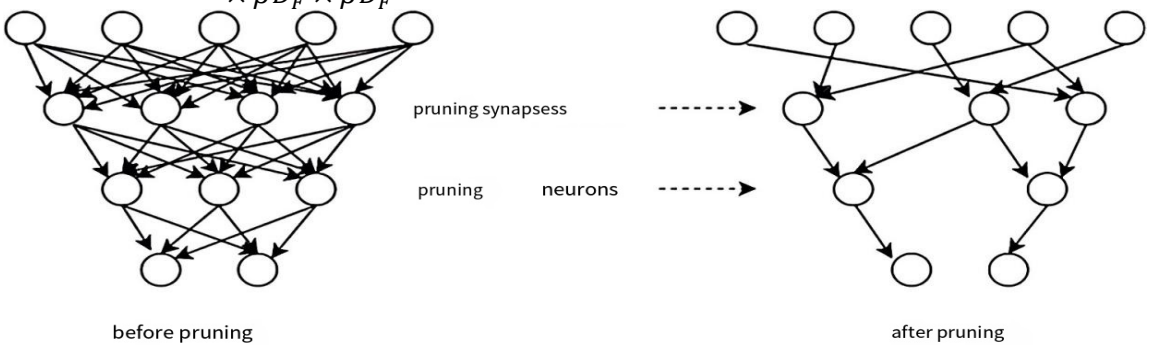

Figure 2 Model clipping process

2.2. 3Improved MobileNetV3 algorithm

Replace the SE module with the CBAM module and build a BCE MobileNetV3 network. the CBAM module considers both channel and spatial attention, which can more effectively extract key features.

2.3 research And Optimization Of Medicine Box Classification Module

The medication box classification module aims to improve the efficiency of drug management.

2.3.1Analysis of Model Pruning Algorithm

Model pruning reduces model size and computational complexity by removing unimportant parameters, solving problems such as slow model running speed and high memory usage.

2.3. 2Channel pruning based on LASSO regression

LASSO regression achieves model compression by adding L1 regularization term to the loss function to make unimportant channel weights approach zero.

$$L = \sum_{(x,y)} l(f(x, W), y) + \lambda \sum_{\gamma \in I} g(\gamma) \quad (1.3)$$

2.2. 3 Model pruning algorithm experiment and verification

Set different hyperparameters in the experiment and observe the performance changes of the model before and after pruning. Determine the optimal pruning strategy and hyperparameter settings through comparative analysis, and fine tune the pruned model to further improve performance.

2.4 system Integration And Testing

Integrate speech recognition, image recognition, and medication box classification modules into the intelligent pharmacy system, and conduct comprehensive testing and optimization to ensure system performance and stability.

2.4.1System integration:

The voice commands are transmitted to the image recognition module, and the medication box image information is transmitted to the classification module. the classification results are fed back to the user or management system, achieving the organic combination of voice, image, and medication box classification modules, realizing automated operations, and improving work efficiency.

2.4.2System testing

Functional testing verifies the accuracy of voice, image, and medication box classification; Performance testing focuses on response time, processing speed, and resource utilization; Stability testing evaluates the reliability of the system under long-term, high load operation. By simulating actual scenarios to evaluate the system and optimizing

adjustments based on test results, overall performance can be improved.

3. RESEARCH METHODS

Model Construction and Optimization of Speech Recognition System

Widely collect speech command data covering different speakers, speech rates, and background noise for training and validating models. And preprocess the voice data to improve data quality and system robustness.

During the model construction phase, GRU is chosen as the core of the speech recognition algorithm. Build a GRU network using the TensorFlow framework and train it using the CTC loss function. Combine the acoustic model with the language model to construct a complete speech recognition system, which is integrated into the unmanned medicine cabinet of an intelligent pharmacy.

Test the system in various practical scenarios, including different background noises and speakers, to verify its robustness and accuracy, and further optimize and adjust it based on the test results to ensure the efficient operation of the speech recognition system.

Model Construction and Optimization of Drug Identification System

The drug recognition system achieves efficient recognition and classification through the improved MobileNetV3 algorithm.

3.1 Image data acquisition and preprocessing

- Collect a large number of high-definition images of different drugs under various angles and lighting conditions to form a high-quality dataset.

Normalize the image, adjust the range of pixel values, and reduce differences.

- Apply image enhancement technology to enhance feature information and improve model recognition capabilities.

3.2 Model construction and optimization

- Conduct in-depth analysis of the MobileNetV3 algorithm and optimize it based on the characteristics of drug images, including adjusting network structure, optimizing hyperparameters, and introducing regularization techniques.

Build a drug recognition model using BCE MobileNetV3 and optimize its performance through transfer learning and fine-tuning.

- Use model pruning techniques to remove redundant neurons and connections, and fine tune the pruned model to maintain high recognition accuracy.

3.3 Medication box multi label recognition system

Design and implement a multi label recognition system for drug packaging based on the characteristics of multi label outsourcing.

Train BCE MobileNetV3 using the data enhanced medication box dataset, achieving a final accuracy of 90%.

4. INNOVATION POINTS AND PROJECT CHARACTERISTICS

4.1 Deep learning driven speech interaction system

A voice control system suitable for intelligent pharmacies has been constructed using deep learning algorithms, which can accurately recognize and understand voice instructions and achieve human-computer interaction.

4.2 Efficient RNN speech recognition architecture

Using RNN network architecture as the core, it can quickly and accurately recognize voice commands, accelerate drug sorting and prescription verification speed. 3. Lightweight

4.3MobileNet drug recognition algorithm

By adopting the lightweight MobileNet algorithm, compared to traditional convolutional neural networks, it significantly reduces the number of model parameters and computational complexity with a slight decrease in accuracy.

4.4 Improved MobileNetV3 algorithm

Optimization and improvement of the MobileNetV3 algorithm were carried out on the self built medication box dataset, including network structure adjustment, hyperparameter optimization, and introduction of regularization techniques, significantly improving the classification and recognition accuracy of the model in complex environments.

4.5 Project Features

Adopting the TensorFlow deep learning framework, it provides powerful computational support and flexibility, accelerating model training and algorithm convergence. For the task of intelligent pharmacy drug recognition, the MobileNetV3 model is carefully improved to enhance its generalization ability and robustness.

5. CONCLUSION

This project innovatively combines deep learning technology with intelligent pharmacy systems, and successfully constructs an efficient and intelligent pharmacy management system by optimizing the two core modules of speech recognition and drug recognition. Through practical testing and verification, the system significantly improves the automation management level and operational efficiency of pharmacies, achieving precise recognition of voice commands, fast and accurate drug classification, and intelligent decision assistance. It provides strong technical support for hospital pharmacy management and opens up new paths for the development of the intelligent pharmacy industry.

References

[1] Sandler M, Howard A, Zhu M, et al. Mobilenetv2: Inverted residuals and linear bottlenecks [C]//Proceedings of the IEEE conference on computer vision and pattern recognition. 2018:4510-4520.

[2] Howard A G, Zhu M, Chen B, et al. Mobilenets: Efficient convolutional neural networks for mobile vision app lications [J]. arXiv preprint arXiv:1704.04861, 2017.

[3] Wang Biao Research progress on intelligent anesthesia drug management system medicine cabinet [J]. Chinese Hospital Management, 2013, 33(4):43

[4] Bahdanau D, Cho K, Bengio Y. Neural machine translation by jointly learning to align and translate [J]. arXiv preprint arXiv:1409.0473, 2014.

[5] Wang Xiumin, Zhang Jun, Yuan Hao, etc Design and Practice of Intelligent Ward Base Drug Management System [J]. China Nursing Management, 2013, 13(9):10

[6] Hochreiter S, Schmidhuber J. Long short-term memory [J]. Neural computation, 1997, 9(8):1735-1780.

Research on the Value Transformation Path of Local Intangible Cultural Heritage Resources in Ideological and Political Course Practice Teaching: Based on the Practical Exploration Perspective of Vocational Undergraduate Teachers

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Abstract: As a living carrier of excellent traditional Chinese culture, local intangible cultural heritage (ICH) embodies the spirit of craftsmanship, ecological wisdom, and collective memory, which are deeply in line with the goal of "forging the soul and educating people" in vocational undergraduate education. As key transformers for the integration of intangible cultural heritage resources and ideological and political education, vocational undergraduate teachers need to solve practical difficulties such as fragmented resource mining, single teaching mode, and insufficient teacher collaboration.

Keywords: Intangible Cultural Heritage; ideological and political education; transform

1. INTRODUCTION

The report of the 20th National Congress of the Communist Party of China emphasized that "adhering to and developing Marxism must be combined with excellent traditional Chinese culture", providing a theoretical foundation for the integration of intangible cultural heritage into ideological and political education. Vocational undergraduate education aims to cultivate high-quality talents with both technical skills and humanistic literacy, and its ideological and political courses need to strengthen practicality and cultural identity. Local intangible cultural heritage resources are characterized by regionalism, liveliness and craftsmanship, which are not only cultural treasures, but also vivid ideological and political textbooks. However, there are practical difficulties in the integration of intangible cultural heritage and ideological and political education in current vocational undergraduate colleges, such as fragmented resource mining, single teaching forms, and insufficient teacher quality. As the leader of practical teaching, teachers urgently need to play the role of "transformers" to connect the channels between intangible cultural heritage resources and educational goals.

2. THE VALUE AND SIGNIFICANCE OF INTANGIBLE CULTURAL HERITAGE RESOURCES IN IDEOLOGICAL AND POLITICAL PRACTICE TEACHING

The spiritual core of intangible cultural heritage resources is highly compatible with the ideological and political education goals of vocational undergraduate education. Firstly, intangible cultural heritage is the foundation of cultural confidence. the local customs and totemic symbols of Jiangnan and Xiangxi wood carvings in Jinshan peasant paintings carry the collective memory of the nation and become the "living fossils" for students to understand regional culture. Through intangible cultural heritage practice, students perceive traditional wisdom such as "unity of heaven and man" and "harmony in diversity" through skill learning, and strengthen their

sense of belonging to Chinese culture. Secondly, intangible cultural heritage is a carrier of the spirit of craftsmanship. the precise composition of Chaoshan Paper Cuttings and the needlework skills of Hangzhou embroidery contain the professional ethics of "striving for perfection" and "abiding by integrity and innovation", which come down in one continuous line with the concept of "dedication" and "skills serving the country" emphasized by vocational undergraduate education. Dongguan Vocational and Technical College integrates the spirit of lion dance into street dance creation, interpreting the modern expression of traditional fighting spirit and deepening students' understanding of professional ethics. Thirdly, intangible cultural heritage is a resource pool for revitalizing ideological and political courses. Its interactivity and practicality can solve the dilemma of "theoretical indoctrination" in ideological and political courses. For example, Jiangxi Modern Vocational and Technical College takes the exhibition of intangible cultural heritage works as the starting point, and through the mode of "teacher led learning+field research+insights sharing", shifts ideological and political courses from "preaching" to "experience", and stimulates students' intrinsic motivation to actively explore.

3. THE PRACTICAL DIFFICULTIES AND ROLE CHALLENGES OF VOCATIONAL UNDERGRADUATE TEACHERS

The ideological and political value transformation of intangible cultural heritage resources requires teachers to break through three bottlenecks. the primary obstacle is the insufficient ability to convert resources. Some teachers have a superficial understanding of intangible cultural heritage, making it difficult to extract deep ideological and political elements. For example, the mortise and tenon structure in traditional architectural techniques contains principles of mechanics and engineering ethics, but requires interdisciplinary knowledge support to achieve value transformation.

The innovation of teaching mode is limited by practical depth. Teaching intangible cultural heritage requires venues, funding, and support from inheritors, while insufficient on-campus training bases can lead to teaching being limited to classroom case studies. In the initial stage of the "Intangible Cultural Heritage Live Streaming" project at Nanjing University of Technology, due to equipment shortage, only simple mobile live streaming could replace professional filming, which affected the dissemination effect.

The lack of collaborative mechanisms increases the difficulty of implementation. the integration of intangible cultural heritage requires multi-party collaboration among schools, localities, enterprises, and communities, but teachers often face difficulties in resource allocation. Teachers from Changde Vocational and Technical College need to coordinate the schedules of inheritors themselves and invest a lot of energy in integrating social resources to conduct research on Xiangxi woodcarving. These challenges highlight the need for teachers to transition from being "knowledge transmitters" to "resource integrators", "curriculum designers", and "cultural decoders" in multiple roles.

4. THE CORE PATH OF VALUE TRANSFORMATION: TEACHER LED PRACTICAL STRATEGIES

4.1 Constructing a three-dimensional integrated teaching system of "professional intangible cultural heritage ideological and political education"

Vocational undergraduate teachers need to base themselves on professional characteristics and design teaching paths in a layered manner. Add special modules on intangible cultural heritage in ideological and political courses, such as embedding cases of "intangible cultural heritage intellectual property protection" in Ideological and Moral Education and the Rule of Law (such as copyright disputes in Chaoshan Paper Cuttings), to guide students to understand the dialectical relationship between the spirit of rule of law and cultural innovation. Integrating intangible cultural heritage elements according to disciplinary characteristics in professional courses: the art and design major introduces the color theory of Jinshan peasant paintings and analyzes the harmonious concept in their aesthetic value; the engineering technology major analyzes the

scientific principles of traditional building mortise and tenon structures, and extracts the connection between "ecological wisdom" and engineering ethics. the development of teaching materials should focus on school-based and visual aspects. For example, Wenzhou Vocational and Technical College has compiled "Jiangnan Intangible Cultural Heritage Skills", which presents the details of the works with color inserts and combines them with labor education practice manuals to make abstract cultural connotations tangible and perceptible.

4.2 Innovative "Trinity" Practical Teaching Model

Teachers need to establish a full chain path of "on campus training, integration of industry and education, and social practice" to promote the integration of knowledge and action. On campus practical training focuses on creating immersive scenarios. Shanghai Zhongqiao Vocational and Technical University has established an "Intangible Cultural Heritage Workshop", inviting inheritors to stay on campus for guidance. Students design cultural and creative products and participate in campus intangible cultural heritage landscape construction (such as lion dance themed sculptures), deepening cultural identity through "learning by doing". the integration of industry and education emphasizes collaborative education between schools and enterprises. Nanjing Vocational and Technical University of Technology has collaborated with digital media companies to develop the "Intangible Cultural Heritage Live Streaming" project. Students plan scripts, promote intangible cultural heritage products, and enhance cultural dissemination capabilities through technological applications. the project has reached 18 rural primary schools with over one million views.

Social practice focuses on field research and volunteer service. Jiangxi Modern Vocational and Technical College organized students to conduct in-depth research on the Qingshanhu Intangible Cultural Heritage Base, write protection reports, and participate in community intangible cultural heritage exhibitions, internalizing social responsibility awareness into action consciousness.

4.3 Building a "dual teacher" collaborative mechanism for teaching staff

Breaking through the bottleneck of teaching staff requires a dual track approach of internal training and external introduction. In terms of internal training, ideological and political teachers were organized to participate in intangible cultural heritage skills workshops (such as Chaoshan Paper Cuttings workshops) to improve cultural decoding ability; externally, a "apprenticeship system" inheritance model is formed by hiring intangible cultural heritage masters as part-time mentors. Zhejiang Vocational College of Special Education invites Hangzhou Embroidery inheritors to teach on campus, and teachers and students will jointly research innovative needlework techniques to achieve resonance between skill inheritance and value guidance. Interdisciplinary collaboration is the key to deepening integration. Chongqing universities have formed a teaching and research team led by experts in education and cultural heritage to develop the course "Multilingual Intangible Cultural Heritage Inheritance". English teachers guide students in writing English drafts of intangible cultural heritage, while ideological and political teachers analyze cultural values, achieving a two-way empowerment of "international expression" and "cultural confidence"

4.4 Building a "Campus Community" Resource Sharing Platform

The synergy between physical and digital platforms enhances efficiency. the construction of physical platforms needs to integrate campus cultural genes. Huizhou University has built an intangible cultural heritage themed education hall to display Paper Cuttings and shadow play techniques with murals and reliefs. Relying on the school-based curriculum of "Huidong Fishing Song", it has carried out the "24 Solar Terms" creative design competition, making the campus a site for the inheritance of intangible cultural heritage.

Digital platforms leverage technology to empower teaching. Nanjing Industrial Vocational and Technical University develops a VR resource library for intangible cultural heritage, restoring the entire process of wood carving production and supporting remote learning; Changde Vocational and Technical College has established a database of Xiangxi wood carving patterns to provide digital

teaching materials for colleges and universities across the country. Platform linkage can break through the limitations of time and space, elevating intangible cultural heritage from "local knowledge" to "shared resources".

5. CONCLUSION: BI DIRECTIONAL EMPOWERMENT AND FUTURE DIMENSIONS

The integration of intangible cultural heritage and ideological and political practice teaching is essentially a symbiotic process of cultural inheritance and value shaping. Vocational undergraduate teachers need to play the role of "transformers" to promote two-way empowerment: conceptually, they should regard intangible cultural heritage as a "living ideological and political textbook", go beyond skill teaching, and focus on spiritual internalization; In terms of action, through curriculum restructuring, platform building, and teacher collaboration, a closed loop of "cultural cognition practice internalization value sublimation" is constructed for education. In the future, it is necessary to further deepen the resource coordination mechanism between government, schools, and enterprises, promote the construction of digital inheritance standards for intangible cultural heritage, and truly make intangible cultural heritage the foundation of ideological and political education that emphasizes depth, transparency, and liveliness. This will inject inexhaustible power into cultivating new era skilled talents who possess both cultural confidence and craftsmanship spirit.

References

[1] Shi Zixin, Wu Haiyan Several Thoughts on Promoting the Integration and Development of Vocational Education and Intangible Cultural Heritage Inheritance [J]. Education and Career, 2024, (17):99-103.

[2] Liang Jing, Dong Yanzong, Gao Xia Research on the Role Positioning and Functional Reconstruction of Vocational Colleges in the Protection and Inheritance of Intangible Cultural Heritage [J]. Education and Career, 2021, (24):98-102.

[3] Sun Fangnan, Lu Xiaolu Construction and Practice of Moral Education System in Higher Vocational Colleges Based on Intangible Cultural Heritage Projects [J]. Journal of Higher Education, 2021, 7(25):193-196

[4] Yu Linlin Exploration of the integration path between intangible cultural heritage and ideological and political education for vocational college students [J]. Journal of Liaoning Vocational College, 2020, 22(12):1-4+9

[5] Li Yun, Tang Jing, Pang Jun, etc Research on the Inheritance of Intangible Cultural Heritage and the Cultivation of "Craftsmanship Spirit" among Vocational College Students [J]. Cooperative Economy and Technology, 2020, (21):130-132.

[6] Sun Fengrui Introduction of Intangible Cultural Heritage into Campus "and" Modern Apprenticeship System "- Rethinking the Role and Function of Vocational Colleges in the Protection and Inheritance of Intangible Cultural Heritage [J]. China Vocational and Technical Education, 2019, (03):25-29.

[7] Sun Jingsong Research on the Inheritance and Development of Intangible Cultural Heritage Crafts and the Cultivation of Art Talents in Vocational Colleges [J]. Vocational Education Forum, 2018, (09):133-136.