Scientific and Social Research

Honorary Editor-in-Chief

Prakash Chandra Agarwal

Regional Institute of Education, NCERT MHRD, Government of India, India

Editors-in-Chief

Vahid Kouhdaragh

Lancaster University, UK

Fei Liu

Sichuan University of Science & Engineering, China

BIO-BYWORD SCIENTIFIC PUBLISHING PTY LTD
(619 649 400)
Level 10
50 Clarence Street
SYDNEY NSW 2000
Copyright © 2024. Bio-Byword Scientific Publishing Pty Ltd.
Complimentary Copy

Scientific and Social Research

Focus and Scope

Scientific and Social Research publishes papers devoted to quantitative social science research and methodology. The journal features articles that illustrate the use of quantitative methods to empirically test social science theory. The journal emphasizes research concerned with issues or methods that cut across traditional disciplinary lines. Special attention is given to methods that have been used by only one particular social science discipline, but that may have application to a broader range of areas with an ultimate goal of testing social science theory.

All relevant papers are carefully considered, vetted by a distinguished team of international experts, and rapidly published. Original articles, short communications, case studies and comprehensive review articles can be submitted online via the journal's submission and peer review site.

About Publisher

Starting 2022, *Scientific and Social Research* is published by Bio-Byword Scientific Publishing, which is a fast growing peer-reviewed and open access journal publisher located in Sydney, Australia. As a dependable and credible corporation, it promotes and serves a broad range of subject areas for the benefit of humanity. By informing and educating a global community of scholars, practitioners, researchers and students, it endeavors to be the world's leading independent academic and professional publisher. To realize it, it keeps creative and innovative to meet the range of the authors' needs and publish the best of their work.

All Bio-Byword Scientific Publishing journals are free from all access barriers, allowing for the widest possible global dissemination of their manuscripts and highest possible citations. Online submissions made to Bio-Byword Scientific Publishing journals will go through a rapid peer review and production, making the process of publishing simpler and more efficient, which benefit from its user friendly online submission system that reduces the overall time from submission to publication.

Publisher Headquarter

BIO-BYWORD SCIENTIFIC PUBLISHING PTYLTD
Level 10
50 Clarence Street
Sydney NSW 2000
Website: www.bbwpublisher.com
Email: info@bbwpublisher.com

2025, Volume 7, Issue 2

Table of Contents

1 **Research on the Performance Evaluation of Green Supply Chain of Papermaking Enterprises based on AHP**
Yuxi Wu

12 **Thoughts on Promoting Carbon Sink Trading in Zhuzhou City under the Background of Urban Integration**
Qiong Guo

18 **Multilingual Recitations of "Ancient Tang Poetry" and Cross-Cultural Appreciation of "Charming Shaanxi"—Exploring Shaanxi Through Tang Poetry**
Shanshan Wang

24 **Visualized Analysis of Research Hotspots in Structural Fire Resistance Based on Bibliometrics**
Yujia Chen, Zhiran Zhang, Jiahang Hao

31 **Analysis of the Style Characteristics of Fujian Nanyin and Minnan Folk Dance**
Meigui Huang

36 **Research on Blockchain-Enabled Resilience Building and Risk Prevention and Control in Shipping Supply Chains Under Multiple Crises**
Wanqi Su

43 **Research on Integrating Excellent Family Traditions and Precepts Culture into College Students' Values Education: A Case Study of the "Three Su" Family Tradition**
Yan Liu

49 **Research on the Construction of Talent Team of Think Tank in Y Field**
Jin Shang

55 **Research on the New Forms of Foreign Language Teaching in Guangdong Higher Vocational Colleges under the Background of Education Digitization**
Xiaoqing Zhang

68 **Greenhouse Environment Monitoring System Based on Wireless Sensor Network**
Bin Liu, Xinyue Dai, Xiangyu Zhang, Qi Cao, Xi Yao, Yanan Chen

74 **Research on the Difficulties and Countermeasures of Promoting the Implementation of College Students' Social Emotional Learning Course**
Hui Zhang

81 **Strategic Decision-Making and Performance Evaluation in the SIM ERP Simulation Game: Insights into Marketing, Finance, and Operations Management**
Junhan Wang

91 **Study on English Translation of Medical Paper Abstract**
Yanyan Huang, Mingzhi Pan, Mingpei Liang, Linkui Wang, Cailiang Li, Shiwu Yang

97 **Exploring the Path of Inheritance, Innovation, and IP Development for Midu Lantern**
Ruiji Shengchuan, Yichun Zhangluo

104 **Integrating Functional Principal Component Analysis with Generalized Regression Neural Networks for Enhanced Forecasting of New Energy Vehicle Market Trends**
Long Chen, Yong Wang, Qianhao Cheng, Shuxian Shen, Ying Wang

115 **Micro-Ethnography Study: Effect of Home Habitus, and Western Cultural Capital on Foreign Students' Small Group Discussion Experience**
Di Yuan

122 **Research Status and Hotspots of Movement Economy: A Visual Analysis based on VOSviewer**
Yuxiao Tan

136 **Research and Design on Building Digital Immersive Exhibitions in Museums — Taking the "24 Solar Terms Exhibition at the China National Film Museum" as an Example**
Chaoyi Huang, Yuxi Chen, Xuanyao Zhang, Yanting Mo

143 **Opportunities and Challenges for Innovative Design of Traditional Tie-dyeing Techniques in the Era of Self-media**
Zhongxiang Feng, Yang Liu

149 **Tourism Culture in Luoshui Town, Shifang, Deyang City from the Perspective of Engineering Design**
Jin Hu, Wei Wei, Wentao Li, Yue Xiao

155 **Group Psychological Emergen cy Management after Suiciderelated Death of Organization Members**
Yuxin Du

164 **Research on Balance Optimization of Garment Production Line Based on Industrial Engineering Methods**
Qingjun Lu

175 **Research on Layout Optimization of Auto Seat Assembly Workshop based on SLP**
Kaixin Zhao

188 **Confucian Governance by Virtue: A Study on the Benevolent Rule as the Core Political Model**
Guizhen Liu, Yuanlongyu Li

195 **Innovative Paths and Cultural Identity Research in Folk Art Education in Guangzhou Universities Enabled by Digital Technology**
Ruiji Shengchuan, Yichun Zhangluo

202 **Constructing a Data Security and Sharing Mechanism for Smart Cities Based on Blockchain Technology**
Yu Wu

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on the Performance Evaluation of Green Supply Chain of Papermaking Enterprises based on AHP

Yuxi Wu*

Business School, Shandong University of Technology, Zibo 255000, China

***Corresponding author:** Yuxi Wu, wuyuxi97@126.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In the context of increasingly stringent global environmental regulations, paper enterprises need to optimize supply chain management and improve green supply chain performance to achieve a balance between economic benefits and environmental sustainability. This paper builds a green supply chain performance evaluation system based on the analytic hierarchy process (AHP), selects three dimensions of economic performance, environmental performance, and social performance, and calculates the index weight through expert scoring and consistency tests. The results show that economic performance (0.56) is the dominant factor in enterprise decision-making, and the energy consumption reduction rate (0.45) and production cost reduction rate (0.30) are the core factors. The environmental performance (0.29) is followed by the carbon emission reduction rate (0.50), which indicates that enterprises have invested in energy conservation and emission reduction but still need to optimize; Social performance (0.15) has the lowest weight, and supply chain transparency and social responsibility implementation still need to be strengthened. The final performance score of 76.9 indicates that the enterprise has achieved some results in green supply chain management, but there is still room for improvement in green product promotion, carbon footprint optimization, social responsibility fulfillment, and other aspects. In this paper, short-term optimization strategies (energy saving, consumption reduction, recycling efficiency improvement) and long-term optimization strategies (intelligent green supply chain, carbon neutral supply chain construction) are proposed to provide decision support for the green transformation of paper enterprises.

Keywords: Paper enterprise; Green supply chain; Performance evaluation; Analytic hierarchy process (AHP); Carbon emission

Online publication: March 10, 2025

1. Introduction

1.1. Research background

In recent years, global environmental issues have become increasingly severe, and carbon neutrality, circular economy,

and sustainable supply chain management have become important expressions of enterprise competitiveness [1]. As a key industry in resource consumption and pollution emissions, the paper industry faces increasingly stringent environmental regulations and market pressure [2]. For example, the Chinese government has proposed a “dual carbon” goal (carbon peak, carbon neutrality), requiring high-energy industries to accelerate green transformation; EU REACH regulations and global supply chain ESG (Environmental, Social, Governance) requirements have also prompted paper companies to increase investment in green supply chain management [3].

The supply chain model of traditional paper enterprises takes cost and efficiency as the core, often ignoring environmental and social factors, resulting in resource waste, excessive carbon emissions, improper waste treatment, and other problems. With the strengthening of policy supervision and the enhancement of consumers’ awareness of environmental protection, paper enterprises not only need to control production costs but also must pay attention to the green development of the supply chain to improve market competitiveness and promote sustainable development [4].

1.2. Necessity of green supply chain performance evaluation

Green supply chain management covers raw material procurement, production, logistics, recycling, and other links, and its performance not only affects the economic benefits of enterprises but also directly relates to environmental protection and social responsibility. Therefore, the construction of a scientific and reasonable green supply chain performance evaluation system is crucial for enterprises to optimize supply chain strategy and enhance green competitiveness [5].

At present, the research on green supply chain performance evaluation mainly focuses on the following aspects:

Qualitative research: Many scholars use case analysis or theoretical modeling to discuss the impact of GSCM on enterprises, but lack quantitative analysis to guide the actual decision-making of enterprises [6].

Evaluation of a single index: Some studies only focus on a single index (such as carbon emission and energy consumption reduction), and fail to comprehensively measure multiple dimensions such as economy, environment, and society [7].

Imperfect evaluation system: The existing research index system is often not comprehensive enough and lacks consideration of supply chain transparency, social responsibility, and other factors.

To make up for the above shortcomings, this paper adopted the analytic hierarchy process (AHP) to build a green supply chain performance evaluation system, evaluated the actual performance of paper enterprises in green supply chain management by quantifying the weights of different performance indicators, and proposed targeted optimization strategies [8].

1.3. Research objectives and methods

1.3.1. Research purpose

Construct a green supply chain performance evaluation system for paper enterprises, comprehensively considering the three dimensions of economy, environment, and society to ensure scientific and comprehensive evaluation.

Use AHP to calculate the weight of indicators, quantitatively analyze the impact of various performance factors on the green supply chain, and provide a quantifiable decision-making basis.

Verify the feasibility of the evaluation system through case analysis, and put forward optimization suggestions based on the calculation results to help enterprises improve the management level of the green supply chain.

1.3.2. Research methods

This paper adopts the analytic hierarchy process, the specific steps are as follows.

Construction of evaluation index system: Based on literature research and expert interviews, a green supply chain performance evaluation index system covering three dimensions: economy, environment, and society is established.

Establish a judgment matrix: Invite industry experts to score the importance of each indicator, and build a pair of comparison matrices.

Calculation weight and consistency test: The AHP method is used to calculate index weight to ensure that the judgment matrix meets the consistency requirements.

Case analysis: Select a paper-making enterprise as the research object, apply AHP to calculate the performance score, and analyze the advantages and disadvantages of the enterprise in green supply chain management.

1.4. Research contribution and innovation

The contribution of this research is mainly reflected in the following three aspects.

Build a systematic performance evaluation system: integrate the three dimensions of economy, environment, and society to make up for the one-sidedness of the traditional performance evaluation system.

AHP is adopted for quantitative analysis: the weight of performance indicators is scientifically calculated through expert scoring and consistency tests to improve the objectivity and operability of evaluation.

Put forward optimization strategy based on case analysis: Based on actual data analysis, provide feasible green supply chain optimization path for papermaking enterprises and improve practical guidance value.

2. Construction of green supply chain performance evaluation index system

2.1. Principles of green supply chain performance evaluation system construction

To ensure the scientificity, rationality, and operability of the green supply chain performance evaluation system, this study follows the following principles when constructing the index system [9].

Comprehensive principle: The index system should cover the three dimensions of economy, environment, and society to comprehensively measure the actual performance of enterprise green supply chain management.

Scientific principle: The selected indicators should be based on supply chain management theory, green development policy, and industry standards, and meet the requirements of the AHP analysis method.

Quantification principle: Quantitative indicators (such as carbon emission reduction rate and energy consumption reduction rate) should be adopted as far as possible. For indicators that are difficult to quantify (such as supply chain transparency), an expert scoring method can be adopted.

The principle of comparability: The selection of indicators should consider the general applicability of the industry, to conduct a comparative analysis between different enterprises.

Operability principle: The calculation method of indicators should be clear and clear, which is convenient for enterprises to collect and apply data in actual management.

2.2. Construction of evaluation system

Based on relevant literature, policies and regulations, and interviews with experts in the paper industry, this study established a green supply chain performance evaluation system consisting of 3 first-level indicators and 9 second-level indicators, as shown in the following **Table 1**.

2.3. Weight setting of performance indicators

In this study, AHP is used to calculate the weight of each index. Through the expert interview, the pair comparison

matrix is constructed, the consistency test is carried out, and the weight distribution is finally obtained as shown in **Table 2**.

Table 1. Construction of evaluation system

Primary indicator	Secondary indicator	Description	Index type
Economic performance (C1)	Production cost reduction rate (C11)	Proportion of cost reduction resulting from green supply chain measures	quantify
	Energy consumption decline rate (C12)	The proportion of energy consumption reduction per unit product by optimizing the supply chain	quantify
	Green product sales growth rate (C13)	Growth in sales of green products	quantify
Environmental performance (C2)	Carbon emission reduction rate (C21)	The contribution of green supply chain measures to carbon emission reduction	quantify
	Waste recovery rate (C22)	The proportion of waste recovered and reused within the supply chain system	quantify
	Supply chain environmental certification rate (C23)	The proportion of supply chain enterprises with environmental certification	quantify
Social performance (C3)	Supply chain transparency (C31)	Supply chain information disclosure degree	Qualitative (expert rating)
	Employee health and safety index (C32)	The impact of supply chain improvement on employee working environment and occupational safety	Qualitative (expert rating)
	Social responsibility performance index (C33)	The impact of supply chain optimization on social responsibility	Qualitative (expert rating)

Table 2. Weight setting of performance indicators

Performance dimension	Weight	Secondary index	Weight
Economic performance (C1)	0.56	Production cost reduction rate (C11)	0.3
		Energy consumption decline rate (C12)	0.45
		Green product sales growth rate (C13)	0.25
Environmental performance (C2)	0.29	Carbon emission reduction rate (C21)	0.5
		Waste recovery rate (C22)	0.35
		Supply chain environmental certification rate (C23)	0.15
Social performance (C3)	0.15	Supply chain transparency (C31)	0.4
		Employee health and safety index (C32)	0.35
		Social responsibility performance index (C33)	0.25

As can be seen from the above table, the economic performance dimension has the highest weight (0.56), indicating that papermaking enterprises still take cost control and energy efficiency optimization as the core goals in green supply chain management. The second is environmental performance (0.29), in which the highest weight of carbon emission reduction rate (0.50), indicates that enterprises pay more attention to carbon footprint management in the green supply chain. The weight of social performance (0.15) is the lowest, reflecting that the investment of paper enterprises in social responsibility, employee health, and supply chain transparency still needs to be strengthened.

2.4. Calculation method of green supply chain performance

To calculate the green supply chain performance score of enterprises, the following calculation formula is adopted in this study:

$$GSP = W1 \times S_{\text{Economic}} + W2 \times S_{\text{Environmental}} + W3 \times S_{\text{Socialc}}$$

Where, W1, W2, and W3 are the weights of economic, environmental, and social performance respectively, while $S_{Economy}$, $S_{Environmental}$, and S_{Social} are the performance scores of each dimension.

The performance scores of paper enterprises are as follows.

Economic performance score: 85

Environmental performance score: 70

Social performance score: 60

GSP=0.56×85+0.29×70+0.15×60=47.6+20.3+9=76.9

According to the calculation results, the enterprise's green supply chain performance score is 76.9, indicating that it has achieved certain results in green supply chain management, but there is still room for optimization.

3. Evaluation process of AHP

3.1. Overview of analytic hierarchy process (AHP)

The analytic hierarchy process (AHP) is a multi-criteria decision-making method proposed by Saaty in the 1970s, which is suitable for weight calculation and priority ranking of complex decision problems. AHP makes decision-making more scientific and reasonable by constructing a hierarchical structure model, combining expert judgment, pair comparison, and consistency tests [10].

In this study, the AHP method is used to calculate the weight of each index of the green supply chain performance evaluation system to ensure a scientific and practical evaluation system.

3.2. AHP evaluation process

The AHP evaluation process usually consists of the following five steps: Construct a hierarchical structure model; Construct a pair comparison matrix; Calculate the weight vector; Consistency check; Calculate green supply chain performance.

3.3. Detailed steps of the evaluation process

3.3.1. Step 1: Build a hierarchical model

The core of the analytic hierarchy process is hierarchical structure modeling, which usually includes a target layer, criterion layer, and index layer. The AHP model of this study is shown in the figure below **Figure 1**.

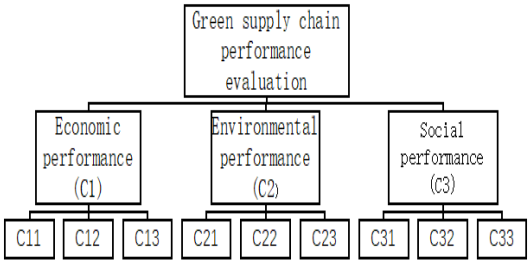


Figure 1. Hierarchical model

Target layer (first layer): Green supply chain performance

Criterion layer (second layer): Economic performance, environmental performance, social performance

Index layer (third layer): 9 specific indicators, such as energy consumption reduction rate, carbon emission reduction rate, supply chain transparency, and so on.

3.3.2. Step 2: Build a pair comparison matrix

A pairwise comparison matrix is used to reflect the important relationship between indicators. Experts use a 9-level scale (**Table 3**) to determine the importance of each indicator.

Table 3. AHP 9 scale method

Scoring value	Implication
1	Both factors are equally important
3	One factor is slightly more important than another
5	One factor is obviously more important than another
7	One factor is strongly more important than another
9	One factor is extremely more important than another
2, 4, 6, 8	An intermediate value between the above judgments

3.3.3. Step 3: Calculate the weight vector

For pairwise comparison matrices, the steps for weight calculation are as follows.

Normalized matrix: Calculate the normalized value of each column (each element divided by the sum of the columns in which it is located), and then average to get the weight.

Eigenvector method to calculate the weight: Calculate the maximum eigenvalue of the matrix λmax and its corresponding eigenvector, and normalize the eigenvector to obtain the final weight of each index.

After calculation, the following is obtained:

$$W = (0.56,0.29,0.15)$$

Economic performance weight: 0.56

Environmental performance weight: 0.29

Social performance weight: 0.15

Step 4: Consistency check

The AHP method requires a consistency check to ensure the consistency of expert scores and avoid logical conflicts. Common testing methods include calculating the consistency ratio (CR value):

$$CI = \frac{\lambda max\ - n}{n - 1}$$

$$CR = \frac{CI}{RI}$$

Among them:

λmax: Maximum eigenvalue

n is the order of the matrix

RI is the random consistency index (**Table 4**)

Table 4. Random consistency index (RI)

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

4. Result analysis

In this study, AHP was used to quantitatively evaluate the green supply chain performance of a paper enterprise. By constructing the judgment matrix, calculating the weight, and combining it with the actual data of the enterprise, the influence weight of each index on the overall performance is obtained. The calculation results are as follows:

4.1. Weight calculation results

According to AHP calculation, the weight distribution of each dimension is as follows:

Performance dimension weight

Economic performance (C1) 0.56

Environmental performance (C2) 0.29

Social performance (C3) 0.15

In addition, the weights of each sub-indicator are calculated in **Table 5**.

Table 5. The weights of each sub-indicator

Performance dimension	weight	Secondary index	weight
Economic performance (C1)	0.56	Production cost reduction rate (C11)	0.3
		Energy consumption decline rate (C12)	0.45
		Green product sales growth rate (C13)	0.25
Environmental performance (C2)	0.29	Carbon emission reduction rate (C21)	0.5
		Waste recovery rate (C22)	0.35
		Supply chain environmental certification rate (C23)	0.15
Social performance (C3)	0.15	Supply chain transparency (C31)	0.4
		Employee health and safety index (C32)	0.35
		Social responsibility Performance Index (C33)	0.25

4.2. Key Findings

Economic performance has the highest weight (0.56), which is the focus of enterprises. The weight of economic performance reached 0.56, much higher than environmental and social performance, indicating that enterprises still take economic benefits as the core goal when promoting green supply chain management.

The weight of energy consumption reduction rate (C12, 0.45) is the highest, indicating that enterprises are most concerned about reducing energy consumption when optimizing the supply chain, which may be due to the high energy

cost of paper enterprises, energy saving, and energy consumption reduction can directly improve corporate profits. The production cost reduction rate (C11, 0.30) is second, indicating that enterprises want to reduce overall operating costs through a green supply chain, such as optimizing procurement, reducing raw material waste, and improving production efficiency. The sales growth rate of green products (C13, 0.25) is relatively low, indicating that the promotion of green products by enterprises may still need to be strengthened, and the market demand has not been fully stimulated. Enterprises should further optimize the supply chain energy structure, such as the use of energy-saving equipment, green energy supply chain, and improve energy efficiency. Reduce the production cost of green products and improve market competitiveness through scale effect.

The weight of environmental performance is medium (0.29), and carbon emission control is the key. The weight of environmental performance is 0.29, reflecting that enterprises have attached importance to environmental factors in supply chain management, but there is still a certain gap compared with economic performance. The emission reduction rate (C21, 0.50) has the highest weight, indicating that the environmental issue that enterprises are most concerned about in green supply chain optimization is reducing carbon footprint, which may be related to the government's "two-carbon" policy and international environmental regulations. The waste recycling rate (C22, 0.35) followed, indicating that enterprises have made progress in solid waste management and resource recycling, but still need to strengthen. The lowest weight of the supply chain environmental certification rate (C23, 0.15) indicates that the enterprise has less investment in green certification, which may be due to the high cost of environmental certification or the imperfect certification system. Enterprises should adopt low-carbon raw materials, optimize production processes, increase the proportion of clean energy use, and further reduce carbon emissions. Improve waste management capabilities, such as the establishment of closed-loop recycling systems to improve the reuse of industrial by-products. Apply for international environmental certification such as ISO 14001 to improve the credibility of the enterprise's green supply chain.

Social performance has the lowest weight (0.15), and transparency and employee health and safety need to be improved. The weight of social performance is the lowest, only 0.15, reflecting that enterprises still pay little attention to social responsibility when promoting green supply chain management. Supply chain transparency (C31, 0.40) has the highest weight, indicating that the market has increased requirements for supply chain information disclosure, such as green product certification, supply chain carbon emission information, etc., and enterprises need to further enhance transparency. The employee health and safety index (C32, 0.35) is high, indicating that the enterprise has a certain investment in occupational health and safety management, but it still needs to improve the papermaking environment. The social responsibility fulfillment index (C33, 0.25) is the lowest, indicating that enterprises invest less in social welfare, community environmental protection, and other aspects, which may affect brand image.

Enterprises should promote the construction of supply chain traceability, such as the use of blockchain, big data, and other technologies, to improve the transparency of green supply chains. Strengthen occupational health management, such as improving production protection measures, providing health training, and improving the papermaking environment. Enhance the image of social responsibility, such as participating in environmental protection public welfare projects, strengthening community cooperation, and enhancing the influence of green brands of enterprises.

4.3. Conclusion summary

Economic performance is the most important factor for enterprises (weight 0.56), but energy conservation and consumption reduction still need to be continuously optimized, and at the same time, the promotion of green products

should be strengthened.

Environmental performance comes in second (0.29), and carbon emission management is particularly important. Enterprises should strengthen carbon footprint control, improve waste recovery rates, and increase environmental certification.

The weight of social performance is the lowest (0.15), and it is necessary to improve the transparency of the supply chain, employee health and safety management, and social responsibility fulfillment.

5. Conclusion and optimization suggestions

5.1. Research conclusions

Based on the analytic hierarchy process (AHP), the paper constructs a green supply chain performance evaluation system for paper enterprises and quantitatively evaluates the green supply chain performance of a paper enterprise through case analysis. The main conclusions of the study are as follows.

5.1.1. Green supply chain performance can be evaluated quantitatively

Through the AHP method, the green supply chain performance is divided into three key dimensions: economic performance, environmental performance, and social performance, and further refined into nine specific indicators to make performance evaluation more scientific, systematic, and operable.

5.1.2. Economic performance has the highest weight, while social performance is relatively low

The results show that the weight of economic performance (0.56) is the highest in green supply chain management, indicating that papermaking enterprises are still highly concerned about economic benefits in supply chain management, such as production cost control, energy efficiency management, and green product sales.

The environmental performance (0.29) is at the medium level, indicating that enterprises have paid some attention to environmentally sustainable development, but there is still much room for improvement, such as carbon emission control, waste recycling, and so on.

Social performance (0.15) has the lowest weight, reflecting that enterprises pay less attention to supply chain transparency, employee health, and safety, social responsibility fulfillment, etc., which needs to be further optimized in the future.

Through AHP calculation, the green supply chain performance score of a paper enterprise is 76.9, indicating that it has achieved certain results in green supply chain management, but there is still room for optimization. In particular, the low social performance indicates that enterprises need to be strengthened in fulfilling their social responsibilities and improving the transparency of the supply chain.

5.2. Suggestions for green supply chain optimization

Based on the research conclusions, this paper proposes the following short-term (1–2 years) and long-term (3–5 years) optimization strategies to help paper enterprises further improve green supply chain performance.

5.3. Short-term optimization strategy (1–2 years)

5.3.1. Improve energy efficiency and optimize economic performance

Optimize the production process and adopt advanced energy-saving equipment to reduce the energy consumption per unit product. Promote digital management, use smart manufacturing and big data analytics to improve the precision of

production planning, and reduce resource waste. Optimize supply chain logistics, reduce energy consumption during transportation, and improve overall supply chain efficiency.

5.3.2. Strengthen environmental management and reduce pollution emissions

Reduce carbon emissions: increase the proportion of new energy utilization, such as the use of clean energy, and improve the utilization rate of waste heat recovery. Improve waste recovery rate: Optimize solid waste and wastewater treatment technology, promote waste reuse, and improve green production levels. Supply chain green certification: Suppliers are encouraged to pass environmental certifications such as ISO 14001, build a green procurement system, and improve the environmental standards of the overall supply chain.

5.3.3. Enhance social responsibility awareness and supply chain transparency

Optimize the information-sharing mechanism of the supply chain, strengthen the data transparency management of all links of the supply chain, and enhance the credibility of enterprises. Improve employee health and safety management, strictly implement the occupational health and safety management system, and improve the safety of the working environment. Strengthen supplier supervision, establish a green supply chain cooperation mechanism, and require suppliers to fulfill environmental protection and social responsibilities.

5.4. Long-term optimization strategy (3–5 years)

5.4.1. Build an intelligent green supply chain to improve economic and environmental performance

Promote smart manufacturing: Use the Internet of Things, artificial intelligence, blockchain, and other technologies to achieve intelligent supply chain management and improve resource utilization. Building a low-carbon supply chain: Phasing out high-energy equipment, introducing renewable energy, and improving the low-carbon level of the overall industrial chain. Optimize the green supply chain finance mechanism: promote the “green finance” policy, cooperate with banks to provide low-interest loans, and encourage upstream and downstream enterprises in the supply chain to invest in environmental protection projects.

5.4.2. Improve corporate social responsibility strategy and build sustainable supply chain ecology

Build green sourcing alliances: Build partnerships with green suppliers and environmental agencies to improve supply chain sustainability.

Enhance corporate Social Responsibility brand influence: Regularly publish corporate social responsibility (CSR) reports to increase consumer awareness of green supply chain management. Promote fair trade and sustainable development of the supply chain: Encourage green supply chain enterprises to participate in international environmental certification, such as the SA8000 social responsibility standard, ISO 26000 social responsibility guide, etc., to enhance global competitiveness.

Disclosure statement

The author declares no conflict of interest.

References

[1] Tao Z, Xu J, 2019, Carbon-regulated EOQ Models with Consumers’ Low-carbon Awareness. Sustainability

(Switzerland), 11(4): 1004.

[2] Taher-Ghahremani F, Omidvari M, 2018, Providing an Evaluation Model of Green Productivity in Paper-making industries. International Journal of Environmental Science and Technology, 15(2): 333–340.

[3] Brolund J, Lundmark R, 2017, Effect of Environmental Regulation Stringency on the Pulp and Paper Industry. Sustainability (Switzerland), 9(12): 2323.

[4] Li S, Li L, Wang L, 2021, 2030 Target for Energy Efficiency and Emission Reduction in the EU Paper Industry. Energies, 14(1): 40.

[5] Han Z, Huo B, 2020, The Impact of Green Supply Chain Integration on Sustainable Performance. Industrial Management and Data Systems, 120(4): 657–674.

[6] Merneedi A, Palisetty R, 2023, Prediction of Drivers' Impact on Green Supply Chain Management using Deep Learning Algorithm. Environmental Science and Pollution Research, 30(3): 8062–8079.

[7] Liao Q, Li P, Roosli R, et al., 2022, Carbon Emission Characteristics of Resource-Based Cities in China. Iranian Journal of Science and Technology: Transactions of Civil Engineering, 46(6): 4579–4591.

[8] Groselj P, Zandebasiri M, Pezdevsek MS, 2023, Evaluation of the European Experts on the Application of the AHP Method in Sustainable Forest Management. Environment, Development and Sustainability, 26(11): 29189–29215.

[9] Mohammadnazari Z, Alipour-Vaezi M, Hassannayebi E, 2023, Green Inventory Management in a Multi-product, Multi-vendor Post-disaster Construction Supply Chain. Environment, Development and Sustainability, 2023(27): 3629–3664.

[10] Pant S, Kumar A, Ram M, et al., 2022, Consistency Indices in Analytic Hierarchy Process: A Review. In Mathematics, 10(8): 1206.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Thoughts on Promoting Carbon Sink Trading in Zhuzhou City under the Background of Urban Integration

Qiong Guo*

School of Business of Hunan Normal University, Changsha 412300, Hunan, China

***Corresponding author:** Qiong Guo, 170839480@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Carbon sequestration trading, as an important market mechanism to address global climate change, is based on the provisions of the United Nations Framework Convention on Climate Change and the Kyoto Protocol. It aims to promote the stability of the global ecological environment by verifying and constraining greenhouse gas emissions. This paper discusses the basic background, practical value, and trading methods of carbon sequestration trading, and puts forward strategies and suggestions for promoting carbon sequestration trading in Zhuzhou City based on its actual situation. Carbon sequestration trading not only promotes sustainable development but also facilitates the compensation of ecological value, providing strong support for the realization of China's dual carbon goals. Through the research in this paper, the author hopes to provide a reference for the practice of carbon sequestration trading in Zhuzhou City and even the whole country.

Keywords: Carbon sequestration trading; Sustainable development; Ecological restoration; Practical value; Zhuzhou City

Online publication: March 10, 2025

1. Introduction

As global climate change becomes increasingly severe, carbon sink trading, as an innovative market mechanism, plays a significant role in promoting emission reduction and achieving sustainable development [1–3]. As an important city in Hunan Province, Zhuzhou faces the urgent task of realizing its dual carbon goals. This paper aims to explore the basic background, practical value, and trading methods of carbon sink trading, and in light of Zhuzhous actual situation, propose strategies and suggestions for advancing carbon sink trading, providing a reference for Zhuzhous green development.

2. Basic background of carbon sink trading

In 2020, the Chinese government set a goal that "China's carbon dioxide emissions aim to peak by 2030 and strive to achieve carbon neutrality by 2060" [4]. This goal not only demonstrates China's firm commitment to global climate governance but also provides important policy guidance for the development of China's carbon trading.

Since 2020, the Chinese government has introduced a series of policy documents on carbon peak and carbon neutrality. It has explicitly proposed to rely on public resource trading platforms to accelerate the construction and improvement of the national carbon emission trading market, incorporate carbon sink trading into it, and establish and improve an ecological compensation mechanism that can reflect the value of carbon sinks.

Hunan Province has also actively responded to the national call, introducing a series of relevant policy documents. It proposes to optimize the regional layout for green and low-carbon development, support the Chang-Zhu-Tan urban agglomeration and other places with conditions to take the lead in reaching peak carbon emissions, and actively participate in the formulation of national standards for carbon accounting and carbon trading.

Zhuzhou City, an important city in Hunan Province, has actively responded to the policy guidance of the state and province by issuing the "Zhuzhou City Carbon Peak Implementation Plan." The plan focuses on promoting carbon peak actions through low-carbon industrial development and green energy transformation, clearly outlining the timeline, roadmap, and implementation plan for achieving peak carbon emissions. Additionally, Zhuzhou City is actively exploring development paths for carbon trading based on local conditions.

3. The practical value of carbon sink trading to Zhuzhou city

Promoting energy conservation and emission reduction. Carbon trading incentivizes companies to reduce carbon emissions and lower production costs through market mechanisms, thereby encouraging greater investment in carbon reduction and technological innovation. In the carbon emission trading system, high-energy-consuming, highly polluting, and high-emission companies are assigned initial emission reduction responsibilities. Companies that exceed their quotas must purchase additional emission rights on the carbon trading platform, while those that reduce emissions can earn economic returns by selling surplus emission allowances. This mechanism effectively promotes energy conservation and emission reduction among enterprises.

Achieve ecological value compensation. Carbon trading compensates for ecological value by converting ecological resources into quantifiable and tradable assets [5]. Through carbon trading, more countries, enterprises, and organizations can be encouraged to adopt emission reduction measures, increase carbon sinks, and thereby mitigate the impact of climate change. This not only helps protect the environment but also promotes harmonious coexistence between the economy and the ecosystem. Zhuzhou City has abundant forest resources, and by developing forestry carbon sink projects, it can maximize the value of these ecological resources.

Provide financing support. Carbon trading provides long-term, low-cost financial support for green and low-carbon projects [6]. Through models such as "carbon sink + fund", "carbon sink + pledge loan", and "carbon sink + insurance", carbon trading facilitates the flow of funds and asset activation, offering strong support for the development of green and low-carbon projects. Zhuzhou City can draw on these models to promote the deep integration of carbon trading with financial services.

Helping farmers increase their incomes. Carbon trading can also help farmers increase their income. By developing forest rights or self-retained mountains of registered poor villages and households in the national poverty alleviation information system into poverty alleviation carbon projects, ecological compensation can be obtained, which

is specifically used to support income growth for registered poor households and subsequent poverty alleviation efforts such as public infrastructure in poor villages [7]. Zhuzhou City can explore this model, combining carbon trading with rural revitalization to achieve a win-win situation for both ecological and economic benefits.

4. Methods of carbon sink trading

Transaction process. Carbon sink trading is mainly based on the Measures for the Administration of Carbon Emission Trading (Trial) issued by the Ministry of Ecology and Environment and the Notice on the Pilot Work of Carbon Emission Trading issued by the National Development and Reform Commission. The specific process and mechanism mainly include the following six steps. Project design: clarify the afforestation site, tree species selection, afforestation area, etc., and formulate detailed management measures. Feasibility study: to evaluate the technical, economic, and social feasibility of the project. Project approval: evaluate the environmental impact, socio-economic impact, and other aspects of the project to ensure that the project complies with relevant standards and regulations. Carbon sink measurement and monitoring: regular monitoring and measurement of carbon sinks in forests, grasslands, wetlands, and other ecosystems by professional institutions [8]. Trading process: Trading in the carbon market, where buyers buy carbon emission targets to offset their own emissions reduction obligations [9–10]. Third-party certification and registration: to ensure the legitimacy and transparency of transactions, third-party institutions will audit and certify carbon sink projects.

Taking the development of forestry carbon sink projects as an example, the development process of CCER (China Certified Emission Reduction) forestry carbon sink projects can be summarized into 7 steps: project design, project approval, project filing, project implementation, project monitoring, emission reduction certification, and its filing and issuance. After the development of the project, there are mainly two trading methods. Main trading methods: After the project forestry carbon sink CCER is registered and issued by the National Development and Reform Commission, it will be traded on the carbon exchange registered by the National Development and Reform Commission for key emission units (emission control units) to fulfill their obligations or relevant organizations to carry out voluntary emission reduction, fulfill their social responsibilities, etc., such as carbon neutrality and carbon compensation. Other transaction methods: After registration, the project owner and the buyer sign an order agreement and pay a deposit or advance payment. The buyer is delivered forestry carbon sink CCER after each emission reduction issued by the competent national authorities.

5. Strategies and suggestions for promoting carbon sink trading in Zhuzhou City

5.1. Find out the number of carbon sink projects and promote their development

Zhuzhou City should focus on the problem of “how to generate” carbon sink, find out the bottom line, and promote the development of carbon sink projects.

5.1.1. Development of ecological business carbon sink projects

For existing forest land, develop business forestry carbon sink projects through measures such as transformation and quality improvement, purchase and stop logging of commercial forests in key ecological areas, and pest and disease control.

5.1.2. Developing afforestation carbon sink projects

Increase the intensity of support policies, actively seek financial and policy project support from higher authorities, and seize market opportunities. During the 14th Five-Year Plan period, plan to add new afforestation and forest tending projects, encouraging state-owned forest farms, forestry enterprises, and other business entities to strengthen forest management, improve forest quality, enhance the carbon sequestration capacity of forest ecosystems, and lay a solid foundation for carbon sink transactions.

5.1.3. Develop clean energy

Increase the development and utilization of clean energy such as hydropower and solar energy, and increase the proportion of clean energy in carbon sink trading. For example, Chaling Tao Shui Reservoir and Youxian Jiubujiang Reservoir can be used as high-quality carbon sink projects.

5.2. Broaden channels and stimulate the vitality of market entities

Zhuzhou City should focus on the problem of how carbon sink circulation, broaden the trading channels, and stimulate the vitality of market entities.

5.2.1. Expand the trading scope

Strive to make national and provincial carbon allowances, as well as nationally certified voluntary emission reductions, the main trading products in Zhuzhou's carbon market. Allow key emission units and social organizations to purchase these for offsetting emissions. Broaden the entities eligible for forestry carbon sink development and trading to independent legal persons, and increase the carbon offset limit to 10%, further boosting trading demand.

5.2.2. Standardize trading procedures

Encourage local governments to actively explore off-exchange trading models for forestry carbon sinks, cultivate institutions with certification qualifications for forestry carbon sink projects, and train a group of professionals related to forestry carbon sinks to participate in national carbon sink trading.

5.2.3. Connecting with external markets

Encourage cooperation with investment companies to develop forest carbon sink projects and trade them on the carbon trading platform, actively participate in the construction of the national carbon market registration and trading system, strive to amplify the demonstration effect of carbon sink trading, and actively benchmark against international carbon sink development rules.

5.3. Innovate models to promote diversified carbon sink finance

Zhuzhou City should focus on the problem of "how to apply" carbon sink, innovate the model, and promote the development of diversified carbon sink finance.

5.3.1. Smooth carbon sink loan financing

Develop carbon sink projects in existing large forest farms, establish forestry financing guarantee companies, and set up forest ecological operation centers to secure long-term loans from state-owned banks. By leveraging market mechanisms, guide bank financial capital and social capital into carbon sink projects, injecting sustained internal momentum for green and low-carbon development.

5.3.2. Developing carbon sink financial products

Based on the increase in forest growth volume, convert it into carbon reduction through measurement methods. Monitor and calculate via third-party institutions, review by experts, approval by forestry authorities, and record-filing by environmental protection departments. Issue "forest tickets" to forest owners, turning these "forest tickets" into tradable, storable, and loanable assets.

5.3.3. Exploring the practice of "carbon sink + rural revitalization"

Targeting carbon sink forests in mountainous rural areas with relatively lagging economic development, this initiative encourages enterprises, organizations, and individuals to subscribe to carbon funds and participate in afforestation, forest management, and protection projects. Integrating government investment with social donations promotes the development of carbon sink projects, achieving increased efficiency and returns. Scientifically measuring carbon sink volumes and selling them at a price of "one yuan per 100 kilograms," subscription fees are deposited into a dedicated account for increasing income in agriculture, forestry, and village collectives. This allows rural areas to share in the benefits of development, thereby consolidating poverty alleviation achievements and vigorously advancing rural revitalization.

6. Conclusions

Carbon trading, as an effective market mechanism for addressing global climate change, has significant advantages in promoting sustainable development and achieving ecological value compensation. As an important city in Hunan Province, Zhuzhou should actively respond to national and provincial policy guidance, combine local realities, plan ahead, and take proactive steps to advance the development of carbon trading. By clarifying the baseline, broadening channels, and innovating models, Zhuzhou can fully leverage the role of carbon trading in energy conservation, emission reduction, realization of ecological product value, financing support, and increased income for farmers, contributing to the achievement of dual carbon goals and promoting green development.

Disclosure statement

The author declares no conflict of interest.

References

[1] Dong HY, 2012, Carbon Sink Summary. Beijing Science Press Co., Beijing.

[2] Su ZH, 2016, Green Carbon Sink. Economic Daily Press, Beijing.

[3] He JJ, 2022, Carbon Neutrality in Europe 2050. Social Sciences Academic Press, Beijing.

[4] Beijing Green Finance and Sustainable Development Research Institute & Hillhouse Industry and Innovation Research Institute, 2022, Towards Carbon Neutrality by 2060: Focusing on Opportunities and Challenges on the Path to Decarbonization. http://www.baogao8.com/d-121369.html

[5] Shu SS, 2011, Research on Forest Carbon Sequestration in China. Economic Science Press, Beijing.

[6] Sha T, Li Q, Yu FW, 2022, China Carbon Neutral Development Report. China Citic Press, Beijing.

[7] Li NY, 2015, Forestry Carbon Sequestration in China. China Agriculture Press, Beijing.

[8] Ravindranath, 2023, Forestry Carbon Sink Measurement. Science and Technology Press of China, Beijing.

[9] International Energy Conservation and Environmental Protection Network, 2023, National Carbon Market Daily Comprehensive Price Trends and Transaction Information as of February 11, 2023. https://huanbao.in-en.com/html/huanbao-2393497.shtml

[10] Sina Finance, 2025, National Carbon Market Weekly Comprehensive Price Trends and Transaction Data Summary. https://finance.sina.com.cn/esg/2025-01-12/doc-ineesqyc3480220.shtml

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Multilingual Recitations of "Ancient Tang Poetry" and Cross-Cultural Appreciation of "Charming Shaanxi"—Exploring Shaanxi Through Tang Poetry

Shanshan Wang*

School of International Languages and Cultures, Xi'an Fan Yi University, Xi'an 710000, Shaanxi, China

***Corresponding author:** Shanshan Wang, 27150344@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In the 5,000-year splendor of Chinese civilization, Tang poetry shines as the brightest star in the cultural firmament. Shaanxi, with its profound history and rich heritage, has inspired countless Tang and Song dynasty verses. As the birthplace of Tang poetry—particularly in its ancient capital Chang'an (modern Xi'an)—Shaanxi offers a unique opportunity to explore cultural landmarks through the lens of classical poetry. This approach not only boosts cultural tourism but also serves as an intelligent pathway to showcase Shaanxi's beauty and disseminate Chinese culture globally. Drawing on master translator Xu Yuanchong's acclaimed English and French renditions of Tang poems, this study intertwines poetic appreciation with introductions to Shaanxi's iconic sites. By conveying the rhythmic elegance and artistic imagery of Chinese poetry, it aims to deepen international audiences' understanding of Shaanxi's regional culture.

Keywords: Tang poetry; Xu Yuanchong; Shaanxi scenic spots

Online publication: March 10, 2025

1. Appreciating the Chan River and Ba River through the Tang Poem "In the Hills"

English version: (Translated by Xu Yuanchong, the only expert on English and French rhymes in Chinese poetry)

In the Hills (Wang Wei) [1]

Translated by Xu Yuanchong

White pebbles hear a blue stream glide;

Red leaves are strewn on cold hillside.

Along the path no rain is seen,

My gown is moist with drizzling green.

French version:
Le Ruisseau brumeux (Wang Wei) [2]
Traduit par Xu Yuanchong
Cailloux blanchis dans l'eau limpide;
Feuilles rougies sur le mont vert.
Est-ce qu'il pleut sur le sentier vide?
En émeraude s'égoutte l'air.

"In the Hills" is a five-character quatrain composed by Tang Dynasty poet Wang Wei. Written during early winter, this work captures the poet's reflections during a mountain journey. It paints a vibrant winter landscape through the imagery of a crystalline stream with glistening stones, crimson autumn leaves, and endless emerald foliage—a scene rich in chromatic contrast and poetic charm, diverging from traditional wintry desolation.

The "Jing Stream" mentioned in the poem refers to the Chan River, originating from Lantian County, Shaanxi Province, which flows northward into the Ba River near ancient Chang'an (modern Xi'an). Collectively called Chanba, these two rivers—the Chan and Ba—both rise from the Qinling Mountains and form part of the historic "Eight Rivers Encircling Chang'an." In September 2004, Xi'an established the Chanba Ecological Zone, spanning 129 km^2 with an 89 km^2 core conservation area, now colloquially known as "Chanba."

2. Exploring the Xianyang Palace Ruins through "Farewell to Yuan Er on His Mission to Anxi"

English version:
Seeing Yuan the Second off to the Northwest Frontier (Wang Wei) [1]
Translated by Xu Yuanchong
No dust is raised on the road wet with morning rain;
The willows by the hotel look so fresh and green.
I invite you to drink a cup of wine again;
West of the Sunny Pass no more friends will be seen.

French version:
Chant d'adieu à l'ouest (Wang Wei) [2]
Traduit par Xu Yuanchong
La pluie au matin fait retomber la poussière;
Autour de l'auberge les saules sont verdis.
De mon vin je vous prie de boire encore un verre:
A l'ouest vous ne trouverez plus de vieux amis.

"Song of Weicheng" (also titled Seeing Yuan the Second off to the Northwest Frontier), a masterpiece by Tang poet Wang Wei, opens with two lines depicting the Weicheng post station's scenery—establishing the time, location, and atmospheric setting of parting. The latter couplet shifts to unspoken sorrow, where a simple wine toast encapsulates profound farewell sentiments. Written in unadorned yet resonant language, the poem achieves a seamless fusion of

scene and sentiment, creating enduring artistic power. Its universal emotional resonance led to immediate musical adaptation, cementing its status as an immortal masterpiece in Chinese cultural history.

The “Weicheng” mentioned in the poem refers to present-day northwest Xi’an City, Shaanxi Province, on the north bank of the Wei River, the site of the ancient Qin-era Xianyang City. Today, visitors can explore the Qin Xianyang City Site to experience the grandeur of the former Qin capital. The Qin Xianyang City Site, the capital of the late Warring States period to the Qin dynasty, is located in Xianyang City, Shaanxi Province. No city walls have been discovered at the site, which spans approximately 870 meters east-west (from Baijiazui to Maowanggou) and 500 meters north-south (up to the Gaogan Canal). The central-northern area contains the ruins of Qin-era palace structures, surrounded by rammed-earth palace walls. On January 13, 1988, the site was designated as part of the third batch of National Key Cultural Relics Protection Units by the State Council of China. It was included in the National Archaeological Site Park List on October 9, 2010, and recognized among the “Top 100 Archaeological Discoveries of the Century” on October 18, 2021.

3. Exploring Shangshan through “Early Departure from Shangshan”

English version:
Early Departure on Mount Shang (Wen Tingyun) [1]
Translated by Xu Yuanchong
At dawn I rise, with ringing bells my cab goes,
But grieved in thoughts of my home, I feel lost.
As the moon sets over thatched inn, the cock crows;
Footprints are left on wood bridge paved with frost.
The mountain path is covered with oak leaves,
The post-house bright with blooming orange trees.
The dream of my homeland last night still grieves,
A pool of mallards playing with wild geese.

French version:
Départ avant l’aube (Wen Tingyun) [2]
Traduit par Xu Yuanchong
Je me lève avant l’aube au son de la clochette.
O mon pays natal, combien je te regrette!
Au chant du coq,de lune la chaumière est ivre;
Le pont en bois est parsemé de pas et givres.
Le sentier est tout couvert de feuilles de chêne;
Les fleurs d’oranger scintillent au mur à peine.
Comment puis-je ne pas rêver de mon village
Où l’étang fait écho aux cris des oies sauvages?

“Early Departure on Mount Shang” was composed by Wen Tingyun as he left Chang’an (modern Xi’an) for Xiangyang to seek refuge with Xu Shang. The poem, celebrated for its lucid language, meticulous structure, and

evocative blend of emotion and scenery, depicts the cold, desolate dawn journey of a traveler, conveying the loneliness, homesickness, and existential weariness of life on the road.

The "Mount Shang" referenced in the poem, also known as Shangban or Chu Mountain, lies at the intersection of modern Shanyang County and Danfeng County in southeastern Shangluo City, Shaanxi Province. Situated 7.5 kilometers west of Danfeng County's urban area on the south bank of the Dan River, Shangshan captivates not only with its fame but also its poetic allure. At its heart stands the ethereal Shangshan Temple, famed for its mist-veiled pavilions and cloud-framed windows, nestled amid emerald peaks, ever-shifting mists, and surreal landscapes akin to a fairyland on earth. Surrounding the temple are scenic wonders like Songyan (Pine Rock), Guilin (Laurel Grove), Meiwu (Plum Valley), Hetang (Lotus Pond), and Luping (Deer Meadow), earning it the title of "foremost scenic wonder of Shangyan."

4. Exploring Leyou Plateau through the Tang Poem "On the Plain of Imperial Tombs"

English version:
On the Plain of Imperial Tombs (Li Shangyin) [1]
Translated by Xu Yuanchong
At dusk my heart is filled with gloom;
I drive my cab to ancient tomb.
The setting sun seems so sublime,
But it is near its dying time.

French version:
Le Plateau d'anciens tombeaux (Li Shangyin) [2]
Traduit par Xu Yuanchong
Au soir, d'un coeur mélancolique,
Je monte sur l'ancien plateau.
Le soleil couchant magnifique,
Hélas! Descend vers son tombeau.

"On the Plain of Imperial Tombs", a five-character quatrain by Tang poet Li Shangyin, praises the twilight landscape of the plateau while expressing the poet's introspective reflections. The first two lines reveal his motivation for ascending the plateau, while the latter two marvel at the beauty of the evening vista, rich in symbolism and profound aesthetic and philosophical significance. The poem's language is unadorned yet rhythmic, blending contemplative depth with universal wisdom.

The "Plain of Imperial Tombs" mentioned in the poem lies south of Chang'an (modern Xi'an), occupying the highest elevation within the Tang capital. Originally established as Leyou Temple (or Leyou Garden) by Emperor Xuan of the Han dynasty, this elevated landform offers sweeping panoramic views, with the entire capital appearing as if "cupped in one's palm" when gazed upon from its summit. It is also strategically positioned near landmarks such as the Qujiang Lotus Garden to the south and the Giant Wild Goose Pagoda to the southwest, both appearing within sight when viewed from afar. These features made it a perennial attraction for visitors. Key sites include the Qinglong

Temple, the Kukai Memorial Monument, and commemorative halls. Beyond its famed cherry blossoms, the plateau is adorned with peonies and lotus flowers. A particularly enchanting spectacle occurs in late April when falling cherry petals intertwine with budding peonies, creating a poetic interplay of seasons.

5. Exploring Xiangji Temple through the Tang Poem "Passing by Xiangji Temple"

English version:
Toward the temple of heaped fragrance (Wang Wei) [1]
Translated by Xu Yuanchong
Not knowing the way to the Temple of Heaped Fragrance,
Under miles of mountain-cloud I have wandered
Through ancient woods without a human track;
But now on the height I hear a bell.
A rillet sings over winding rocks,
The sun is tempered by green pines....
And at twilight, close to an emptying pool,
Thought can conquer the Passion-Dragon.

French version:
En passant par le temple au parfum cache (Wang Wei) [3]
Traduit par HE Ru
Qui le connaît, le temple au parfum cach**é,**
A plusieurs li d'ici, sur le pic nuageux?
Sentier à travers la forêt ancienne: nulle trace...
Au coeur du mont, sons de cloche, venant d'où?
Bruit de sources, sanglots de rocs dressés,
Teinte de soleil, fraîchie entre les pins.
Au soir, sur le lac désert, méditant au Ch'an,
Quelqu'un apprivoise le dragon venimeux.

"Toward the temple of heaped fragrance", a landscape poem by Tang dynasty poet Wang Wei, exudes a serene and tranquil tone. Through a Buddhist-inspired calm, Wang Wei paints the secluded environment of the ancient mountain temple, crafting a reclusive and meditative atmosphere. The poem focuses on the temple while subtly highlighting its surroundings to accentuate its spiritual grandeur. Its concluding lines—reflecting on an emptied deep pool and the subdued metaphorical "poisonous dragon" of delusion from Buddhist scriptures—symbolize the mastery of worldly desires as a path to profound Zen enlightenment.

The "temple of heaped fragrance" referenced in the poem was a renowned Tang-era monastery. According to the Comprehensive Gazetteer of the Qing Dynasty, it stood on the Shenhe Plateau south of Chang'an County (modern Xi'an, Shaanxi Province). Built in 681 CE (the second year of the Yonglong era under Emperor Gaozong of the Tang), its original site is now lost to time. The present-day Xiangji Temple, bordering the Hao River to the south and Fanchuan Plain to the north, is led by Abbot Benchang. It was established by Huaiyu—disciple and successor of Shandao, the

second patriarch of Pure Land Buddhism—as a memorial following Shandao's passing. Upon completion, the temple became the epicenter of Pure Land Buddhist practice, earning recognition as the sect's birthplace. It remains a vital institution, designated by the State Council as a key Buddhist temple for Han Chinese regions.

Funding

2024 Shaanxi Provincial Social Science Popularization Funding Project (Grant No. 2024KP066) — "Multilingual Recitations of "Ancient Tang Poetry" and Cross-Cultural Appreciation of "Charming Shaanxi": Promotional Short Videos for "Exploring Shaanxi Through Tang Poetry."

Disclosure statement

The author declares no conflict of interest.

References

[1] Xu YC, 2021, Three Hundred Tang Poems. China Publishing Group Zhongyi Press, Beijing, 30–31, 84–85, 194–195, 690–691.

[2] Xu YC, 2008, Selected Tang Poems and Painting. Five Continents Communications Press, Beijing, 32, 36, 120, 124.

[3] He Ru, 2003, One Hundred Tang Poems in French Translation. Foreign Language Teaching and Research Press, Beijing, 24.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Visualized Analysis of Research Hotspots in Structural Fire Resistance Based on Bibliometrics

Yujia Chen*, Zhiran Zhang, Jiahang Hao

China People's Police University, China

***Corresponding author:** Yujia Chen, chenyvjia@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: This study adopts the bibliometric method to explore the development paths of research hotspots and future directions in the structural fire resistance field. Within the CNKI database, this study utilizes CiteSpace software to visually analyze academic papers and journal articles themed on structural fire resistance from 2012 to 2025 in terms of publication time, institutional and author distributions, keyword co-occurrence, and keyword bursts. Based on the analysis results of these graphs, this study reveals research hotspots and development trends in each period. Overall, the analysis results reveal that structural fire resistance research has evolved from basic theories to practical applications. The focus has shifted to hybrid simulation and interdisciplinary research, with its application potential in complex fire scenarios increasingly enhanced.

Keywords: Structural fire resistance; Building fire protection; Bibliometrics; CiteSpace

Online publication: March 10, 2025

1. Introduction

Structural fire resistance has long been a core concept attracting scholars' attention in the fire protection domain. The research mainly encompasses: fire temperature field, high-temperature mechanical and thermal properties of structural materials, fire-resistance ratings and endurance limits of components, stress states and internal force redistribution of components post-temperature rise, overall structural responses under fire conditions, and post-fire structural damage assessment as well as reinforcement and repair [1]. Standards set fire-endurance limits and design methods, but real-fire building collapse is not simply related to fire exposure time [2]. Judging structural safety by component fire-exposure time at fire scenes is unwise, and more actual fire-based experiments and simulations are needed.

2. Materials and methods

The data sources for this paper are derived from China National Knowledge Infrastructure (CNKI). Using "structural fire resistance" as the subject and setting the time range from 2012 to 2025, this study excluded literature from irrelevant fields (such as studies on bridge and tunnel engineering) and non-academic materials (like announcements and news reports). Finally, 352 documents were selected. The CiteSpace software used in this study, which is widely applied in literature visualization analysis, can systematically organize literature and efficiently generate intuitive knowledge network maps.

3. Results and analysis

3.1. Analysis of publication trends

The variation in the number of publications in the field of structural fire resistance from 2012 to 2025 is shown in **Figure 1**. Starting with 45 in 2012 (12.8% of the total number of publications), the number of publications generally declined with fluctuations and two peaks. It dropped slightly to 44 in 2013 and more sharply to 24 in 2014, then recovered to a 2016 peak (10.8%). From 2017 to 2020, it fell yearly, hit bottom in 2020, rebounded, and peaked again in 2022 (8%). In the past two years, it dropped to more than ten. Overseas structural fire resistance research began in the 1950s. In China, reinforced concrete structure fire-resistance performance research started in the mid-to-late 1980s, and steel structure research using structural analysis methods began around 1970. In the early 1990s, the Building Research Establishment (BRE) in the UK conducted six sets of fire tests on an eight-storey full-scale steel-frame building [3].

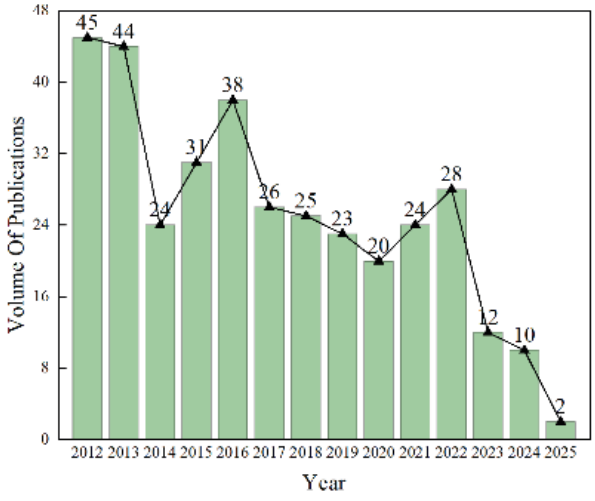


Figure 1. Distribution diagram of publication volume

3.2. Distribution of research institutions

In **Figure 2**, for timeline nodes, a darker color indicates a later year of first appearance, and the color width shows annual occurrences. With a density of 0.0036, the nodes are scattered. Most cooperation is among institutions within the same field, university, or province. Suzhou University of Science and Technology, its School of Civil Engineering, and Jiangsu Key Laboratory of Structural Engineering publish many papers annually, with a total of 32, accounting for 9.1% of all the papers. Universities like Chongqing University, Tongji University, Harbin Institute of Technology, Shandong Jianzhu University, etc. also cooperate closely

at times. **Table 1** shows that most domestic institutions have participated in structural fire resistance research, highlighting its significance in building fire protection and broad application prospects.

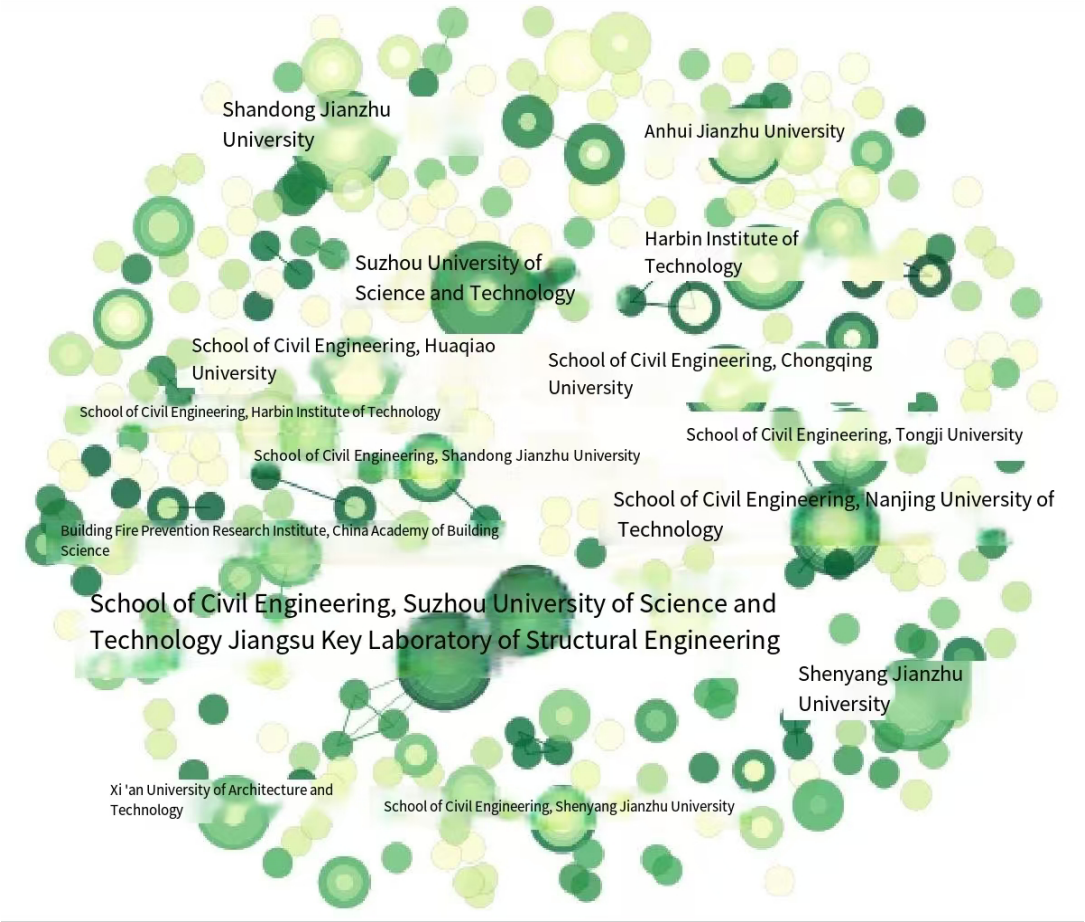


Figure 2. Co-occurrence map of research institutions

Table 1. Top six institutions ranked by publication volume

No.	Institution	Publication quantity	Starting year
1	Suzhou University of Science and Technology	32	2016
2	Tongji University	18	2012
3	Chongqing University	18	2012
4	Shandong Jianzhu University	18	2012
5	Harbin Institute of Technology	16	2012
6	China Academy of Building Research	12	2014

3.3. Distribution of literature authors

Analysis of **Figure 3** enables accurate evaluation of the academic contributions and influence of research teams and individuals. On the graph in **Figure 3**, early collaborations are marked in light colors, while recent ones are in dark colors. With a density of 0.0047, author connections are closer than those of institutions. The connection

colors between Mao Xiaoyong, Tian Shizhu, Cai Xinjiang, etc., indicate they have extensive collaborative networks and are actively researching with recent outputs. Simpler collaborations of other high-output authors may reflect their diverse research styles.

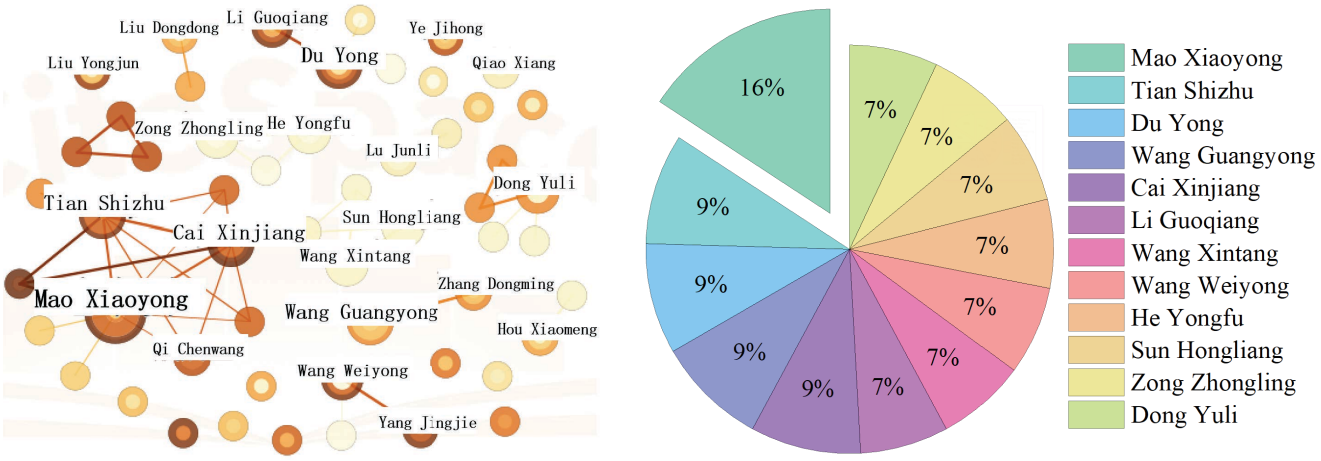


Figure 3. Composite chart of literature authors' co-occurrence and prolific authors' publication volume

The data in **Table 2** indicate the authors' significance and research vitality. The authors' work enriches the structural fire-resistance academic content and propels the scientific frontiers of the field forward.

Table 2. Top six authors ranked by the number of publications

No.	Author	Publication quantity	Starting year
1	Mao Xiaoyong	9	2016
2	Tian Shizhu	5	2019
3	Du Yong	5	2015
4	Wang Guangyong	5	2016
5	Cai Xinjiang	5	2021
6	Li Guoqiang	4	2017

3.4. Research fields

An in-depth analysis of **Figure 4** uncovers correlations among research topics and key nodes in technological development. The outer rings of keywords such as "fire-resistance performance", "steel structure" are purple, signifying high centrality, underlining these keywords' crucial role in the research network. Specifically, as a core node, fire-resistance performance is closely connected to others by multiple lines, highlighting its central position and close ties in structural fire-resistance research.

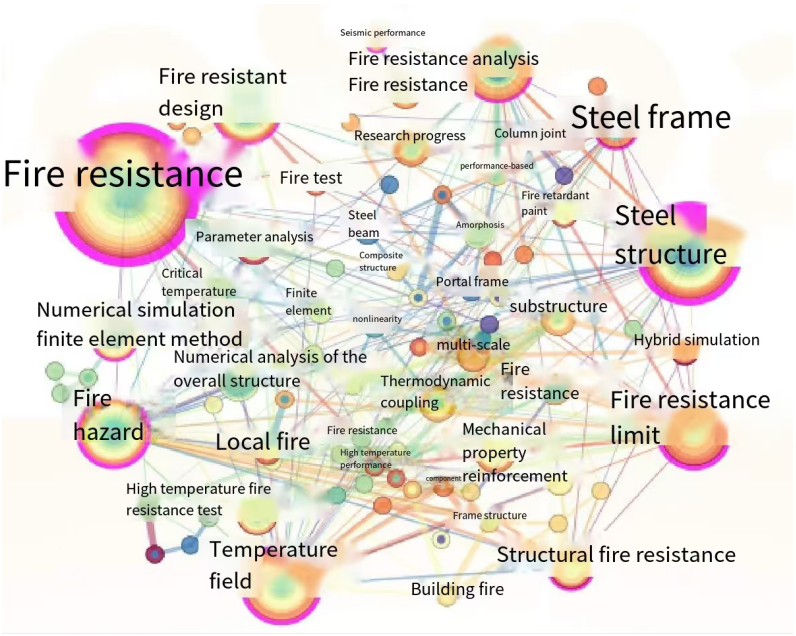


Figure 4. Co-occurrence map of keywords in literature

Analyzing **Table 3** assesses the significance of the top-ranked keywords in structural fire resistance research. “Fire resistance performance” leads with a frequency of 111 times and a centrality of 0.7, followed by “steel structure”, “temperature field”, “fire”, “fire resistance limit”, and others. All these keywords have frequencies over 20 times and centralities above 0.2, indicating their high importance and wide application in facilitating practical engineering applications in the field of structural fire resistance.

Table 3. Top five keywords ranked by centrality

No.	Keyword	Centrality	Count	Starting year
1	Fire resistance performance	0.7	111	2012
2	Steel structure	0.42	57	2012
3	Temperature field	0.26	45	2012
4	Fire	0.23	40	2012
5	Fire resistance limit	0.22	29	2015

CiteSpace provides two network-modularity metrics: Modularity Q metric and Mean Silhouette metric. A Modularity Q above 0.3 indicates significant clustering and a mean silhouette value above 0.7 shows high reliability [4]. With Q = 0.57 and S = 0.85, the clustering is highly significant and reliable. Keyword clustering shows 11 clusters, and core clusters on steel structures, fire resistance performance, fires, and fire resistant design, which are also related to mechanical and seismic performance research.

Research on fire resistance limit, temperature field, performance, and mechanical properties of building components including steel, concrete, prestressed concrete, and reinforced concrete structures. In recent years, new materials and structures like inorganic composite bamboo materials have emerged.

Research on fire resistance properties of building structures, including steel frames, portal frames,

and large-space trusses. Exploration of research methods for component or structure properties, including experimental and numerical simulations and related software.

4. Research hotspots and research trends

4.1. Analysis of research hotspots

Fire resistance performance remains a research hotspot and cornerstone in structural fire resistance. With the application and development of numerical simulations, scholars are exploring the fire resistance performance of new building materials and complex structures.

Researchers in the early stage (2012–2015) focused on parametric analysis, performance-based methods, and fire experiments. They centered on critical temperature, fire-exposed and high-temperature performance, fire-resistance duration, and seismic performance. In the middle period (2015–2020), fire simulation deepened structural fire-resistance studies. Load ratio, fire protection, and slab-column building structures became key terms. Multidisciplinary integration expanded, focusing on fire damage, repair, and evacuation. In the past five years (2020–2025), high-rise buildings grew and interdisciplinary ties tightened amid industry growth. Research hotspots multiplied, with fire simulation remaining crucial. Hybrid simulation, fire spread, earthquake-induced damage, and timber structures gained focus.

4.2. Analysis of research trends

Using CiteSpace for keyword burst detection, the study identified 15 burst keywords (**Figure 5**). This helped identify research hotspots and key points in a specific period and explore development trends.

In the early research stage, structural fire-resistance research centered on basic theories and simulations. Burst keywords included “critical temperature.” Then, the focus shifted to integrating theoretical analysis, practical applications, and technical optimization to prevent fire-induced building collapse. “Finite element” remained crucial. In the recent research stage, research advanced, with burst keywords such as “multi-scale”, “hybrid simulation”, “fire resistance”, and “spreading fire” in scholars’ work. Sample analysis reveals that research hotspots and challenges vary by period and research methods. By integrating knowledge from other fields, researchers are steadily advancing structural fire resistance studies.

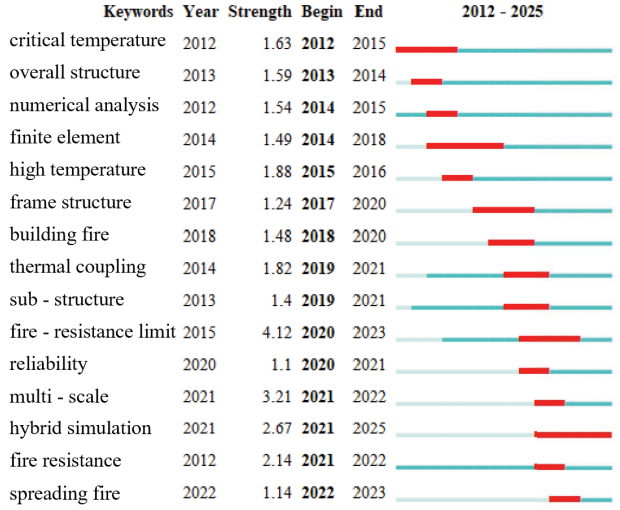


Figure 5. Distribution of burst keywords

5. Conclusion

Using CiteSpace, this study analyzes 352 CNKI documents on structural fire resistance. The number of papers in this field has declined over time, so new research topics exploration is crucial. Most research institutions work independently or with few partners, lacking cross-field and large-scale cooperation. High-output authors drive research but cooperate scarcely with weakly-linked institutions. Integrating keyword co-occurrence, cluster, timeline, and burst-keyword distribution maps reveals "hybrid simulation" as the main hotspot in the past three years, highlighting simulation's importance. Researchers should foster problem-based interdisciplinary communication and research and explore new integrative research areas. Given practical weaknesses, new research methods are needed, and academic achievements should be applied to real life.

Disclosure statement

The authors declare no conflict of interest.

Author contributions

Paper writing: Chen Yujia
Paper editing and proofreading: Zhang Zhiran
Graphic design: Hao Jiahang

References

[1] Cao B, Chu ZY, 2015, A Review of Experimental Research on the Fire-Resistance Performance of Structures. Fire Protection Today (Electronic Edition), 8(1): 114–116.

[2] Fang ZL, 2021, Collapse Monitoring and Early Warning Technology for Building Structures under Fire. Fire Science and Technology, 40(10): 1555–1558.

[3] Li GQ, Wu B, Han LH, 2006, Research Progress and Trends in Structural Fire Resistance. Progress in Steel Building Structures, 2006(1):1–13.

[4] Chen Y, Chen CM, Liu ZY, et al., 2015, Methodological Functions of CiteSpace Knowledge Map. Studies in Science of Science, 33(2): 242–253.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Analysis of the Style Characteristics of Fujian Nanyin and Minnan Folk Dance

Meigui Huang*

Zhejiang Yuexiu University, Zhejiang 312000, China

Corresponding author: Meigui Huang, 13906854588@139.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Music and dance are interdependent and develop jointly within the realm of art. Nanyin, a distinctive musical form in Quanzhou, Fujian, and folk dance have been closely linked and developed together throughout history. At the beginning of this article, the concepts of Fujian Nanyin and folk dance are respectively explained, with an emphasis on exploring their individual and common stylistic features demonstrated during their closely related development processes.

Keywords: Nanyin; Fujian folk dance; Stylistic characteristics

Online publication: March 10, 2025

1. Introduction

The southern Fujian region has always played a crucial role on the historical stage. In particular, the uniquely styled folk dance forms are so dazzling that people are reluctant to leave, each of which is a wonderful manifestation of the rich cultural heritage, local customs, and practices of this area. Among them, “Quanzhou Chest Slapping Dance”, “Zhangzhou Big Drum and Parasol Dance”, “Colorful Ball Dance”, “Quanzhou Ball Kicking Dance”, “Huoding Gong and Huoding Po Dance” and so on are especially well-known both at home and abroad. As is known to all, the charm of dance unfolds in tandem with the musical rhythm. Excellent dance works surely need extraordinary musical accompaniment to be realized. Therefore, the folk dance art in the southern Fujian region has developed an interdependent and indispensable relationship with Nanyin.

2. Overview of Fujian Nanyin and Minnan region folk dance

2.1. Nanyin overview

Nanyin originated in Quanzhou, Fujian, and is a highly distinctive form of musical art that fully integrates the local customs and reflects the living conditions of the people. Chinese culture is extensive and profound, with a long history. As history has progressed, it has amassed a profound cultural heritage, and its richness is further enhanced by the unique

traditional cultural and artistic forms in various regions. Nanyin, as a characteristic music of southern Fujian, is hailed as a "living fossil" of traditional Chinese music culture. Nanyin also has other names such as "Xianguan", "Nanqu", "Nanguan", and "Langjunyue." With the passage of time, it was collectively referred to as "Nanyin."

Historically, due to the well-developed transportation and prosperous economic activities in Quanzhou, merchants from all over the country gathered there. Thus, the Quanzhou dialect has evolved based on elements including the elegant language of the Six Dynasties, the ancient Yue language, the Wu language, and the Chu language. Nanyin, as a unique form of musical art in this area, gradually took shape on this basis. This gives Nanyin's tunes an ancient, elegant, gentle, and beautiful charm, and it has been widely borrowed and absorbed by operas such as Liyuan Opera, Gaojia Opera, and Puppet Opera. Moreover, in the wedding and funeral customs of Quanzhou, Fujian, Nanyin has provided a lot of inspiration for the timbre display of musical instruments such as Longchui, Naoting, and Shiyin.

In addition, the musical score of Nanyin is a pipa score that uses the characters of the pentatonic scale as the backbone notes to accompany the vocal music. Among the four-piece instruments, the sanxian plays the backbone notes following the pipa, and the dongxiao (a vertical bamboo flute) and erxian play the melody along with the singer's vocal ornamentation. This gives rise to the characteristic of "simple score, elaborate singing." Nanyin skillfully ornaments the originally simple notes on the score, thus forming a unique vocal ornamentation in the singing, which makes Nanyin extremely melodious and full of endless charm.

2.2. Overview of folk dance in the southern Fujian region

The forms of folk dance art in southern Fujian, Fujian, have gradually taken shape and developed based on the daily living habits and conditions of the local people, as well as the economic and social development. They are forms of cultural and recreational activities that adapt to social needs. During the development of folk dance, Nanyin plays a very important role. According to the "Annals of Quanzhou Prefecture Seasonal Events", "On the night of the Lantern Festival, lanterns are hung, and glutinous rice balls are used to worship ancestors and gods. Some people offer wine and food in the ancestral hall, which is called the Spring Sacrifice. Also, during the Lantern Festival, there are temple fairs inside and outside the city to welcome the gods. In some rural areas, this activity is called paying respects to the gods in February." This vividly demonstrates how the ingenious combination of Nanyin and folk dance brought the local customs and traditions of that area during the early Qing Dynasty to life. The performance of dance itself cannot be separated from the rhythm of music. Therefore, when exploring and studying the stylistic features of Fujian folk dance, it must be placed within the historical context of the formation and development of Nanyin. Only in this way can we embody the sense of wholeness in Chinese cultural aesthetics, which emphasizes "harmony in the overall structure."

2.3. The internal relationship between Fujian Nanyin and southern Fujian folk dance

In fact, the musical accompaniment used in the folk dances of southern Fujian, Fujian, has a very close connection with the vocal melodies of Nanyin. The "juxtaposition of multiple major thirds" demonstrated in the vocal melody of Nanyin, along with the "Zeng system" of the music from the Marquis Yi of Zeng's chime bells in Suizhou, the "responding tones" in the Sui Dynasty, the "Gou" character in the Song Dynasty, and the pitch sequence of the Jian'ou tone cups in Fujian, have all been subtly absorbed, borrowed, and applied in the music of southern Fujian folk dances.

3. Analysis of the style characteristics of Fujian Nanyin and folk dance in southern Fujian

3.1. Pursue the exuberant and unrestrained expression of joy

In many folk dances in southern Fujian, Fujian, there is an exuberant, vibrant, and joyous atmosphere, which is reflected

in the rhythm of the music. In the selection of music for these folk dances, a large number of the overlapping beat vocal melodies in Nanyin are absorbed. The rhythm of this singing method is moderately fast. Within or between musical phrases, fourth-degree or fifth-degree notes are interspersed in step-by-step progressions. The overall musical sense is bright, smooth, and full of vitality. At the same time, between musical segments, fourth-degree and fifth-degree notes or fifth-degree and fourth-degree notes continuously rise, showing a bold and enthusiastic style.

The accompaniment music of the famous folk dance "Zhangzhou Big Drum and Parasol Dance" embodies these characteristics. The "Zhangzhou Big Drum and Parasol Dance" originated and became popular in Zhangzhou and Longxi areas of Fujian, China. During the performance, the dancers fully demonstrate the lively and cheerful atmosphere of the whole scene. The male dancers wear ancient warrior costumes and tie a big drum in front of their chests. When the music starts, they vigorously strike the drum with drumsticks in both hands according to the rhythm of the music. The female dancers are dressed as Dan role characters in ancient-style operas. They hold a long-handled parasol with tassels hanging from the edge in both hands. The dancers dance gracefully following the rhythm of the music and the beats of the drum. With the changes in the dance environment and emotions, the movement rhythms and amplitudes change accordingly, fully demonstrating the masculinity of men and the graceful beauty of women. The "Zhangzhou Big Drum and Parasol Dance" is very popular in southern Fujian. When people listen to the accompaniment music of the "Big Drum and Parasol Dance", it is not difficult to find the phenomenon of the alternating upward movement of fourth-degree and fifth-degree notes in the melody. This is related to the large amplitude, fast and slow-paced fluttering of the parasol tassels following the drumbeats. When the music progresses to the upward movement of fourth-degree or fifth-degree notes, the dancers shout along, with high and excited emotions. The striking of the drumsticks and the dancing of the parasol tassels become more rapid, which also sets off the lively scene from another side and shows people's satisfaction with their colorful lives at that time.

In addition, the music "Ba Gu Yue" of the "He Fan Dance" also has this characteristic. The "He Fan Dance", also known as "Qian Gu Nong", is a dance in the traditional operas of Liyuan Opera and Gaojia Opera in Quanzhou, "Wang Zhaojun", in the scene of "Wang Zhaojun's Departure to the Frontier." It shows the foreign soldiers and generals welcoming Wang Zhaojun into the Yanmen Pass, singing and dancing. There are five dancers in the "He Fan Dance." Wang Zhaojun holds a pipa in her hands, plays and sings the southern tunes "Leaving the Han Pass" and "Ba Gu Yue", and makes various movements according to the changes in the lyrics, singing and dancing in a solemn and elegant manner. The other two male and two female dancers play the roles of foreign soldiers and generals. One male actor holds a money drum, one holds a money stick, one female actor holds a Sibao (a kind of percussion instrument), and one holds four small wine cups. They make various different movements with the changes of the fourth-degree and fifth-degree notes in the music, changing the formation around Wang Zhaojun to set off Wang Zhaojun's emotions and dance. During the performance, the props in the hands of the four actors ring together, making the whole dance atmosphere cheerful, warm, and full of vitality.

3.2. Focus on the reproduction of humorous folk customs

The accompanying music in Fujian folk dances usually mostly adopts the Yu mode and Shang mode. Nanyin, on the other hand, takes notes such as Yu, Shang, and Jue as the axis. The melody circles around the axis notes, showing an up-and-down surrounding characteristic, forming an undulating line of movement, which is cheerful, humorous, and amusing. This characteristic coincides with the rhythm of the "clown" dance in southern Fujian folk dances.

"The Quanzhou Ball Kicking Dance" is a famous piece in the "clown" dance. The dance performance takes the form of a group dance where a male ball player, a colorful old woman, and four to ten young girls follow the beat. The

dancers' actions such as competing for the ball, kicking the ball, and heading the ball vividly reproduce the sincere joy of people in group entertainment activities at that time. The Ball Kicking Dance is one of the main folk dances performed on occasions such as festivals, temple fairs, weddings, and funerals in Quanzhou, Jinjiang, Nan'an, Taiwan region, and other places. The characteristic of the melody of the music circling up and down around the axis note of Yu is integrated with the horizontal swaying and snake-like waist-moving rhythms of the clown character, the colorful old woman, in the Quanzhou Ball Kicking Dance, as well as the facial expressions of the colorful old woman. In "The Quanzhou Ball Kicking Dance", the horizontal swaying step rhythm lines of the colorful old woman from left to right, the undulating lines of her snake-like waist moving back and forth, the large amplitude swinging lines of her arms following the snake-like waist rhythm, together with the expression rhythms of the eyebrows, eyes, and mouth of the colorful old woman, complement the undulating line of movement of the accompanying music circling up and down around the Yu note. The humorous and witty performance of the dancer playing the colorful old woman is highly characteristic of the southern Fujian clown dance.

Another example is "Huoding Gong and Huoding Po Dance", which is another folk dance loved by the masses. Its accompanying music is the folk tune "Ten Flowers String." This tune is light-hearted, lively, and has a strong sense of rhythm, filled with a joyous atmosphere. The dance performance of "Huoding Gong and Huoding Po Dance" is completed by three people. Among them, Huoding Gong is dressed in a black lambskin fur coat, holding a long tangerine wood tobacco pipe in one hand and a banana leaf fan in the other. This is the costume of a "tattered clothes clown", and his funny dance movements make people burst into laughter. Huoding Po, on the other hand, is dressed in a red-trimmed front-buttoned long gown, holding a red handkerchief in one hand and a large round cattail fan in the other, which is the costume of a "housewife clown." The village girl is dressed in a turquoise-trimmed front-buttoned long coat and wide-legged trousers, carrying a load of firewood tied with ropes on a shoulder pole, which is the appearance of a "maid." Huoding Gong and Huoding Po carry a large iron cauldron placed on a wooden frame, with the firewood in the cauldron burning brightly red. The melody of "Ten Flowers String" is brisk and jumps from time to time, which complements the funny dance postures of Huoding Gong and Huoding Po, creating an interesting contrast. Following the beat of "Ten Flowers String", they either quickly dash through the crowd or slowly stroll. Their dance postures and expressions change at will, being unruly but not wild, tipsy but not muddled. They also fan the cauldron with the cattail fan from time to time, making all kinds of funny actions or using humorous words along the way, which makes the audience laugh heartily. The one carrying the firewood follows closely behind. This dance implies the hope for a prosperous and thriving life. Humorous and amusing dances like this are widely spread in various parts of southern Fujian.

4. Conclusion

Folk dances in southern Fujian, Fujian, are an artistic representation of the local social and economic development, local customs, and people's living conditions during the evolution of social history. Each local dance performance embodies a unique cultural connotation. Moreover, the development of dance is inseparable from music. As a characteristic art form in southern Fujian, Nanyin has played a crucial role in the development of folk dances and reflects profound artistic value. The reference and absorption of Nanyin in the development of folk dances in southern Fujian have not only ensured the enduring popularity of these dance forms but also led to their spread to the Taiwan region and even abroad. Therefore, the study of the stylistic features of Fujian folk dances and Nanyin has positive and far-reaching practical significance.

Disclosure statement

The author declares no conflict of interest.

Reference

[1] Xiao D, 2011, The Style Characteristics of Nanyin and Minnan Folk Dance. Journal of Beijing Dance Academy, 2011(4): 107–111.

[2] Lin RZ, 2013, On the Historical Characteristics of Fujian Folk Dance. Journal of Yangtze University (Social Science edition), 2013(2): 181–182.

[3] Li X, 2012, Analysis of the Current Status and Future of Quanzhou Nanyin. Literary Circle (Theoretical Edition), 2012(11): 163–164.

[4] | Zhou Y, 2012, The Charm of Fujian Nanyin. Democracy, 2012(11): 36–38.

[5] Bai ZY, 2012, Research on the Musical Form of Nanyin Music. Journal of Yangtze University (Social Science Edition), 2012(10): 175–177.

[6] Lin SW, 2007, From Regional to National: On the Unique Personality and Development of Fujian Folk Dance. Art Garden, 2007(8): 24–26.

[7] Li L, 2012, On Fujian Folk Dance. Popular Literature and Art, 2012(10): 86–87.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on Blockchain-Enabled Resilience Building and Risk Prevention and Control in Shipping Supply Chains Under Multiple Crises

Wanqi Su*

College of Foreign Languages, Shanghai Maritime University, Shanghai 201306, China

***Corresponding author:** Wanqi Su, 2135658683@yeah.net

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Under the wave of economic globalization, the development of a global shipping network urgently requires the enhancement of supply chain resilience and risk prevention mechanisms. In recent years, the world has experienced multiple crises, including the public health crisis and the geopolitical crisis represented by the Red Sea shipping crisis. These crises have severely impacted international logistics and supply chains. The public health crisis has led to disconnections between production and demand, increased trade barriers, and higher shipping costs. The suspension and rerouting of the Red Sea shipping route via the Cape of Good Hope have resulted in extended shipping times, delayed deliveries, and soaring freight rates. The widespread application of blockchain technology can alleviate these issues. This paper investigates the positive effects of blockchain technology's high transparency, automated risk control, and promotion of multi-party collaboration in addressing current crises, enhancing shipping supply chain resilience, and strengthening risk management. The paper aims to contribute to cost reduction, quality improvement, and high-quality development of international logistics.

Keywords: Blockchain; Shipping supply chain; Risk management; Decentralization

Online publication: March 10, 2025

1. Introduction

1.1. Current pain points in shipping development

The global shipping industry is facing a digital transformation wave. However, the current progress of shipping digitalization is hindered by several pain points, such as information asymmetry and data silos, contract disputes, legal adaptation delays, lagging risk response and rigid emergency mechanisms, and the contradiction between technology and cost. Under public health and geopolitical crises, these pain points in shipping digitalization have impeded the process of economic globalization and increased the difficulty of international trade.

1.2. Supply-demand imbalance under public health crisis impact

Geopolitical conflicts have forced shipping companies to reroute their vessels to avoid high-risk areas (e.g., bypassing the Red Sea region), increasing transportation costs and time. It is estimated that the cost of rerouting via the Cape of Good Hope is 15%–20% higher than that of the Suez Canal route, with additional risks of piracy. Moreover, trade sanctions have directly cut off some supply chain nodes, leading to the fragmentation of the global energy transportation network.

1.3. Logistics route restructuring triggered by regional disputes

Geopolitical conflicts have forced shipping companies to reroute their vessels to avoid high-risk areas (e.g., bypassing the Red Sea region), increasing transportation costs and time. It is estimated that the cost of rerouting via the Cape of Good Hope is 15%–20% higher than that of the Suez Canal route, with additional risks of piracy. Moreover, trade sanctions have directly cut off some supply chain nodes, leading to the fragmentation of the global energy transportation network.

1.4. Increased coordination difficulty of multimodal transport

The lockdown of ports (e.g., the temporary suspension of some operations at the Port of Shanghai) and insufficient railway capacity (e.g., the strained capacity of the China-Europe Railway Express) during 2019 have exposed the fragility of coordination across different transportation modes. For example, the blockage of the Suez Canal in 2021 triggered a “domino effect” in the global supply chain, affecting ports, highways, and warehousing systems [1].

Furthermore, low efficiency in multi-party collaboration is also hindering global shipping trade. In the event of sudden risks, coordination across enterprises and governments is required, but traditional communication methods (e.g., emails and phone calls) are inefficient. During the 2021 Suez Canal blockage, the lack of a collaborative scheduling platform led to a 48-hour delay in dredging decisions, resulting in global trade losses exceeding USD 10 billion [2].

2. Theoretical and practical significance

The core characteristics of blockchain technology are highly compatible with the needs of the shipping supply chain.

2.1. Decentralization and multi-party collaboration

The shipping industry involves multiple stakeholders such as shipowners, ports, and freight forwarders. Blockchain technology breaks down information silos through a distributed ledger, ensuring real-time data sharing (e.g., the TradeLens platform connects global shipping nodes) and avoiding the single-point failure risk of traditional centralized systems [3].

2.2. Data immutability and trust mechanism

Key information such as cargo status and contract terms, once recorded on the blockchain, cannot be tampered with and is highly traceable. This reduces the risks of bill of lading forgery and cargo damage liability disputes. For example, electronic bills of lading with blockchain notarization can shorten dispute resolution time by 60% [4].

2.3. Smart contracts and process automation

Smart contracts automatically execute rules such as freight payment and insurance claims, reducing manual intervention and operational delays. Maersk’s use of smart contracts has improved cross-border settlement efficiency by 80% while

lowering the risk of breach of contract [5].

2.4. Transparency and risk control optimization

Full-chain data transparency helps in the real-time identification of anomalies (e.g., deviation from the shipping route, temperature control failure). Combined with AI prediction models, it enables early warning and enhances supply chain resilience.

The blockchain technology studied in this paper, which reconstructs trust through technology, is becoming a core tool for the shipping industry to cope with the fragmentation of globalization and improve collaborative efficiency.

3. Theoretical basis and technical architecture

3.1. Blockchain technology principles

3.1.1. Distributed ledger

The core mechanism of a distributed ledger is that data is stored in a shared ledger across multiple participating nodes, with each node independently maintaining a complete copy of the data. Consistency is ensured through synchronization mechanisms. For example, the status of goods in shipping (e.g., location, temperature, and humidity) is jointly recorded by shipping companies, ports, and freight forwarders. The failure of any single node does not affect the overall system operation. Distributed ledgers break down the single-point failure risk of traditional centralized databases, enhancing supply chain transparency and resistance to attacks.

3.1.2. Consensus mechanism

The consensus mechanism ensures that all nodes reach an agreement on ledger updates to prevent malicious tampering. Typical consensus algorithms include as following.

PBFT (Practical Byzantine Fault Tolerance): Suitable for consortium chains, it allows consensus to be reached even if up to 1/3 of the nodes are malicious. It is fast (in milliseconds) and suitable for high-real-time scenarios (e.g., synchronization of vessel arrival information at ports). It can support thousands of transactions per second (TPS), meeting the high-frequency needs of shipping operations such as bill of lading circulation and customs clearance.

PoW (Proof of Work): High energy consumption and slow speed, mainly used in public chains (e.g., Bitcoin), and not suitable for shipping.

Comparing the two algorithms, PBFT is more efficient in a scenario with known trusted nodes (e.g., members of a shipping consortium) and can support thousands of transactions per second (TPS), meeting the trading needs of shipping.

3.1.3. Smart contracts

Smart contracts are automated agreements based on code that execute operations automatically when predefined conditions are triggered (e.g., payment, cargo release). These smart contracts can be applied to freight payment and document verification: after cargo receipt, the smart contract calls the bank's API to complete freight payment, eliminating payment delays (e.g., Maersk and IBM's automated insurance claims); automatically verifying the bill of lading and letter of credit information reduces the error rate of manual review (case: Rotterdam Port's blockchain customs clearance system shortened clearance time by 70%). This enhances the efficiency of shipping transaction processes.

3.1.4. Cryptography

Cryptography typically includes the following.

Asymmetric Encryption: Using a public-private key system to ensure controllable data access permissions. For example, after the shipper signs the bill of lading with a private key, customs can verify its authenticity with the public key to prevent forgery.

Hash Algorithm: Converts data (e.g., contract text) into a fixed-length hash value, where any modification results in a change in the hash value, ensuring data integrity. In shipping, it is used to verify whether cargo status records have been tampered with (e.g., temperature data in cold chain logistics).

3.2. Blockchain type selection: The suitability of consortium chains for shipping

3.2.1. Comparison of public, private, and consortium chains

Public Chain (e.g., Ethereum): Fully open with anonymous nodes, but low performance (e.g., Ethereum's TPS is about 15), and public data, which does not meet the privacy needs of shipping.

Private Chain: Centrally controlled (e.g., owned by a single enterprise), which contradicts the multi-party collaboration scenario in shipping.

Consortium Chain: The optimal choice, maintained by pre-selected organizations (e.g., shipping companies, ports, banks), balancing efficiency and privacy. Typical frameworks include Hyperledger Fabric and R3 Corda.

3.2.2. Core advantages of consortium chains in shipping

Permission Control: Node access requires voting by consortium members to prevent malicious participation (e.g., restricting unauthenticated freight forwarders from joining).

Performance Optimization: Through efficient consensus mechanisms such as PBFT, high throughput can be achieved (Hyperledger Fabric's TPS can reach over 2000), meeting the high-frequency trading needs of shipping.

Data Privacy Grading: Supports channel technology to isolate different business data. For example, the bill of lading data is shared between the shipper and customs, while fuel purchase information is only accessible to shipping companies and suppliers.

Compliance: Meets regulatory requirements such as GDPR and supports data localization storage (e.g., data from European port nodes is stored only on EU-based servers).

4. Risk management

Shipping supply chain risk management requires a systematic approach to potential threats in each link. The framework consists of four stages.

4.1. Risk identification

The goal of risk management is to identify potential threats to the supply chain. This can be achieved through the following methods.

PESTEL Analysis: Identifies macro risks such as political (e.g., sanctions), economic (e.g., exchange rate fluctuations), and technological (e.g., hacker attacks).

Process Mapping: Locates vulnerable nodes through supply chain process diagrams (e.g., dependency on a single port).

Typical risks in shipping trade include:

Operational Risks: Such as pirate attacks (a 50% increase in pirate attacks in the Red Sea in 2023) and crew shortages (a global deficit of over 100,000 crew members).

Market Risks: Such as freight rate volatility (the Shanghai Containerized Freight Index (SCFI) has an annual fluctuation rate of over 200%).

Compliance Risks: Such as fines for exceeding carbon emission limits (the IMO's Carbon Intensity Indicator (CII) took effect in 2023).

4.2. Risk Assessment

The following models illustrate the application of blockchain technology in risk assessment.

Quantitative Analysis: Calculating the probability and impact of risks

Monte Carlo Simulation: Predicting the probability and cost losses of extreme weather causing port closures.

Value-at-Risk (VaR) Model: Estimating the potential impact of freight rate volatility on corporate cash flow.

4.3. Risk response

Based on risk identification and assessment, blockchain technology can provide different strategies for navigation to achieve relatively low-cost, low-risk, and high-efficiency route design. These strategies include:

Avoidance Strategy: Rerouting to avoid high-risk routes.

Mitigation Strategy: Diversifying supply sources and strengthening technology.

Transfer Strategy: Purchasing war risk insurance and supply chain interruption insurance (global shipping insurance premiums increased by 18% in 2022).

Acceptance Strategy: Reserving emergency budgets for low probability/low impact risks (e.g., minor customs delays).

4.4. Risk monitoring

Through real-time data tracking, KPI alerting, and periodic auditing, closely monitor shipping-related data, integrate diverse resources, and ensure real-time follow-up of shipping information. Real-time data tracking involves integrating data sources such as AIS (vessel positioning), weather, and political dynamics on the blockchain platform. KPI alerting can be achieved by setting thresholds (e.g., triggering an alarm if port stay time exceeds 72 hours) and linking smart contracts to initiate emergency procedures. Periodic auditing involves reviewing supply chain resilience quarterly (e.g., the effectiveness of alternative supplier plans).

5. Specific applications of blockchain in shipping supply chains

5.1. Automated risk identification

Blockchain technology can integrate historical data on-chain, for example:

Vessel Accident Data: Shipping companies and insurance firms upload accident records (e.g., collisions, mechanical failures) to the blockchain. Each record includes fields such as time, location, cause, and loss amount, with digital signatures to ensure authenticity.

Supplier Credit Ratings: Third-party rating agencies (e.g., Lloyd's Register) write suppliers' compliance and on-time delivery rates into the chain, with data updates verified through consensus mechanisms.

Real-Time Operational Data: IoT devices collect data such as vessel position (AIS), engine status, and cargo temperature and humidity, synchronizing it in real-time to blockchain nodes.

5.2. Collaborative assessment and response

Blockchain smart contracts can execute cross-organizational data in a joint manner, achieving multi-layer data linkage, for example:

Pirate Alert Triggering: Through off-chain oracles (Oracle) connected to the International Maritime Bureau's (IMB) real-time pirate activity database, if a particular sea area reports ≥2 pirate attacks within 24 hours, it is marked as a high-risk zone.

Vessel Dynamic Monitoring: Blockchain synchronizes AIS data of vessels. If a vessel enters a high-risk zone without requesting an escort, the smart contract is triggered.

In addition to data warning and monitoring, blockchain can also complete further responses:

Notify Shipowners: The smart contract calls the shipowner's reserved API interface (e.g., enterprise WeChat, Slack) to push warning information and suggestions (e.g., request escort, change route). Coordinate with Insurers: The contract automatically generates a warning record and sends it to the insurance company's system to initiate a quick claim preparation process (e.g., pre-review policies, and prepare rescue funds).

Blockchain technology upgrades traditional passive risk management, which relies on manual labor, to a data-driven active defense system through automated risk identification and collaborative response. This enhances risk response efficiency, precise decision-making, and supply chain resilience.

6. Retrospect and prospect

6.1. Research conclusions

Blockchain technology demonstrates significant value in shipping supply chains and risk management. The complexity and globalization of shipping supply chains make them susceptible to multidimensional risks, necessitating a systematic management framework. Blockchain technology enhances supply chain resilience by improving data transparency, automating processes, and facilitating multi-party collaboration.

6.2. Challenges and risks

However, the widespread application of blockchain still faces real challenges.

Technical Limitations: Mainstream consortium chains (e.g., Hyperledger Fabric) have a throughput of about 2000 TPS, which is insufficient to support large-scale global shipping networks (with daily data points in the hundreds of millions).

Legal Conflicts: The EU's eIDAS (Electronic Identification and Trust Services) Regulation has not yet recognized the legal validity of blockchain bills of lading, leading to the detention of 12 batches of blockchain-based goods by Italian customs in 2023.

Ecosystem Fragmentation: There are currently 27 shipping blockchain platforms worldwide that are incompatible with each other. The annual data interoperability cost between COSCO's GSBN and Maersk's TradeLens is as high as USD 3 million.

Blockchain is driving the transformation of shipping supply chains from "experience-driven" to "data-intelligent," but continuous breakthroughs are needed in technical performance, legal adaptation, and ecosystem integration.

Disclosure statement

The author declares no conflict of interest.

References

[1] Liu X, 2025, Digitalization of Bills of Lading Accelerates the Green Transition of Trade. International Commerce News, Trade and Investment, February 14, 2025, 3.

[2] Shi CL, Li FY, 2024, Suggestions for China to Enhance International Logistics Supply Chain Security under the Red Sea Shipping Crisis. Journal of the Ministry of Transport Management Cadre College, 34(4): 12–18.

[3] Kjaergaard-Winther C, 2022, A.P. Moller-Maersk and IBM to Discontinue TradeLens, A Blockchain-enabled Global Trade Platform. https://www.maersk.com/news/articles/2022/11/29/maersk-and-ibm-to-discontinue-tradelens

[4] Zhou B, 2024, Research on Shipping Supply Chain Security under the Red Sea Crisis. China Maritime, 2024(8): 63–65. https://doi.org/10.16831/j.cnki.issn1673-2278.2024.08.020

[5] Zheng JY, 2018, IBM and Maersk Aim to Use Blockchain Platforms to Break Down Shipping Barriers. Tianjin Navigation, 2018(3): 77.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on Integrating Excellent Family Traditions and Precepts Culture into College Students' Values Education: A Case Study of the "Three Su" Family Tradition

Yan Liu*

Southwest University of Science and Technology, Mianyang 621000, Sichuan, China

***Corresponding author:** Yan Liu, weiyi9099@126.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Family tradition is not only the core values and valuable spiritual wealth of the family but also the cognitive concept and cognitive orientation of the family members. Excellent family culture can also affect the growth of family members. This paper focuses on the "three Su" family tradition integration into the dilemma of college students' values education to explore and clear the important impact of this family tradition on college students' values education, and put forward the main path of integration of "three Su" family tradition and college students' values education, aiming to use excellent family culture to shape students' cognitive concepts, and promote college students to become outstanding builders and successors of the country. In the future development process, it can contribute its own strength to the realization of the "Chinese dream."

Keywords: Family tradition and family training; Values education; "Three Su" family style

Online publication: March 10, 2025

1. Introduction

Excellent family culture is the cultural treasure of the country after thousands of years, which embodies a large number of wisdom crystals, and is also the soul of the inheritance of excellent traditional culture, which not only contains the ancestors of family rules, family education, family customs and lessons and other rich philosophy and wisdom, but also plays a certain role in promoting talent training and spiritual breeding. "Three Su" family style culture is also the perfection of our sage culture, which includes a large number of cultural elements, as well as the crystallization of wisdom between families. "Three Su" family style can be condensed into five parts: "diligence, filial piety, loyalty, integrity, and propriety", on this basis, the construction of family style in the new period can be summarized as hard work, filial piety to the elders, caring for the country, incorruptible and polite to others [1]. College students inherit and

carry forward the “three Su” family tradition culture has an important value that cannot be ignored, which promotes the construction and development of socialist core values, and also creates a good atmosphere in the social scope. In this regard, in the stage of socialist development with Chinese characteristics, the “three Su” family culture and college students’ values education will be effectively linked to help college students grow up healthily.

2. The difficulties of integrating the “Three Su” family culture into college students’ values education

2.1. There is a disconnect between family education and college students’ values education

The development of the economy and the continuous progress of society have brought about great changes in the mode of economic rotation, which has a profound impact on the multi-subject structure of society and family [2]. The socialization and simplification of family functions have become the current trend, and the attention paid to family education will have a direct impact, such as students’ weak cognitive concept of family and insufficient efficiency of family style construction. It can be divided into three categories. First, the acceleration of the pace of life and the rapid development of the social economy make the education field more inclined to the way of school education, and the role of family education cannot be fully played. In this case, teaching activities will be more in-depth, weakening the effectiveness of family education to some extent [3]. Second, the professional and social degree of the school is increasing, and the family’s dependence on school education work can be constantly expanded. The school is committed to enhancing the cognitive foundation and practical ability of the students, aiming at cultivating the students into the compound talents urgently needed in the stage of social development, which will make the family members pay too much attention to the cultivation of the student’s personal ability, ignoring the importance of family education for the student’s education work. Thus, family education and college students’ values education cannot be effectively connected.

Based on this, the value education of college students cannot be separated from the self-restraint of students, the construction of school family style, and the guidance of education. Third, it requires knowledge accumulation and family attention to expand family-style construction activities in combination with the “three Su” family style. The integration of the “three Su” family style into the values education of college students has a very positive impact, but limited by family education’s understanding of the construction of this family style, many families are unable to implement the “three Su” culture and hinder the important role of “three Su” family style in family construction.

2.2. College students’ values education and the “Three Su” family style cannot be effectively connected

First, due to the influence of utilitarian factors, many college students’ value education is more inclined to cultivate talents and integrate classroom teaching activities. The student-oriented value education will make students contact with traditional culture in a relatively simple way, and the link of knowledge introduction is relatively static. In this regard, the essence of the “three Su” family tradition has always been unable to connect with the value education of college students. Closely focus on the values education activities of college students, actively invite schools, families, society, and other subjects to participate in it, and gradually build a more complete engineering system. As far as the current situation is concerned, the values education of college students is mostly carried out by schools, and the participation of families and society is less, which cannot be gathered into a joint force for educating students. Second, the inheritance and promotion of the “three Su” family tradition culture is restricted by different factors. As an important part of excellent traditional culture, students should understand the traditional cultural resources carried in the “three

Su" family style culture, and deepen their own accumulation and understanding of traditional cultural knowledge [4]. For example, how to explore the essence of Su Shi's family tradition from the ups and downs of his diet culture, poems, and eunuchs, select the essence and discard the dross, choose a more appropriate way to complete the interpretation, and inherit and carry forward among college students needs to spend a lot of time and energy. In addition, limited by the funds, resources, education platform, and education path of moral education in colleges and universities, the training of college students' family tradition and family training culture is obviously insufficient, which cannot stimulate students to take the initiative to participate in it and complete the expected goal of teaching activities. Therefore, the connection between the "three Su" family tradition culture and college students' values education is insufficient, and the efficiency of students' values education has not reached the expectation.

3. The main path of integrating the "Three Su" family culture into college students' values education

3.1. Giving full play to the role of the main position of education classroom

The learning career of college students is more concentrated in the school, and the setting of classroom activities can integrate the "three Su" family style into it and become the main position of education. First, it can condense the content of the "Three Su" family tradition culture and integrate it into the values education. Schools can explore the elements of ideological and political education from the "Three Su" family tradition, and integrate classic cases to guide students to feel the feelings of family and country and the cultural connotation. Educators can also explore the meaning of the family tradition from the poetry and background of "Three Su". Educators should not only pay attention to the famous aphorisms passed down by the family, but also explore the hidden spirit, refine such spirit, explore the practical significance of its existence, and give it the connotation of the new era. Based on criticism and promotion, centering on the core values of socialism as the main line, synthesizing the focus and characteristics of construction in the new period, selecting more practical content, and creating a more educational value of the "Three Su" family tradition culture [5]. This culture can be integrated into the course of Ideology, Morality, and Rule of Law, and the patriotic thoughts in the "Three Su" family tradition can be integrated into it. Students can also correctly understand the meaning of the implementation of the ideological and political curriculum with the help of this content, and understand the important value of the "Three Su" family tradition in the learning process, to improve the comprehensive quality of college students and finally realize the purpose of discipline education. Second, educators cannot ignore the training of professional teachers to improve the connotation of traditional culture and the level of education of teachers. Teachers need to accurately connect with the content related to this kind of knowledge, combined with the cultural charm, to understand the essence of family culture. Traditional cultural literacy is not strong among teachers, so they cannot improve its impact effectiveness in the classroom. To educate others, they must first learn this knowledge. They are not qualified to educate others if they have not learned it. Teachers should always maintain the good habit of lifelong learning, take the initiative to explore the cultural content related to the "three Su" family tradition, enhance their cultural cultivation, constantly explore the existing values and educational elements, improve the quality of classroom teaching, and stimulate students' interest in active participation [6]. Teachers should also set up certain teaching skills to enhance the attractiveness of classroom content. Third, the establishment of the "three Su" family culture classics reading club and reading club. Integrate the reading of classics into the value education of college students.

3.2. Scientific setting of practical activities

The school should create a good learning and cultural atmosphere for students, and create different forms of campus

cultural activities, combined with practical activities to promote the "three Su" family tradition. One is to set up "family style stories" to preach and organize language to discuss the stories of famous writers about family style and family training. For example, Mr. Chen Jiageng has a strong sense of family and country and also emphasizes that his children should not only plan for their personal lives but also strive for the country and the nation [7]. Loyal to the country, he took the initiative to devote himself to public welfare undertakings, established several schools in his hometown, and truly realized the concept of taking money from society and applying it to society. Chen Jiageng's words and deeds also affected every family member and made a positive impact on the construction of a good family atmosphere. This kind of spiritual inheritance can infect students, encourage students to establish a sense of identity in the learning process, and consciously practice the core values of socialism. The second is to set up a collection activity of "My family style and family training" to show the excellent family style and family training in real life. For example, the "Three Su" family style can be integrated into the practice class, the construction of the Three Su family style training system, and the practice of family style education guarantee. In addition, the school can also create a practical exchange platform to guide students to perceive the profound meaning of the "Three Su" family tradition from practical activities [8]. Such as building training bases inside and outside the school, visiting Three Su Temple, holding Three Su family style poetry recitation, "Three Su" family style art performance theme activities, etc., to improve students' cognition and understanding of this culture, and inherit the socialist core values in their future life and practice.

3.3. Enhancing the communication between school and family

In addition to integrating the "three Su" family culture in the classroom and practical activities, colleges and universities should also pay attention to improving students' self-cognition and strengthening students' socialist core values, but also realize the interaction between schools and families in teaching activities, and promote family education to inherit and promote socialist core values [9]. On the one hand, educators cannot ignore the important role of "please come in", and actively invite parents to participate in campus construction and visit services, and understand the effectiveness of "three Su" cultural Settings with students. On the other hand, it can also continue the concept of "going out", actively integrate into the profound connotation of the "three Su" family tradition, complete the construction of socialist core values education, go deep into the community, and guide students to understand the "three Su" family culture [10]. Before, there is "Su Xun did not want to study when he was young, when he was 27 years old, he began to make up his mind to study hard, and later he even became a great writer." Su Xun in the twenty-seven years old installment reading story, after the end of the cloud tour guides children to read, and compiles the "Name two sons said" article, encourages Su Shi and Su Zhe to fight bravely, and indicates that the article creation must be promising and do, said or done must be true and effective. Students in the family should create a more harmonious learning atmosphere, the family space makes students interested in books, so that students can finish reading at any time and anywhere [14]. Students will enjoy reading and get more interesting knowledge from it. Parents cannot ignore the cultivation of students' reading habits, and play an exemplary role in leading students to fall in love with reading [11]. Students can also gradually develop good learning habits under the influence of family traditions so that they can cultivate their self-cultivation and take the initiative to make development plans [12]. Students can also maintain their temperament after entering society and then lay a solid foundation for the cultivation of socialist core values.

4. Conclusion

To sum up, the inheritance and promotion of the "Three Su" family tradition is also a key part of inheriting an excellent traditional culture, which has a great impact on guiding college students to establish correct cognitive concepts and

cognitive orientation [13–14]. It is promising for colleges and universities to integrate the "Three Su" family tradition into college students' value education [15]. Whether from the aspects of theoretical training or practical application, it is necessary to explore the main path of the integration of the two and complete innovation and reform based on inheriting and promoting the "Three Su" family tradition, giving it new connotation and definition, and helping students grow up healthily.

Funding

Sichuan Historical and Cultural Story Popularization Base (Project Number: SCPJY202307); Quality-oriented Teaching Reform Project of Southwest University of Science and Technology (Project Number: 22szjg07)

Disclosure statement

The author declares no conflict of interest.

References

[1] Yang X, 2023, On the Feelings of the "Three Su" Family Style. Guoxue (Hans), 11(3): 342–346.

[2] Luo XQ, Qiu XL, 2022, Inherit the "Three Su Good Family Tradition" and Nourish the Youth in Meizhou. Care for Tomorrow, 2022(8): 4.

[3] Liu HB, Xiao JY, 2019, Research on the Integration of Three Su Culture into Teenagers' Moral and Legal Education. China Ethnicities Expo, 2019(4): 3.

[4] Qian YH, 2020, Some Research on the "Three Su" Family Tradition and Family Training, thesis, New Academic Vision of Sichuan Institute of Business and Technology.

[5] Tan JH, 2022, The Moon Lingran Washes my Heart — The Inheritance of 4,000 years of Chinese family Discipline in Bashu. Journal of Literature and History, 2022(5): 4–9.

[6] Lin XT, 2022, Analysis on Young Students' Emotional Identification of Socialist Core Values. Journal of Henan Polytechnic University (Social Science Edition), 2022(1): 11–16.

[7] Fu L, 1998, Fu Lei's Family Letters. Life, Reading, Xinzhi Sanlian Bookstore, Beijing.

[8] Pan MF, 2018, Inheriting the Traditional Village Sage Family Style and Family Training and Practicing Socialist Core Values. Jiangnan Forum, 2018(4): 51–53.

[9] Zhu LT, Chen YB, 2020, Nourishing Socialist Core Values with Traditional Family Discipline and Family Style Culture. Chongqing Social Sciences, 2020(9): 6–16.

[10] Huang CQ, 2020, Some Thoughts on Integrating the Fine Traditional Chinese Family Values into the Value Education of College Students. Youth and Society, 2020(12): 151–152.

[11] Luo Wenjuan. The Practical Significance of Excellent Traditional Chinese Culture to the Education of Socialist Core Values for College Students. Middle School Political Teaching Reference, 2021(33): 85.

[12] Li GL, 2019, Research on the Integration of Excellent Family Culture into the Education of Socialist Core Values for College Students. Modern Commerce and Industry, 40(31): 136–137.

[13] Lin WJ, Cheng W, 2019, Chinese Excellent Traditional Culture Education and the Cultivation of College Students' Socialist Core Values. Journal of Guangzhou Institute of Socialism, 2019(2): 99–102.

[14] Li Q, 2022, How to Develop Sumen Family Tradition. People's Weekly.

[15] Lin BH, 2022, Teaching the Chinese Family Discipline, Educating the Family Style and Cultivating the New Civilization in the New Era. Manuscript of Red Flag, 2022(12): 46–48.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on the Construction of Talent Team of Think Tank in Y Field

Jin Shang*

Office of Cybersecurity and Informatization Committee of the Xinjiang Uygur Autonomous Region Committee of the Communist Party of China, Urumqi 830000, Xinjiang, China

***Corresponding author:** Jin Shang, 17699052605@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In the context of globalization and a knowledge-based economy, the think tank, as a key institution for policy research and decision support, has become increasingly important. As the intelligence engine of economic development in X region, the think tank in Y field is directly related to the scientific and democratic process of regional decision making. Through in-depth analysis of the current situation, challenges and existing problems of talent team construction of think tanks in the Y field, such as imperfect selection mechanism, inadequate role of experts, unreasonable talent structure, and imperfect training and incentive mechanism, this paper puts forward targeted construction paths and improvement suggestions. The suggestions include improving the selection and management mechanism, strengthening the role of experts, optimizing the structure of talents, improving the training and incentive mechanism, and emphasizing the importance of top-level design, capital investment, evaluation system construction, international exchanges, cultural atmosphere creation, deep integration with decision-making institutions and brand building. The aim is to build a high-quality and professional think tank talent team through these strategies and provide solid intellectual support and decision-making reference for the sustainable development of the Y field.

Keywords: Think tank in Y field; Talent team construction; Selection mechanism; Incentive mechanism; International communication

Online publication: March 10, 2025

1. Overview of the current situation

Since its inception, Y Field Think Tank has adhered to the principle of high starting points and high standards and is committed to building a communication platform that gathers the top wisdom of the industry. After unremitting efforts, the think tank has successfully hired 260 experts from all walks of life, among which 4 academicians of the Chinese Academy of Engineering have joined, which undoubtedly adds a heavy weight to the academic level and influence of the think tank. These 260 experts cover many sub-fields of the Y field and build a relatively complete and well-structured expert system, which provides solid talent support for the comprehensive development of the think tank [1].

To better manage and utilize this valuable expert resource, the think tank in the Y field has formulated a detailed management system, clarifying the responsibilities, rights, and obligations of the experts, and ensuring the orderly progress of the experts' work. At the same time, the think tank has also actively built an information platform to realize the centralized management and sharing of expert information. The establishment of this platform has not only improved work efficiency, but also promoted exchanges and cooperation among experts, laying a solid foundation for the standardized operation of think tanks [2].

During the operation of the think tank, experts give full play to their professional advantages and wisdom and actively participate in important work such as top-level design, regulation formulation, and project review. Their professional insights and unique insights have provided strong intellectual support for the development of the Y field. Whether in policy research, technical consultation, or project evaluation, the experts have played an irreplaceable role, effectively promoting the innovation and development of the Y field. It can be said that the establishment and development of think tanks in the field of Y cannot be separated from the hard work and selfless dedication of these experts [3].

2. Problems and challenges

In the development process, think tanks in the field of Y have made certain achievements and built a relatively complete expert system. However, there are still some problems to be solved in the selection and management mechanism, the role of experts, the structure of talents, and the training and incentive mechanism.

In terms of selection and management mechanisms, think tanks currently lack open and transparent selection standards and procedures. This makes the selection process of experts seem not fair and equitable enough to ensure that the experts selected really have the required professional knowledge and ability. At the same time, expert management is also not systematic and normative and has not established a set of perfect management systems and processes. As a result, the work roles and responsibilities of experts in think tanks are not clear enough, management efficiency is low, and it is difficult to give full play to the role of experts [4–5].

In terms of the role of experts, some experts do not know enough about the work of think tanks and the importance of participating in decision-making consultation. Therefore, they are not motivated to participate in decision-making consultation, and often just passively accept tasks, lacking initiative and innovation. In addition, the research results of some experts also lack innovation, and it is difficult to provide valuable decision-making suggestions for think tanks. This not only affects the quality of think tanks' decision-making but also reduces their influence and reputation in the industry [6].

In terms of talent structure, think tanks currently lack interdisciplinary and cross-field compound talents. With the rapid development of science and technology and continuous changes in the industry, experts in a single field have been unable to meet the needs of think tanks for diversified and comprehensive talents. At the same time, the proportion of young talents in think tanks is also low, which makes the talent team of think tanks lack vitality and innovative spirit. In the long run, this will seriously affect the sustainable development and competitiveness of think tanks [7].

In terms of training and incentive mechanisms, the training plan of the think tank is not systematic and perfect. The training plan lacks targeted training content and methods, so it is difficult to meet the needs of experts in different fields and at different levels. At the same time, the incentive mechanism is not perfect enough to fully stimulate the enthusiasm and creativity of talents. This makes experts less motivated to work in think tanks and difficult to devote themselves fully to the work of think tanks. To improve the overall strength and competitiveness of think tanks, it is necessary to strengthen

the training and incentive of experts, establish a sound selection and management mechanism, optimize the talent structure, and increase the participation and innovation of experts [8–9]. Only in this way can we ensure that the think tank maintains its leading position in the industry and provides strong intellectual support for the development of the Y field.

3. The construction path

In the process of development, think tanks in the field of Y must constantly improve their own management mechanism, give full play to the role of experts, optimize the structure of talents, and establish a sound training and incentive mechanism to enhance the overall strength and competitiveness of think tanks.

In terms of selection and management, think tanks in the Y field should establish an open and transparent selection mechanism to ensure the fairness of the selection process. They can make sure that the selected experts truly have the required professional knowledge and ability by issuing selection announcements, clarifying selection criteria and procedures, and setting up independent review committees. At the same time, think tanks should strengthen cooperation with all walks of life, broaden the source channels of experts, and attract more outstanding talents to join. In addition, the expert management system should be improved, the responsibilities, rights, and obligations of experts should be clearly defined, and regular evaluation and assessment should be carried out to ensure the orderly and efficient performance of experts' work [10].

In terms of giving play to the role of experts, think tanks need to enhance their understanding of the work of think tanks and let them deeply understand the importance and significance of participating in decision-making consultation. Experts' sense of responsibility and mission can be enhanced by organizing special training sessions and holding symposiums. At the same time, experts should be encouraged to conduct in-depth research at the grassroots level to understand the actual situation and provide more realistic suggestions for decision-making. Think tanks should also build exchange and cooperation platforms to promote the collision of ideas and cooperation among experts, stimulate innovative thinking, and improve the quality and level of decision-making consultation [11].

In terms of optimizing the talent structure, think tanks should increase efforts to introduce interdisciplinary talents and focus on bringing in experts with interdisciplinary and cross-field knowledge and capabilities. At the same time, interdisciplinary training should be strengthened to improve the comprehensive quality and innovation ability of existing experts. In response to the low proportion of young talents, think tanks should formulate young talent training plans to provide more growth opportunities and development space, attract and retain outstanding talents, and lay a solid foundation for the sustainable development of think tanks [12].

In terms of improving the training and incentive mechanism, think tanks should establish a systematic talent training system and provide targeted training content and methods according to different fields and levels of experts. At the same time, opportunities for further study at home and abroad should be provided to broaden experts' horizons and knowledge. In terms of incentive mechanisms, incentive measures such as salary, promotion, and honor should be improved to fully stimulate the enthusiasm and creativity of experts. In addition, think tanks should also actively enhance the social influence of talents, and showcase the academic achievements and contributions of experts by organizing academic exchanges and releasing research results, to improve their visibility and influence in the industry [13].

4. Suggestions for improvement

4.1. Top-level design and planning

Top-level design and planning are the cornerstone of think tank development. To ensure the long-term and stable

development of think tanks, they must formulate a detailed talent development plan. This plan should clearly define the talent development goals of the think tank, including short-, medium- and long-term goal setting. Short-term goals may focus on quickly attracting a group of experts with professional backgrounds to join. The medium-term goal may be to cultivate a group of interdisciplinary and interdisciplinary talents; The long-term goal is to build a high-end think tank team with international vision and innovation ability [14].

Based on clear goals, the think tanks also need to set specific tasks and implementation paths. Tasks may include formulating selection criteria, improving management systems, and building communication platforms. In the implementation path, the operation process and time node of each step should be planned in detail to ensure that all tasks can be carried out in an orderly manner. Through top-level design and planning, they can provide a clear direction and path for the development of think tanks and ensure the smooth progress of all work.

4.2. Capital investment and guarantee

Capital investment is an important guarantee for think tank operations. To ensure adequate funds for think tanks and their compliance and efficient use, they should set up special funds to support the daily operation, personnel training, international exchanges, and other activities of think tanks. At the same time, they should also actively explore diversified financing channels, such as government funding, corporate donations, and social fundraising, to broaden funding sources and reduce funding risks.

In terms of the use of funds, they must strictly abide by relevant laws and regulations to ensure the compliance of funds. At the same time, they should also establish a sound financial management system to monitor and audit the use of funds throughout the process to ensure the efficient use of funds. Through investment and guarantee of funds, they can provide a solid material foundation for the development of think tanks.

4.3. Evaluation system and assessment

A scientific and reasonable evaluation system and assessment mechanism is an important basis for think tank personnel management. They should set up a complete evaluation system to comprehensively evaluate the academic level, working ability, and innovative achievements of experts. At the same time, they should also formulate a clear evaluation mechanism, and link the evaluation results with the salary, promotion, and honor of the experts, to motivate the experts to actively participate in their work and improve their work performance.

In the process of establishing the evaluation system and evaluation mechanism, they should fully consider the characteristics and needs of think tanks to ensure the scientificity of the evaluation system and rationality of the evaluation mechanism. Through the evaluation system and assessment, they can stimulate the enthusiasm and creativity of experts and promote the continuous development of think tanks.

4.4. International exchanges and cooperation

International exchange and cooperation is an important way for think tanks to broaden their international horizons and attract international talents. They should actively participate in international think tank activities, establish cooperative relations with internationally renowned think tanks, and jointly carry out research projects and exchange activities. Through international exchanges and cooperation, they can learn about the academic developments and research results at the forefront of the world and broaden our international vision.

At the same time, they should also actively attract international talents to join our think tanks to inject new vitality into their development. Through international exchanges and cooperation, they can enhance the international influence

of think tanks and provide intellectual support with a more international perspective for the development of the Y field [15].

4.5. Cultural atmosphere and working environment

A good working atmosphere and attention to the physical and mental health of talents are the keys to enhancing team cohesion. They should foster an open, inclusive, and innovative working atmosphere, encourage exchanges and cooperation among experts, and stimulate innovative thinking. At the same time, they should also pay attention to the physical and mental health of talents, provide necessary health security and welfare benefits, and reduce their work pressure and living burden.

By creating a good cultural atmosphere and working environment, they can enhance the cohesion of the team and improve the job satisfaction and loyalty of experts. This will contribute to the stable development and long-term prosperity of think tanks. To sum up, top-level design and planning, capital investment and guarantee, evaluation system and assessment, international exchange and cooperation, and cultural atmosphere and working environment are the five indispensable aspects for the development of think tanks in the Y field. They will continue to strive to improve these aspects to provide strong support and guarantee for the development of think tanks.

5. Conclusions and prospects

Y field think tank talent team construction is the core of think tank development. By implementing the above strategies, think tanks in Field Y will be able to build a team of high-quality and professional talents to provide strong intellectual support for regional development. In the future, think tanks in the field of Y should continue to adhere to innovation leadership, promote cooperation, strengthen exchanges and cooperation with think tanks at home and abroad, pay close attention to policy dynamics and social needs, and constantly improve service quality and level, to become indispensable intellectual support and policy advisory institutions in regional development.

Disclosure statement

The author declares no conflict of interest.

References

[1] Zhang ZQ, Su N, 2016, The Development Trends and Characteristics of International Think Tanks and the Construction of New-Type Think Tanks in China. Think Tank Theory and Practice, 1(1): 9–23.

[2] Di XK, Zhang H, Qin XJ, et al., 2023, Construction of Information Resource Guarantee System Supporting Think Tank Research. Chinese Journal of Agricultural Engineering, 13(5): 27–33.

[3] Zhou XX, Zeng Q, 2017, Research on the Operating Mechanism of New Think Tanks under the Background of Innovative Internet. Journal of Chongqing University of Technology (Social Sciences), 31(5): 48–52.

[4] Tang N, 2016, Analysis on the Path of Think Tank Talent Team Construction. China Science and Technology Journal Database Research, 2016(4): 276.

[5] Wang HY, 2012, Thinking on Talent Team Construction of New Think Tank of Academy of Social Sciences in Innovation areas. Social Science Management and Review, 2012(1): 58–63.

[6] Wang YY, Li LY, Liu HL, et al., 2017, Thoughts and Countermeasures on Accelerating the Construction of New Think Tanks in Guangdong. Guangdong Economy, 2015(7): 6–18.

[7] Huang LM, 2017, Analysis on the Path of Local Think Tank Talent Team Construction. Science and Technology Entrepreneurship Monthly, 2017(18): 69–70.

[8] Wan RH, 2021, Research on the Construction of China's New Science and Technology Innovation Think Tank in the New Development Stage. Management Science and Engineering, 10(2): 209–214.

[9] Li GQ, 2020, Innovative China Think Tank Construction. China Finance and Economics Press, Beijing.

[10] Ren H, 2021, Construction of China's New Think Tank "Revolving Door" Mechanism: Connotation, Current Situation and Ideas. Journal of Beijing University of Technology (Social Sciences Edition), 21(1): 75–84.

[11] Chen YC, Gao YZ, 2021, Research on Optimization of University Think Tank Management Mechanism from the Perspective of Social Work. Progress in Education, 11(6): 2251–2257.

[12] Wen H, Li YL, 2021, Target Guidance, Resource Drive and Environment Cultivation: The Internal Logic of the Construction of a New Type of Think Tank with Chinese Characteristics — Based on the Text Content Analysis of 82 Policies. Journal of Beijing University of Technology (Social Sciences Edition), 21(1): 63–74.

[13] Wang JH, Qi BB, 2022, Problems and Countermeasures of Big Data Empowering Think Tank Construction in the New Era. Journal of North China Electric Power University (Social Sciences Edition), 3(4): 58–64.

[14] Xu F, 2024, Research on Hot Spots of New Think Tanks with Chinese Characteristics from the Perspective of Social Network Analysis. Modern Management, 14(10): 2513–2519.

[15] Xuan KOK, 2017, Analysis on the Influence Improvement of Think Tanks in China from the Perspective of Innovation-driven Development Strategy. Economic and Social Development, 2017(3): 68–71.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on the New Forms of Foreign Language Teaching in Guangdong Higher Vocational Colleges under the Background of Education Digitization

Xiaoqing Zhang*

Guangzhou Huanan Business College, Guangzhou 510000, Guangdong, China

Corresponding author: Xiaoqing Zhang, 13570208071@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: This study focuses on the new forms of foreign language teaching in Guangdong's vocational colleges against the backdrop of education digitization. Through questionnaires and interviews, it identifies the different needs of employers, graduates, teachers, and current students regarding foreign language teaching in vocational colleges. Subsequently, a new digital model for foreign language teaching is designed and implemented in teaching practice. The results demonstrate that the new model has a significant effect on English teaching in vocational colleges, providing theoretical and practical support for foreign language teaching reform, enhancing teaching quality, promoting the growth of teachers and students, and driving the digital transformation of education.

Keywords: Education digitization; Guangdong's vocational colleges; Foreign Language teaching; New forms

Online publication: March 10, 2025

1. Introduction

With the rapid development of information technology, the global education sector is undergoing profound changes. Digital technologies, such as cloud computing, big data, artificial intelligence, and mobile internet, have widely penetrated various aspects of education. Internationally, many developed countries have already actively explored digital education models and achieved remarkable results.

China has successively proposed strategies such as building a digital China and developing a digital economy and has made a series of policy deployments centered on building an education power, modernizing education, and improving the quality of education. In April 2018, the Ministry of Education released the "Education Informatization 2.0 Action Plan", emphasizing the promotion of deep integration and innovation between information technology and education and teaching, to facilitate educational equity and enhance educational quality. In February 2022, the "Key

Points of the Ministry of Education's Work in 2022" clearly put forward the strategic action of education digitization. The report to the 20th National Congress of the Communist Party of China also reiterated the importance of "advancing education digitization and building a learning society and a great learning country that promotes lifelong learning for all." This series of actions and reports signifies that China's education informatization has entered a new stage of digital transformation. Under this digital transformation, foreign language teaching in vocational education presents distinct characteristics of the current era.

Guangdong holds a significant position in international trade, export-oriented economy, cross-border e-commerce, and cultural exchanges, so there is a growing demand for composite foreign language talents who not only possess solid foreign language skills but are also proficient in digital tools and have digital literacy. Foreign language teaching in Guangdong vocational colleges must adapt to the new demand of regional economic development and innovate teaching forms with the help of digital means so that the trained students can better serve the development of the digital economy industry in Guangdong and even the whole country.

2. Literature review

2.1. Current research abroad

Foreign experts initiated research on digital education relatively early, and with advancements in technology, the level of attention has been increasing. Since 2016, research literature has grown rapidly, with main research hotspots focusing on teaching practices and their impact on teacher development. For example, Kmecová emphasized the digitization of the educational process and the importance of using digital technologies in teaching [1]. It first highlighted the necessity of guiding students to develop their digital competencies and digital and information literacy, as well as the significant role of teachers in the educational process, where they serve as management consultants influencing the effectiveness of education. Questionnaires were used to collect students' views on the importance of using digital technologies in the classroom, aiming to elucidate the details of the educational process. The research conclusions emphasized the importance of innovative learning plans and the introduction of new learning plans that focus on supporting the development of digital literacy and collaboration with digital technologies. Quaicoe and Pata proposed a model describing the status of digital teaching and learning (TD-TaL) in Ghanaian schools from the perspective of teachers. Using survey data collected from 256 teachers in 45 schools across 6 districts in the Western Region of Ghana, the model was tested in the Ghanaian context. The results indicated that, apart from the digital attitudes of most teachers, personal and digital cultural factors directly influence teachers' digital activities, while from an environmental perspective, only the school's digital agenda directly or indirectly affects teachers' digital actions (ZPA) through digital training. The model particularly emphasizes that in the observed Ghanaian schools, the ZFM factor (digital infrastructure and digital support for digital teaching) is not associated with the ZPA factor (digital teacher training) and teachers' digital knowledge, competencies, and action factors [2].

2.2. Current research in China

Chinese scholars started researching digital teaching relatively late but have developed rapidly. Zhu Zhiting et al. pointed out that understanding and recognizing the digital transformation of foreign language education is crucial for promoting innovation in foreign language education models and upgrading learning paradigms, which is of great value for adapting foreign language education to changes in the external competitive environment and future social adjustments [3]. Yang Zongkai et al. proposed that foreign language teaching under digital transformation should create an integrated and immersive teaching environment, adopt intelligent and convenient teaching tools, provide rich and

open resource supplies, and innovate flexible and diverse teaching modes [4]. Liu Guimei suggested that the construction of digital foreign language teaching resources should meet the urgent needs of higher vocational students to improve their job-related foreign language skills and comprehensive professional development, utilizing smart information technology to comprehensively reconstruct the foreign language curriculum system in higher vocational colleges, implementing "explicit + implicit" layered teaching strategies, optimizing assessment and quality evaluation diagnosis and improvement mechanisms, and enhancing foreign language teachers' digital teaching abilities, thereby promoting the in-depth progress of the entire teaching reform process [5]. Hong Huaqing proposed a series of action paths for the digital transformation of foreign language education, including optimizing resource analysis and evaluation models, increasing investment in intelligent applications in learning environments, enhancing teachers' digital literacy levels, strengthening data-supported teaching analysis capabilities, and improving data-driven teaching management and evaluation mechanisms [6].

Through the review of domestic and foreign literature, it is found that scholars' research on digital education mostly focuses on the introduction of theories or specific teaching aspects such as development trends, teacher roles, and teaching resources, with relatively little research on the new form of foreign language teaching as a whole. Therefore, this topic believes it is necessary to construct a new model of foreign language teaching in higher vocational colleges under the background of educational digitization and to conduct research and exploration on the teaching environment, teaching resources, teaching methods, and teaching evaluation required for foreign language courses, providing valuable practical and theoretical references for foreign language curriculum and teaching reforms in higher vocational colleges under the background of educational digitization.

3. Research design

3.1. Research questions

In the context of the digital era, this study aims to delve into several key issues:

Investigate the new demands of employers and vocational college graduates for foreign language knowledge, skills, literacy, and other aspects to adapt to the new requirements for foreign language talents in the digital era.

Focus on the current situation of foreign language teaching in Guangdong vocational colleges, specifically investigate the prevalence and application of digital technology in foreign language teaching; simultaneously, study the demand and usage of online teaching resources by teachers and students; furthermore, investigate the experiences and feedback of teachers and students in foreign language teaching and learning in a digital environment.

Design a new model for digital foreign language teaching and attempt to implement it in English teaching at vocational colleges, testing the application effect of the new model in practical teaching in the digital era.

3.2. Survey on the needs of vocational college graduates for foreign language knowledge, skills, and literacy in the digital era

3.2.1. Participants

To better understand the current needs of vocational college graduates for foreign language knowledge, skills, literacy, and other aspects in the digital era and clarify the direction of talent cultivation, a questionnaire was developed. The questionnaire mainly includes six dimensions: basic information, foreign language knowledge and skills, professional competence, professional literacy, feedback on school education and training, and deficiencies and suggestions. The questionnaire was distributed via WeChat, with a total of 50 questionnaires distributed, 45 collected, a response rate of 90%, and 45 valid questionnaires, yielding an effective rate of 100%. Among the respondents, there were 12 males

and 33 females; the majority worked in the service industry, accounting for 35.6%, followed by business and trade, and others.

3.2.2. Data analysis

The results of the independent sample *t*-test show that the significance level of the difference in professional competence between genders is 0.568, which is greater than 0.05, indicating no difference in professional competence among vocational college graduates of different genders. Similarly, there is no gender difference in professional literacy and feedback on school education and training. However, the significance level of the difference in foreign language knowledge and skills between genders is 0.001, which is less than 0.05, indicating a difference in foreign language knowledge and skills among vocational college graduates of different genders.

According to the results of multiple comparisons, in terms of foreign language knowledge and skills, the manufacturing industry scores higher than information technology, services, and others; education and training score higher than information technology and services; and business and trade score higher than information technology, services, and others.

According to the correlation analysis results, there are significant correlations between foreign language knowledge and skills and professional competence, foreign language knowledge and skills and professional literacy, professional competence and professional literacy, and school education and training feedback and professional literacy. However, there is no significant correlation between foreign language knowledge and skills and school education and training feedback, or between professional competence and school education and training feedback.

3.3. Survey on the current situation of digital teaching by foreign language teachers in higher vocational colleges

3.3.1. Participants

To better understand the current application status of digital tools and resources in foreign language teaching in vocational colleges and to improve teaching quality and efficiency, a questionnaire was developed. It mainly includes eight dimensions: basic information, usage of online teaching resources, demand for online teaching resources, the prevalence of digital technology in foreign language teaching, application of digital technology by teachers in foreign language teaching, satisfaction with digital teaching resources, satisfaction with digital teaching tools, and digital teaching environment and teaching experience. The questionnaire was distributed in higher vocational colleges nationwide through WeChat groups, with 100 questionnaires distributed, 96 collected, a response rate of 96%, 2 invalid questionnaires excluded (some questions unanswered), and 94 valid questionnaires, yielding an effective rate of 98%.

3.3.2. Data analysis

The survey shows that 72 responses are from Guangdong Province, accounting for 76.6%, and 22 from other provinces, accounting for 23.4%. It can be seen that the survey results are heavily weighted towards the situation in Guangdong Province. There are 48 public and 46 private schools, accounting for 51.1% and 48.9% respectively, with no significant difference. There are 16 male teachers (17%) and 78 female teachers (83%), indicating that the results are biased towards the perspectives of female teachers. In terms of professional titles, there are no assistants, 50 lecturers (53.2%), 36 associate professors (38.3%), 4 professors (4.1%), and 4 others (4.1%), biased towards the views of lecturers and associate professors. The number of years engaged in foreign language teaching is as follows: less than 1 year, 10 (10.6%); 1–5 years, 8 (8.5%); 6–10 years, 8 (8.5%); 11–20 years, 52 (55.3%); and 21 years and above, 16 (17%).

The results of the independent sample *t*-test show that the significance level of the difference in the usage of

online teaching resources between provinces is 0.854, which is greater than 0.05, indicating no difference in the usage of online teaching resources among higher vocational colleges in different provinces. Similarly, there is no difference in the prevalence of digital technology in foreign language teaching, the application of digital technology in foreign language teaching, satisfaction with digital teaching resources, satisfaction with digital teaching tools, or the digital teaching environment and teaching experience between provinces. However, the significance level of the difference in the demand for online teaching resources between provinces is 0.017, which is less than 0.05, indicating a difference in the demand for online teaching resources among higher vocational colleges in different provinces.

Differences in various dimensions based on the nature of the school: The significance level of the difference in the usage of online teaching resources between school types is 0.968, which is greater than 0.05, indicating no difference in the usage of online teaching resources among higher vocational colleges of different natures. Similarly, there is no difference in the demand for online teaching resources, the prevalence of digital technology in foreign language teaching, the application of digital technology in foreign language teaching, satisfaction with digital teaching resources, or the digital teaching environment and teaching experience based on the nature of the school. However, the significance level of the difference in satisfaction with digital teaching tools based on the nature of the school is 0.022, which is less than 0.05, indicating a difference in satisfaction with digital teaching tools among higher vocational colleges of different natures.

Differences in various dimensions based on gender: The significance level of the difference in the usage of online teaching resources between genders is 0.935, which is greater than 0.05, indicating no difference in the usage of online teaching resources among teachers of different genders. Similarly, there is no difference in the demand for online teaching resources, the prevalence of digital technology in foreign language teaching, the application of digital technology in foreign language teaching, satisfaction with digital teaching resources, or satisfaction with digital teaching tools based on gender. However, the significance level of the difference in the digital teaching environment and teaching experience based on gender is 0.017, which is less than 0.05, indicating a difference in the digital teaching environment and teaching experience among teachers of different genders.

According to the results of the one-way ANOVA, among the seven dimensions, only the application of digital technology in foreign language teaching and satisfaction with digital teaching resources differ by professional title, with significance test results of 0.001 and 0.031, respectively, both significantly less than 0.05. According to the results of multiple comparisons, in terms of the application of digital technology in foreign language teaching by professional title, lecturers score higher than associate professors. However, in terms of satisfaction with digital teaching resources, teachers with other professional titles score higher than lecturers, associate professors, and professors.

There are no significant differences in the seven dimensions of the questionnaire based on teaching experience, as the significance levels are all greater than 0.05.

According to the correlation analysis results, there are significant correlations between all variables, and the correlation coefficients are all greater than 0, indicating positive correlations.

3.4. Survey on digital foreign language learning among higher vocational college students

3.4.1. Participants

To better understand the satisfaction of digital foreign language learning in higher vocational colleges and improve teaching efficiency and effect, a questionnaire was developed. The questionnaire covered eight dimensions: basic information, usage of digital teaching resources, demand for digital teaching resources, usage of digital teaching tools, application of digital technology in foreign language learning, satisfaction with digital teaching resources, satisfaction

with digital learning tools, and digital teaching environment and learning experience. The questionnaires were distributed via WeChat, with a total of 100 questionnaires sent out and 97 returned, yielding a response rate of 97%. After excluding 4 invalid questionnaires, 93 valid questionnaires remained, with an effective rate of 95.9%.

An analysis of the survey results reveals the numerical characteristics of demographic variables, reflecting the distribution of the respondents. Based on the frequency analysis of each variable, the distribution generally meets the requirements of the sample survey. Among the respondents, there are 19 males and 74 females. In terms of majors, 57% are liberal arts, 15.1% are science, 4.3% are engineering, and 23.7% are other majors.

3.4.2. Data analysis

According to the results of the independent sample *t*-test, the significance level of the difference in digital teaching resource usage between genders is 0.145, which is greater than 0.05, indicating that there is no significant difference in digital teaching resource usage between male and female vocational college students. Similarly, there are no significant differences in demand for digital teaching resources, usage of digital teaching tools, application of digital technology in foreign language learning, satisfaction with digital teaching resources, satisfaction with digital learning tools, and digital teaching environment and learning experience between genders.

According to the results of the one-way ANOVA, among the seven dimensions, only the usage of digital teaching resources shows significant differences across majors, with a significance level of 0.046, which is less than 0.05. Based on the results of multiple comparisons, it can be seen that liberal arts students use digital teaching resources more than science and engineering students.

Based on the above correlation analysis results, there are significant correlations between all variables, and the correlation coefficients are all greater than 0, indicating positive correlations.

3.5. Interviews with employers on the demands of higher vocational college graduates in the digital era

3.5.1. Interview design

For this interview, five principals from different industries were selected. The interview outline was sent via WeChat, and the respondents replied with voice or text messages, which were then compiled.

3.5.2. Interview analysis

In the digital era, employers have diversified and specific demands for the foreign language-related professional knowledge of vocational college graduates. The summary is as follows:

International trade and cross-border e-commerce: Proficient in international trade terminology and understanding the operating rules of cross-border e-commerce platforms. Able to use foreign languages for product descriptions, customer service, and marketing promotion. Possess foreign language understanding of international trade regulations, payment and settlement methods, and cross-border logistics.

Business communication and office skills: Solid business English skills, including listening, speaking, reading, and writing, especially business correspondence writing and business negotiation skills. Cross-cultural communication strategies to adapt to business exchanges in different cultural backgrounds. Familiarity with various office software and online collaboration platforms to meet the demands of digital office work.

Foreign language education and training: Strong language foundation, mastery of modern foreign language teaching methods, and course design principles. Understanding of educational psychology to better adapt to student needs. Familiarity with the use of online teaching platforms and possession of skills in the production and integration of

multimedia teaching resources to cope with the trend of digital education.

In summary, employers' demands for the foreign language-related professional knowledge of higher vocational college graduates in the digital era extend beyond language skills themselves, encompassing various aspects such as international trade, cross-border e-commerce, business communication, digital office work, and foreign language education, emphasizing the importance of comprehensive application abilities and digital skills.

4. Results

These research findings reflect the diversified and differentiated needs and experiences in the education field, as well as the impact of different background factors on students, teachers, and the usage of teaching resources.

4.1. Differences in the demand for online teaching resources among higher vocational colleges in different provinces

This phenomenon may stem from the uneven development of the regional economy, culture, and education. As an economically developed region, the higher vocational colleges of Guangdong Province may pay more attention to international integration and the integration of industry-leading technologies, so the demand for online teaching resources may be more diversified and cutting-edge. In contrast, other provinces may focus more on basic teaching and practical skill training due to limitations in resources, funding, and concepts [7].

4.2. Differences in satisfaction with digital teaching tools among higher vocational colleges of different natures

Public and private higher vocational colleges differ in funding sources, management modes, and teaching resources, which may directly affect the investment and usage of digital teaching tools [8]. Public colleges may introduce more high-quality digital teaching tools due to sufficient funding, thereby improving teacher and student satisfaction. However, private colleges may have limited investment in digital teaching tools due to funding constraints, leading to lower satisfaction.

4.3. Differences in digital teaching environment and learning experience among teachers of different genders

Gender differences may lead to different attitudes, habits, and adaptability among teachers when adopting and using new technologies. Some studies have shown that female teachers may be more meticulous and detail-oriented when using new technologies, while male teachers may be more inclined to explore the potential functions and applications of new technologies [9]. These differences may result in different perceptions and evaluations of the digital teaching environment and learning experience.

4.4. Differences in foreign language knowledge and abilities among higher vocational college graduates of different genders

Gender differences in foreign language learning performance have been a long-standing phenomenon. This may be related to differences in language abilities, learning styles, and interest preferences between males and females [10]. Some studies have found that females may have advantages in language memory and application, while males may excel in logical reasoning and spatial imagination. These differences may be reflected in foreign language learning, thereby affecting the foreign language knowledge and abilities of vocational college graduates.

4.5. Differences in foreign language knowledge and abilities, and professional competencies across industries

Different industries have varying requirements for foreign language knowledge, abilities, and professional competencies due to differences in business nature, market demand, and internationalization levels. For example, industries such as foreign trade and tourism have higher requirements for foreign language communication skills, while technology and manufacturing industries may focus more on professional competencies and technical abilities. These industry differences require graduates to possess knowledge and abilities that match the industry they are employed in.

Meanwhile, employers' demands for the foreign language-related professional knowledge of vocational college graduates in the digital era extend beyond language skills themselves, encompassing various aspects such as international trade, cross-border e-commerce, business communication, digital office work, and foreign language education, emphasizing the importance of comprehensive application abilities and digital skills.

4.6. Differences in the usage of digital teaching resources among students of different majors

Students of different majors have differences in learning content, learning methods, and learning needs, which directly lead to differences in their usage of digital teaching resources [11]. Science and engineering students may focus more on learning professional terminology and practical communication skills, tending to use digital resources such as vocabulary banks and simulated dialogues. In contrast, liberal arts students may pay more attention to an in-depth understanding of language culture and literary works and prefer to use digital resources such as e-books and online courses for extensive reading and in-depth analysis. These differences result in diversified and personalized applications of digital teaching resources across various majors.

5. Design and practice of new teaching modes

5.1. New digital foreign language teaching mode

The new digital foreign language teaching mode is supported by modern information technology, integrating online learning platforms, multimedia teaching resources, intelligent auxiliary teaching tools, and other digital means to achieve clear teaching objectives, intelligent teaching environments, digitized teaching resources, integrated teaching content, diversified teaching methods, pluralistic teaching evaluations, and intelligent teaching management. This mode not only provides students with richer, more vivid, and intuitive learning experiences but also offers personalized learning paths and resource recommendations based on students' learning situations and interests, thereby stimulating their learning enthusiasm and enhancing learning outcomes. The teaching elements and their connotations are as follows.

5.1.1. Teaching objectives

Knowledge objective: Through digital platforms, students are equipped with solid language basics, integrated with knowledge of international trade terminology, cross-border e-commerce platform operation rules, international trade regulations, payment and settlement methods, and cross-border logistics [12].

Skill objective: Enhance students' comprehensive application abilities in listening, speaking, reading, writing, and translating in a digital environment, especially their abilities to conduct autonomous and collaborative learning using digital technologies [13].

Literacy objective: Cultivate students' information literacy, cross-cultural communication skills, and innovative

thinking, enabling them to adapt to the career development needs of the digital era.

5.1.2. Teaching environment

Constructing a digital environment: Leveraging big data, virtual reality, and other technologies to build an integrated, open, shared, and collaborative smart teaching environment that supports blended learning, remote live interactive teaching, and routine recording [14].

Introducing new teaching modes: Introducing AI assistants to aid teaching, promoting a transition from a "teacher-student" binary structure to a "teacher-machine-student" ternary structure [15].

Encouraging collaborative participation: Encouraging teachers to integrate AI technologies and tools into teaching, creating teaching scenarios; encouraging students to use AI tools to assist in self-study and conduct extension training [16].

5.1.3. Teaching resources

Integrating digital resources: Through digital technology, integrate suitable foreign language platforms, online courses, and other resources, introduce cutting-edge content, and gather excellent teaching cases, courseware, videos, and other teaching resources [17].

Dynamically adjusting content: Dynamically adjust teaching content based on learning progress and level to ensure that students learn the most timely and relevant foreign language knowledge [18].

Introducing enterprise cases: Timely integrate real enterprise cases and cutting-edge knowledge and technologies into teaching content to enhance the alignment between talent cultivation and enterprise needs.

5.1.4. Teaching methods

Creating simulation scenarios: Establish virtual laboratories, rely on simulation software to mimic real work scenarios, and conduct teaching activities in realistic teaching environments, making the learning process more intuitive and interactive, which helps students deeply understand and grasp knowledge.

Personalized learning: Provide learning paths based on situations and interests, supporting students' autonomous learning and in-depth exploration.

Building learning communities: Support cooperative learning methods such as group projects, online discussions, and collaborative documents, building an open and interactive learning community that cultivates interaction, collaboration, teamwork, and communication skills among students [19].

5.1.5. Teaching evaluation

Constructing big data for teaching evaluation: Utilize big data for learning analysis, diagnosis, process monitoring, and comprehensive evaluation, providing a comprehensive, multi-dimensional, and multi-subject evaluation of students' learning effectiveness.

Innovating evaluation content and forms: Use project outcomes, internship reports, skill competition results, etc., as evaluation bases and incorporate certificate exam scores into the evaluation system.

Creating electronic learning archives: Record students' mastery and growth in knowledge points, providing support for personalized evaluation.

5.1.6. Teaching management

Data analysis: Utilize big data and AI technologies to conduct in-depth analysis of data on students' learning behaviors and effectiveness, providing a scientific basis for teaching decision-making.

Teaching feedback: Regularly collect feedback from teachers and students, and promptly adjust and optimize teaching strategies.

Teacher training: Organize teachers to participate in activities such as digital teaching ability enhancement training and digital collaborative teaching and research, use big data technology to monitor teachers' teaching data, and provide stratified and classified "precision training" programs [20].

5.2. Teaching practice of the new foreign language teaching mode in higher vocational colleges under the background of education digitization

5.2.1. Participants

This study selected research subjects from first-year non-English major students at Guangzhou Huanan Business College, ultimately determining four large classes (eight small classes, with every two small classes forming one large class for combined instruction), totaling 256 students. Among them, there were 135 students in the experimental class (109 males and 26 females) and 121 students in the control class (98 males and 23 females). Additionally, the course was taught by an experienced English teacher.

5.2.2. Methods

In this study, a pre-test, mid-test, and post-test design was adopted to comprehensively assess the performance of the experimental and control classes. Through horizontal comparisons, the aim was to reveal performance differences between the experimental and control classes at the same testing stages, thereby evaluating the teaching effectiveness of virtual assistant intervention in in-depth English reading in higher vocational education. Simultaneously, through longitudinal comparisons, the performance changes of the experimental and control classes at different testing stages were tracked to observe the trends and magnitudes of their learning progress. This dual comparative analysis method not only helps to deeply understand the effectiveness of teaching measures in the experimental class but also provides a scientific basis and improvement direction for future teaching practices.

5.2.3. Results

This study conducted pre-test, mid-test, and post-test performance assessments for both the experimental and control classes. Through comparisons, it was found that the experimental class showed significant performance improvement. Starting from a wide distribution in the first test, with the lowest score being 10 and the highest 100, it gradually transitioned to the third test where the score distribution was most concentrated, with the lowest score being 10 and most students scoring between 80 and 100. Although the control class also showed some performance improvement, the magnitude was relatively small. Scores improved significantly from many low scores in the first test to most students scoring between 50 and 90 in the third test, but the overall improvement was not as significant as that of the experimental class. Overall, the performance improvement in the experimental class was more notable, which may reflect the effectiveness of the digital teaching mode.

When comparing the English scores between the experimental and control classes, the study found some significant differences. The scores of the experimental class showed a significant increase, with the mean of Score 1 being 62.35, while the mean of Score 2 rose to 68.24, an increase of 5.89 points. By Score 3, the mean jumped to 81.57, which was not only 13.33 points higher than Score 2 but also 19.22 points higher than Score 1. This significant progress was also verified statistically, with paired sample *t*-tests showing significant differences between the three scores of the experimental class (all *P*-values less than 0.05), and there was a significant correlation among them.

Although the control class also showed some performance improvement, the magnitude was relatively small. The

mean of Score 1 for the control class was 63.95, the mean of Score 2 rose to 69.82 (an increase of 5.87 points), and the mean of Score 3 was 75.61 (5.79 points higher than Score 2 and 11.66 points higher than Score 1). Similarly, the three scores of the control class also passed the paired sample *t*-test, indicating significant differences among them (although the *P*-values for Scores 2 and 3 were close to the significance level of 0.05). However, compared to the experimental class, the magnitude of performance improvement in the control class was smaller, which may indicate that the application of virtual assistants in higher vocational English reading teaching has a more significant effect on improving students' performance (**Table 1**)

Table 1. Performance assessments of the experimental and control classes

	Pair	Test	Mean	Standard deviations	Standard error mean
Experimental class	Pair 1	Score 1	62.35	30.23515	2.44437
		Score 2	68.24	30.73909	2.48511
	Pair 2	Score 2	68.24	30.73909	2.48511
		Score 3	81.57	24.49806	1.98055
	Pair 3	Score 3	81.57	24.49806	1.98055
		Score 1	62.35	30.23515	2.44437
Control class	Pair 1	Score 1	63.9 5	28.55265	2.67420
		Score 2	69.82	27.00319	2.52908
	Pair 2	Score 2	69.82	27.00319	2.52908
		Score 3	75.61	24.92591	2.33453
	Pair 3	Score 3	63.9 5	28.55265	2.67420
		Score 1	75.61	24.92591	2.33453

In summary, the experimental results show that the scores in the experimental class became more concentrated, with an increase in high-scoring students and significant improvement in overall performance. Although the control class also saw some improvement, the magnitude was smaller, and there remained a large variance in student scores. This indicates that the new digital foreign language teaching mode has a positive effect on English language teaching in higher vocational colleges, significantly enhancing student performance.

6. Conclusion

The new digital foreign language teaching mode can effectively improve the quality and efficiency of foreign language teaching in higher vocational colleges, meeting the new demands for foreign language talents in the digital era. By integrating various digital means, this mode not only enriches teaching resources but also diversifies teaching methods and assessment approaches, providing a valuable reference for foreign language teaching reform in higher vocational colleges. In the future, the digital teaching mode should be further promoted and applied to facilitate the mutual growth of teachers and students, contributing to the cultivation of foreign language talents who can adapt to the needs of the global digital era.

Funding

Special Project of Higher Education in the 2023 Educational Science Planning Project of the Leading Group Office of the Guangdong Provincial Educational Science Planning "Research on the New Forms of Foreign Language Teaching in Guangdong Higher Vocational Colleges under the Background of Education Digitization" (Project No.: 2023GXJK1052)

The 2024 Quality Project of Guangzhou Huanan Business College "Research on the Application of Virtual Assistants in Deep English Reading Instruction for non-English majors in Higher Vocational Education" (Project No.: 2024HMZLGC31)

Disclosure statement

The author declares no conflict of interest.

References

[1] Kmecova I, 2020, Digitization, Digital Technology, and Importance of Digital Technology in Teaching, in Digital Age: Chances, Challenges and Future 7. Springer International Publishing, Berlin, 526–537.

[2] Quaicoe JS, Pata K, 2018, Basic School Teachers' Perspective to Digital Teaching and Learning in Ghana. Education and Information Technologies, 2018(23): 1159–1173.

[3] Zhu ZT, Luo HW, Wang CQ, et al., 2022, Digital Transformation and Integrated Innovation in Foreign Language Education. Foreign Language Audio-Visual Education, 2022(4): 7–17 + 110.

[4] Yang ZK, Wang J, Wang MQ, 2022, Digital Transformation Drives Innovative Development of Foreign Language Teaching. Foreign Language Audio-Visual Education, 2022(5): 3–5 + 105.

[5] Liu GM, 2024, Research on the Construction and Application Path of Digital Teaching Resources for Foreign Language Courses in Higher Vocational Colleges. Knowledge Treasury, 40(19): 92–95.

[6] Hong HQ, Qiao YF, 2024, Elements, Challenges, and Paths of Digital Transformation in Foreign Language Education. Foreign Language World, 2024(3): 28–34.

[7] Du YS, Feng SY, 2023, Practices and Future Prospects of Digital Transformation in Higher Education: A Review of the International Symposium on Digital Transformation in Higher Education. China Education Informatization, 2023(5): 31–40.

[8] Li LN, Zhao DZ, 2024, Construction of a Practical Teaching System in Higher Vocational Colleges under the Background of Education Digitization: Taking the Accounting Major as an Example. Vocational and Technical Education, 45(29): 45–49.

[9] Chen DD, 2024, Research on the Reform of the S-4Cs Teaching Mode for Foreign Languages in Higher Vocational Colleges under the Background of Digital Transformation. Southern Vocational Education Journal, 14(5): 94–102.

[10] Jin HF, Kan X, 2024, Research on the Construction of Teaching Resource Libraries for Network Majors in Higher Vocational Colleges under the Background of Education Digitization. Modern Vocational Education, 2024(22): 133–136.

[11] Zhang HB, Lu Z, 2023, Digital Transformation of Vocational Colleges under the Background of the "Digital Economy": Motivation, Obstacles, and Strategies. China Adult Education, 2023(21): 43–49.

[12] Yang ZL, Wu XJ, Guo YH, et al., 2023, Exploration of Optimization Strategies for Process-based Evaluation in Classroom Teaching Driven by Big Data. Computer Knowledge and Technology, 2023(14): 57–59.

[13] Zhuang ZW, 2024, Design and Implementation of a Multimodal PEAK Teaching Mode in Higher Vocational Colleges under the Background of Education Digitization: Taking the Intelligent Connected Vehicle Technology Course as an Example. Journal of Harbin Vocational and Technical College, 2024(6): 48–51.

[14] Dai L, Zhu ZT, 2023, Logical Starting point, Goal Orientation, and Action Path of Education Digitization. China Education Journal, 2023(7):14–20.

[15] Shu XY, Wang LX, 2023, Exploration of a Multimodal Teaching Mode in Higher Vocational Colleges in the Digital Era. China Vocational and Technical Education, 2023(14): 80–87.

[16] Liu RY, 2023, Transformation and Reshaping: Digital Empowerment of a New Ecosystem for Vocational Education — A Summary of the Forum on "Digital Transformation and Development of Vocational Education" at the World Digital Education Conference. China Vocational and Technical Education, 2023(7): 12–17.

[17] Zhu ZT, Hu J, 2022, Exploration of the Essence and Research Prospects of Education Digitization. China Electrified Education, 2022(4): 1–8 + 25.

[18] Benavides LMC, Tamayo Arias JA, Arango Serna MD, et al., 2020, Digital Transformation in Higher Education Institutions: A Systematic Literature Review. Sensors, 20(11): 3291.

[19] Paulin AA, 2017, Informating Public Governance: Towards a Basis for a Digital Ecosystem. International Journal of Public Administration in the Digital Age (IJPADA), 4(2): 14–32.

[20] Ahmadi RA, 2018, The Use of Technology in English Language Learning. International Journal of Research in English Education, 3(2): 115–125.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Greenhouse Environment Monitoring System Based on Wireless Sensor Network

Bin Liu, Xinyue Dai, Xiangyu Zhang, Qi Cao, Xi Yao, Yanan Chen*

Chaohu University, Chaohu 238024, Anhui, China

***Corresponding author:** Yanan Chen, 17307480536@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: This paper aims to solve the defects of the existing greenhouse environmental monitoring system, and proposes a monitoring scheme relying on the ZigBee wireless sensor network, which realizes the real-time tracking of greenhouse environmental data with the help of hardware and software cooperation. At the hardware level, the ZigBee wireless sensor network architecture is built with a CC2530 chip as the center, covering the sensor node and the sink node. The software level involves the data collection and transmission of the sensor node, the data receiving and forwarding of the sink node, and the monitoring and management of the host computer. After testing and verification, the system is stable and reliable, the overall structure is simple, the layout is flexible, and can effectively achieve the goal of wireless monitoring of greenhouse environmental data.

Keywords: ZigBee; CC2530; Greenhouse; Wireless sensor networks; Environmental monitoring

Online publication: March 10, 2025

1. Introduction

Recently, the field of agricultural technology has developed rapidly in the country, and greenhouse cultivation technology has been widely adopted. Environmental factors such as temperature, humidity, light intensity, and carbon dioxide concentration in the greenhouse play a key role in the growth of crops. Real-time monitoring of these factors is conducive to improving the greenhouse environment. At present, China adopts the wired connection method in greenhouse environmental monitoring, but this method has shortcomings such as cumbersome wiring, weak anti-interference, high cost, and complex maintenance. With the continuous progress of wireless communication technology, the ZigBee wireless network has many advantages, such as short-distance communication, low cost, and low energy consumption, and its application in the field of agricultural greenhouse is gradually increasing. The greenhouse environmental monitoring system designed in this paper introduces ZigBee technology, takes the CC2530 chip as the core, and designs a sink node and sensor node [1]. The sensor node collects the greenhouse environmental parameters, sends the data to the sink node through the ZigBee network, and then uploads the data to the monitoring center through

the RS-232 serial port for storage, display, and query [2]. In addition, the monitoring center can send control instructions to the sensor node to complete the collection and adjustment of environmental indicators, to reduce system expenses and energy consumption, enhance the expansion of the monitoring network and the maintenance efficiency of the equipment, and then improve the performance of the entire monitoring system.

2. The design goal of the work

2.1. Build an accurate and stable greenhouse environmental monitoring system

The system focuses on the continuous detection of key environmental indicators such as temperature, humidity, and light intensity in the greenhouse, and is equipped with a remote operation function to achieve the purpose of accurate adjustment of the greenhouse environment.

2.2. Continuous detection of greenhouse environmental indicators

With the help of wireless sensor network technology, a large number of high-precision and stable performance sensing units are deployed in the greenhouse to collect environmental information continuously and send it to the core control node for processing and analysis.

2.3. Realize the remote control function

With the help of mobile phone or computer client software, it is convenient for greenhouse managers to remotely view and adjust the greenhouse environment, such as adjusting the temperature, humidity, light intensity, and other factors, to meet the growth needs of different crops, so that greenhouse management becomes easier and more efficient.

3. Analysis of relevant status quo

The greenhouse environmental monitoring system has evolved from the previous wired sensing mode to the wireless sensing unit, overcoming the problems of cumbersome wiring and high costs, and enhancing the flexibility and expansibility of the system.

The vigorous development of the Internet of Things technology has promoted the wide use of real-time observation and remote control functions, and managers can monitor and adjust the greenhouse without time and space restrictions, thus significantly improving management efficiency and convenience.

The system will accumulate massive data in the operation process, and data processing and analysis methods such as data mining and machine learning are deeply integrated into it, providing strong support for scientific decision-making.

4. Technical scheme and analysis

4.1. Overall system structure

This system is mainly used for monitoring farmland environmental information, and its overall structure design is shown in **Figure 1**. It consists of three parts: a data information collection module, an information transmission module, and a remote monitoring module.

Data acquisition unit: Composed of many soil temperature and humidity sensor nodes and a multi-functional wireless sensor network, with the help of sensor probes to obtain the soil temperature and humidity, air temperature and humidity, carbon dioxide concentration, and other environmental data.

Information transmission module: The use of ZigBee wireless communication technology to build a collection network. The ZigBee coordinator module will be the sensor node data convergence, through the GPRS/4G/WIFI module uploaded to the remote monitoring terminal [3].

Remote monitoring unit: Based on WEB technology to create a monitoring website and background SQL database, to complete the collection of data storage, management, and query display functions.

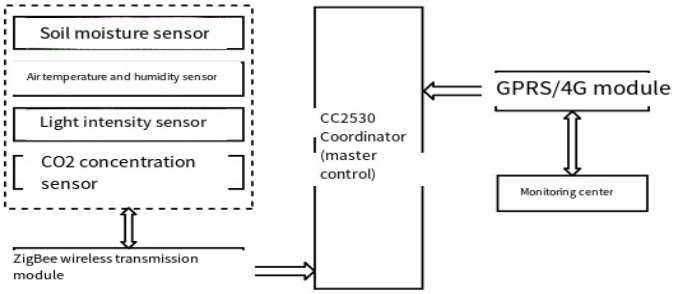


Figure 1. The overall design of the monitoring system

4.2. Network topology

This system adopts the star network topology [4]. A large number of wireless sensing units are uniformly distributed in the greenhouse. These units act as end nodes and the main task is to collect environment-related data. In addition, a summary node is also set up to act as a core node, which is installed outside the greenhouse to receive the data transmitted from the sensor units and transmit this data to the back-end processing system by other means. This architecture is concise and easy to expand and maintain management.

4.3. System hardware design

4.3.1. Main control module

The main control module adopts CC2530 as the core processor. CC2530 supports multiple channel selection and ZigBee 2007/PRO protocol stack [5]. This makes the node based on the design of CC2530 reach a farther communication range, have a more stable networking efficiency, and meet the requirements of the system. Selecting CC2530 as the central processing unit of the main control module can complete the data collection, transmission, and processing of the sensor node. Its low energy consumption also makes the system durable and reduces the frequency of battery change. Through the programming of the CC2530 digital I/O interface and built-in peripherals, the interaction and control with the sensor nodes can be realized. In addition, the wireless communication function of CC2530 can ensure stable wireless data interaction with sensor nodes.

4.3.2. Sensor selection

Temperature sensor: The DS18B20 temperature sensor was chosen, and the DS18B20 is a digital temperature detector with excellent accuracy and stability [6]. It can be connected to ZigBee sensor nodes through a single data cable and communicate with digital signals. The sensor has a wide operating voltage range of 3V to 5.5V, and the temperature measurement accuracy reaches ±0.5°C, which is very suitable for the temperature detection work in the greenhouse.

Humidity sensor. The DHT22 humidity sensor was selected, and the DHT22 sensor combines humidity and temperature detection in one [7]. It excels in measurement accuracy and stability, being able to measure a wide range of relative humidity from 0% to 100%. The DHT22 sensor utilizes digital signals for data transmission with ZigBee sensing nodes, making it ideal for greenhouse humidity monitoring.

Light sensor: This project selected BH1750 as the light detection element, BH1750 is a digital light intensity detector. It has high sensitivity and a wide range of light intensity detection, measuring from 0 to 65535 lux, and communicates with ZigBee sensor nodes through the I2C interface [8]. The BH1750 sensor is suitable for light monitoring in greenhouses.

CO2 sensor: MG811 is selected as the system CO2 concentration sensor in this paper [9]. The MG811 sensor uses NDIR (non-distributed infrared) technology to achieve more accurate CO2 concentration detection, with a wide detection range, generally covering hundreds to thousands of ppm (some models can detect even higher concentrations) and has excellent long-term stability, even if long-term use can maintain more accurate measurement results [10].

Soil moisture sensor. The capacitive soil moisture sensor was selected, a volumetric soil moisture sensor that measures the moisture of the soil [11]. For example, the SEN0114 soil moisture sensor can output soil moisture values through analog signals. It can be connected to the analog input interface of ZigBee sensor nodes and is suitable for monitoring soil moisture in greenhouses.

4.3.3. Design schematic diagram

The design schematic diagram is shown in **Figure 2**.

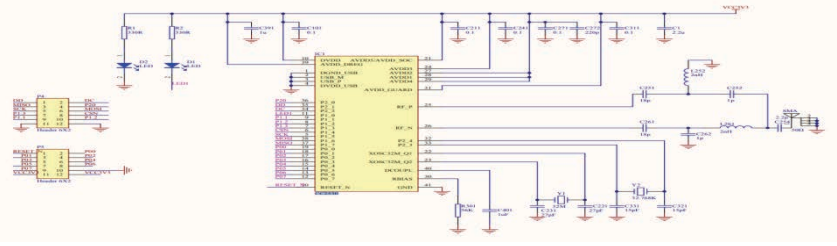


Figure 2. Schematic diagram of CC2530 Zigbee RF module

4.4. System software design

4.4.1. Zigbee protocol

The Zigbee protocol uses IEEE 802.15.4 physical layer communication technology as its underlying communication standard [12]. IEEE 802.15.4 is a standard designed for low energy consumption, low transmission rate, and short-distance wireless communication scenarios, and is widely used in the construction of wireless sensor networks and personal local area networks (pans). It specifies the related technical requirements of the physical layer and MAC layer in detail, thus providing a solid foundation for the stable physical layer communication of the Zigbee protocol.

4.4.2. Routing protocol

Given the star topology architecture of the Zigbee network, each sensor node only needs to transmit data to the coordinator, without performing multi-hop forwarding. Therefore, each sensor node sends data directly to the coordinator, eliminating the tedious routing decision process. As the root node, the coordinator adopts the table alternative routing strategy to maintain the network topological relationship table and simplify the route search process. It uploads the collected data to the monitoring terminal through TCP/IP to achieve stable and reliable data transmission [13].

4.5. PC software design

4.5.1. Website interface development

The use of HTML and CSS technology to build the front end of the website, covering the login registration, data

presentation, system configuration, and other core functional plate pages.

4.5.2. Build back-end database

Database architecture planning: Build a variety of data tables to store the collected data and system-related information.

Data interaction interface: Using Flask to develop a web service interface to realize the data communication between the background system, the database, and the equipment [14].

Periodic acquisition task: The design acquisition thread regularly captures real-time data from the device and inserts it into the database.

4.5.3. Design of data display module

Report display: Using Echarts/Highcharts to achieve a variety of dynamic reports such as charts, tables, and so on [15].

GIS positioning: Display real-time location of collection points in reports combined with open-source map API

Data query: Design time and condition query interface to achieve multi-dimensional filtering query function.

4.6. Test and result analysis

The system uses 4 data collection nodes to realize the comprehensive network monitoring of the greenhouse, transmits the data obtained by the sensor to the upper computer, and then presents the collected data by logging in to the web interface, thus obtaining the following results (**Figure 3**).

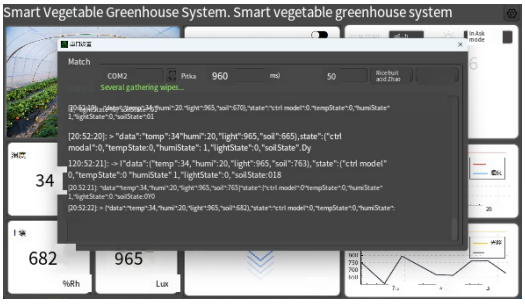


Figure 3. Collected data

It can be found that the temperature, humidity, and light data in the greenhouse have been effectively collected and displayed on the web interface.

This study developed a set of greenhouse environment monitoring systems relying on a wireless sensor network, which can achieve real-time monitoring and data collection of the greenhouse environment, supply accurate environmental data for greenhouse managers, help them improve the planting environment, and then improve the yield and quality of crops.

5. Conclusion

The system has many advantages: Relying on wireless sensor network technology, the system shows high flexibility and expansibility, which can fit the layout and scale of various greenhouses; The use of low-power wireless communication protocol, ensures that the system can be durable and stable operation, reduce energy consumption; With the help of remote terminal equipment, managers can obtain environmental information of the greenhouse at any time, which is easy to monitor and adjust the growth environment. The experimental results show that the system is effective and

feasible. It can collect and transmit data in real-time and accurately, and provide decision reference for managers to optimize the growth conditions of plants.

Funding

Chaohu University National College Students Innovation and Entrepreneurship Training Program funding project (202410380029); Chaohu University Quality Engineering Project (ch21jxyj1)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Kinney P, 2003, ZigBee Technology: Wireless Control that Simply Works. White Paper.

[2] Fritz M, 2005, Interfacing an Electronic Balance Through the RS232 Serial Port Using the "C" Programming Language. 35 Years of Education in Measurement Science: 1997 Measurement Science Conference (MSC'97).

[3] Ingole M, Rane SS, 2022, WIFI Module Based Smart Waste Management System. International Journal of Innovations in Engineering and Science, 7(5): 39–48. https://doi.org/10.46335/ijies.2022.7.5.8

[4] Cena G, Durante L, Valenzano AA, 2001, New CAN-like Field Network Based on a Star Topology. Computer Standards & Interfaces, 23(3): 209–222. https://doi.org/10.1016/S0920-5489(01)00069-1

[5] Zhang WC, Yu XW, Li ZC, 2011, Wireless Network Sensor Node Design Based on CC2530 and ZigBee Protocol Stack. Computer Systems & Applications, 20(7): 120–184.

[6] Claussen M, 2023, Sensor 101: The DS18B20 Temperature Sensor: Connection to the 1-Wire Bus. Elektor, 2023(Jul./Aug.): 48–53.

[7] Thomas H, 2013, The DHT22 Humidity/Temperature Sensor Demystified. Nuts & Volts, 34(3): 50–53.

[8] Chen SG, 2006, The Design of I2C-Bus Interface Based on FPGA. Shanxi Electronic, 2006(6): 20 + 38.

[9] Chen SC, Yang ZY, Ke W, 2014, Carbon Dioxide Capture System Based on MG811 Probe. Microcontrollers & Embedded Systems, 2014(1): 47–50.

[10] Tang P, 2025, Non-dispersive Infrared (NDIR) Gas Sensor: US201113039187, patent, US8471208B1.

[11] Lima RDCR, Edmundo RE, 2014, Development of a Capacitive Sensor to Measure the Soil Moisture Content. Conference: 22nd University of Sao Paulo International Symposium of Undergraduate Research.

[12] Yuksel E, Nielson HR, Nielson F, 2011, A Secure Key Establishment Protocol for ZigBee Wireless Sensor Networks. Computer Journal, 54(4): 589–601.

[13] Liu W, Matthews C, Parziale L, et al., 2002, TCP/IP Tutorial and Technical Overview. Upper Saddle River, New Jersey.

[14] Dwyer G, 2016, Flask by Example. Packt Publishing Ltd, Birmingham.

[15] Sun E, Chen Z, Li S, et al., 2020, Real-time Data Visualization of Intelligent Networked Vehicles. Proceedings of the 2020 International Conference on Computing, 180–184.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on the Difficulties and Countermeasures of Promoting the Implementation of College Students' Social Emotional Learning Course

Hui Zhang*

Dalian Jiaotong University, Dalian 116000, Liaoning Province, China

***Corresponding author:** Hui Zhang, dawaizhanghui@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The university stage is the key period of individual social emotional development. Good social emotional ability can not only help college students better adapt to college life but also improve their interpersonal communication, emotional management, self-awareness, and other abilities, laying the foundation for future career and life development. Therefore, colleges and universities need to cultivate college students' social emotional abilities through relevant courses, to promote their all-round development. This paper aims to systematically analyze the difficulties faced by college students in the implementation of social emotional learning courses and put forward corresponding countermeasures and suggestions to provide a reference for colleges and universities to better promote the opening and implementation of the course.

Keywords: College students; Social emotional learning; Curriculum; Implementation; Dilemma; Countermeasures

Online publication: March 10, 2025

1. Introduction

In recent years, with the continuous deepening and reform of higher education, colleges, and universities have paid more attention to college students' social emotional learning. Many colleges and universities have set up relevant courses to cultivate students' compassion, responsibility, and cooperation spirit so that they can develop good interpersonal and communication skills, enhance self-awareness and social responsibility, improve their comprehensive quality, and prepare for future social development. However, in the actual educational practice, promoting the implementation of college students' social emotional learning courses still faces some difficulties and obstacles. It is of great significance to analyze these difficulties and put forward practical countermeasures for promoting the effective implementation of college students' social emotional learning curriculum.

2. Contents of college students' social emotion learning course

College students' social emotional learning course is an important course in higher education to cultivate students' comprehensive development and good social adaptability. The course mainly includes the following contents.

2.1. Self-cognition and emotion management

The course focuses on cultivating students' understanding and cognition of themselves, improving their self-awareness, mastering the methods of emotion regulation, and enhancing their ability to emotion management. The content involves self-cognition, emotional expression, stress management, and so on.

2.2. Interpersonal and teamwork

The course aims to improve students' social skills, cultivate good interpersonal skills, and enhance their sense of teamwork. The main contents include effective communication, conflict management, team building, and so on.

2.3. Career planning

The course helps students clarify their career goals, formulate reasonable career development plans, and prepare for their future careers. The contents include self-assessment, career exploration, employment skills training, and so on.

2.4. Awareness of social responsibility

The course guides students to establish a correct view of social responsibility, cultivate civic awareness, and enhance the spirit of social service. Relevant contents include moral cultivation, social participation, voluntary service, and so on [1].

3. Characteristics of college students' social emotional learning course

3.1. The nature of the course is comprehensive

The course involves psychology, sociology, pedagogy, and other disciplines, with obvious interdisciplinary characteristics. It not only pays attention to the mental health and development of students but also pays attention to the benign interaction between students and society.

3.2. The teaching objectives are complex

This course should not only impart knowledge and skills, but also cultivate students' comprehensive qualities such as social responsibility consciousness, communication and cooperation ability, and self-management ability. The goal is high.

3.3. There are various teaching methods

The course adopts a variety of teaching methods, such as theoretical teaching, practical training, case analysis, group discussion, and so on, and pays attention to the organic combination of theory and practice.

3.4. The learning effect is implicit

The cultivation of social emotional ability is a long-term and slow process. It is difficult to directly quantify the learning effect of students, which needs continuous observation and multi-dimensional evaluation [2].

4. The importance of college students' social emotional learning

First of all, it helps students establish correct values and social responsibility consciousness. College students' social emotional learning course focuses on guiding students to establish a correct outlook on life and values and cultivate a sense of responsibility and mission to serve society and give back to society. Through learning, students can correctly understand the status and role of themselves in society, enhance the consciousness of making contributions to society, and lay a good value foundation for the future society.

Secondly, it helps students improve their interpersonal and communication skills. College students' social emotion learning course focuses on cultivating students' empathy, compassion, and cooperation spirit, so that they can actively pay attention to others' feelings, communicate with others with empathy, better resolve interpersonal disputes, and establish a harmonious interpersonal network. The cultivation of this ability is crucial for students' future social adaptation and career development [3].

Thirdly, it helps students to develop in an all-round way and improve their comprehensive quality. College students' social emotional learning course focuses on cultivating students' social skills, emotional management ability, self-cognition, and problem-solving ability so that they can develop in an all-round way at the level of knowledge and skills and emotional psychology, and grow into fully developed social citizens. This undoubtedly has a positive impact on students' personal achievements and social contributions in the future [4].

5. Difficulties in the implementation of college students' social emotional learning curriculum

5.1. Teachers' and students' attention to emotional education needs to be improved

In the current classroom teaching, both teachers and students have not paid enough attention to the significance of social emotional education. Most students tend to pay more attention to learning professional knowledge after entering the university while ignoring the value of social emotional learning. On the other hand, some college teachers fail to pay enough attention to the cultivation of college students' social emotional quality in teaching. However, social emotional education is very important. It can not only promote students' mental health but also cultivate their social abilities such as communication skills and cooperative spirit. It can be said that improving teachers' and students' awareness of the importance of emotional education is one of the key problems that need to be solved urgently [5].

5.2. Curriculum integration needs to be strengthened

As a new educational concept, social emotional learning has not yet become an independent part of the curriculum system. On the one hand, schools need to explore the practice of curriculum integration. Given the heavy learning task of college students, how to skillfully integrate different types of course content under the premise of ensuring learning efficiency, to improve students' social emotional quality, is a problem worthy of high attention. On the other hand, most university teachers focus on imparting knowledge in their professional fields, lacking systematic training and practical experience related to social emotional learning. Requiring teachers to consider the teaching of subject knowledge and the cultivation of social emotions within a limited teaching time undoubtedly increases the workload of teachers, and there are also great challenges for some teachers who lack relevant background. Therefore, how to provide targeted training and support for teachers has become the key to the construction of college students' social emotional learning curriculum [6].

5.3. Social emotional learning curriculum system needs to be improved

At present, the design of social emotional learning only stays at the level of moral education and mental health education, lacking scientificity and systematicness, and has not formed a complete teaching system. At the same time, the implementation process of social emotional learning needs effective evaluation and feedback mechanisms. In the actual teaching, the lack of effective evaluation and feedback hinders the effective implementation of social emotional learning. In general, the construction of social emotional learning curriculum system still needs to be further improved [7].

6. Countermeasures to promote the implementation of college students' social emotional learning course

6.1. Enhance teachers' and students' attention to social emotional learning

Enhancing teachers' and students' attention to social emotional learning not only helps to cultivate students' empathy and compassion but also helps to enhance mutual trust and understanding between teachers and students. Schools should pay attention to the cultivation of teachers' social emotions, improve teachers' cognitive levels, enable teachers to treat students with a more open and inclusive attitude and create a good relationship between teachers and students. Students should also recognize the importance and value of social emotional learning, which not only helps to improve personal communication and coordination ability but also helps to enhance the team spirit, to better adapt to social life. Social emotional learning can cultivate students' empathy and emotional management ability, which are essential for personal growth and development. Only by fully recognizing the significance of social emotional learning can students actively participate in it and continuously improve their comprehensive quality [8].

6.2. Improve the curriculum system and clarify the curriculum orientation

Improving the curriculum system of college students' social emotional learning is an important basis to promote the effective implementation of the curriculum. First of all, schools need to establish a sound curriculum management system with the joint efforts of education departments and universities and clarify the status and role of social emotional learning curricula in talent training. It can be listed as a compulsory course for college students and included in the credit assessment system to ensure students' full participation. Secondly, schools should reasonably define the teaching objectives of social emotional learning courses according to the actual needs and characteristics of college students. Schools should not only cultivate students' social communication skills, teamwork spirit, and other "soft power", but also pay attention to enhancing students' self-awareness, emotional management, and other abilities, to help them better adapt to college life and future career development. On this basis, schools will build a systematic and complete curriculum system, including compulsory courses and elective courses, covering multiple modules such as social adaptability, interpersonal skills, and emotional regulation, to ensure the comprehensiveness and consistency of the course content [9].

6.3. stimulate students' learning enthusiasm

As the main body of social emotional learning courses, students' learning attitudes and participation directly affect the effect of the course. Therefore, effective measures should be taken to effectively mobilize students' learning enthusiasm and initiative. First, the credit weight of the course can be appropriately increased to make students aware of its importance and actively participate in learning. Secondly, in the teaching process, interactive teaching methods such as group discussion and scenario simulation can be used to enable students to actively participate in and give full play to the main role [10]. Moreover, some practical assignments can be designed, such as social research and volunteer

service, to guide students to apply the knowledge they have learned to practice and enhance their sense of achievement in learning. At the same time, the school can regularly organize some theme activities, such as social training camps, employment skills competitions, etc., to create a good campus atmosphere and stimulate students' learning enthusiasm [11].

6.4. enrich the supply of teaching resources

Good teaching resources are the basis for the smooth implementation of social emotional learning courses. Schools should increase investment in teaching resources and enrich teaching contents and forms. First of all, the school should develop social emotional learning course textbooks that meet the students' age characteristics and cognitive level according to their actual needs, to ensure that the content of the textbooks is vivid and the form is close to the students. Secondly, schools should make full use of information technology to develop social emotional learning curriculum resources combining online and offline, such as video, animation, games, etc., to increase the attractiveness of the curriculum. Thirdly, the school should also establish a social emotional learning curriculum resource-sharing platform to facilitate resource exchange and reference between teachers [12].

6.5. Strengthen the integration of social emotional learning

In the teaching process, teachers should integrate the teaching objectives of social emotional learning, moral rule of law, and mental health education to form a complete teaching system. For example, in the course of morality and the rule of law, teachers can introduce some examples of social emotional learning to help students better understand the relevant content. In the course of mental health education, some social emotional learning skills can be taught to help students better deal with negative emotions. At the same time, teachers should diversify their teaching methods and promote the integration of the above three kinds of teaching methods. For example, in social emotional learning, teachers can use interactive teaching methods such as role play to enhance students' social skills and emotional management ability. In addition, to better promote the integration of these courses, teachers also need to constantly improve their professional level. For example, teachers can participate in relevant training, read relevant literature, and constantly update their teaching methods and contents [13].

6.6. strengthen the professional training of teaching staff

High quality teachers are the key factor to ensure the quality of social emotional learning courses. First of all, schools should establish a sound teacher training mechanism, actively introduce outstanding talents in psychology, sociology, and other related majors, and provide systematic training for existing teachers. Based on professional knowledge, teachers should pay attention to the cultivation of teachers' communication and interaction abilities and emotional support skills, so that they can accurately grasp the psychological dynamics of students and adopt targeted teaching methods. At the same time, schools should establish a teacher performance evaluation mechanism and pay attention to process evaluation, including the evaluation of teachers' professional quality, as well as their teaching methods and student feedback, to promote teachers to continuously improve their teaching level. In addition, interdisciplinary collaborative teaching is encouraged, so that teachers' teams from different backgrounds can participate in the design and implementation of courses, give full play to their professional advantages, and improve the systematicness and practicality of teaching [14].

6.7. Establish a sound curriculum evaluation mechanism

A perfect curriculum evaluation mechanism is an important guarantee to promote the implementation of social

emotional learning curriculum. First of all, colleges and universities should establish a diversified evaluation index system, including not only students' knowledge but also students' interpersonal skills, emotional management level, social responsibility consciousness, and other aspects. At the same time, the evaluation methods should also be diversified, including daily homework and examinations, as well as organizing students' practice exercises and psychological tests. In addition, the evaluation results should be fed back to students in time to help them objectively understand their own progress and shortcomings, and encourage students to actively participate in the course evaluation, to play the main role of students. At the same time, colleges and universities should also establish teachers' self-reflection and supervision mechanisms, timely adjust teaching content and methods according to the evaluation results, and continuously improve the quality of courses. Only by establishing a sound curriculum evaluation mechanism can schools promote the continuous improvement and development of social emotional learning curricula.

7. Conclusion

To sum up, to promote the effective implementation of college students' social emotional learning courses, schools need to take systematic measures from multiple levels. Schools should strengthen the attention of teachers and students to emotional education, improve the curriculum system, enrich teaching resources, pay attention to the construction of teaching staff, stimulate students' learning motivation, and improve the curriculum evaluation mechanism. Only with all-around efforts can schools promote the social emotional learning course to play its due role in the growth of college students, and cultivate more excellent talents with good social adaptability.

Disclosure statement

The author declares no conflict of interest.

References

[1] Wu H, Jiang Y, 2024, The Development Process, Implementation Strategies and Enlightenment of Social Emotional Learning. Basic Education Reference, 2024(11): 41–48.

[2] Mao YQ, Du Y, Zhang WY, et al., 2024, Cultivating Warm Students: A Practical Framework and Strategy for Schools to Promote Social Emotional Learning. Primary and Secondary School Management, 2024(6):10–14.

[3] Tai NZ, 2021, Reconstructing Classroom Teaching and Promoting Social Emotional Learning. Shanghai Education, 2021(26): 74–75.

[4] He D, 2023, Training Strategies of Students' Social Emotional Learning Ability from the Perspective of Multidimensional Collaboration. Forest Teaching, 2023(10): 96–99.

[5] Li HW, Huang YY, 2024, Research on the Development Dilemma and Countermeasures of Social Emotional Learning. Qiaoli, 2024(2): 182–184

[6] Zhang JJ, 2023, Construction and Implementation of Social Emotional Learning Curriculum in Teacher Education Curriculum. Global Education Outlook, 52(12): 70–82

[7] Mao YQ, 2021, Cultivating Students' Social Personality for the New Era based on Social Emotional Learning. People's Education, 2021(24): 30–32.

[8] Zhi AL, 2019, Social Emotional Learning: Implications, Implementation, and Suggestions. Ningxia Education, 2019(10): 9–13.

[9] Gong Y, 2019, Research on the Significance, Background and Countermeasures of Social Emotional Learning. Mental Health Education in Primary and Secondary Schools, 2019(14): 4–7.

[10] Wu J, 2019, Analysis of Problems in the Implementation of Social Emotional Learning Curriculum. Mental Health Education in Primary and Secondary Schools, 2019(6): 50–51.

[11] Zeng LL, Yang CL, 2021, Analysis on the Structure of the Development of Social Emotional Learning Curriculum System. Basic Education Research, 2021(3): 22–23 + 27.

[12] Chen CP, Huang Y, He ZG, 2024, Types of College Students' Learning Engagement and its Impact on Social Emotional Ability. China Agricultural Education, 25(3): 43–51 + 110.

[13] Wu J, "Social Emotional Learning" from the Perspective of Curriculum. Mental Health Education in Primary and Secondary Schools, 2018(3): 4–8.

[14] Guo YX, Wang J, 2022, How can Classroom Teaching Cultivate Students' Social Emotions. Journal of Central China Normal University (Humanities and Social Sciences Edition), 61(5): 159–166.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Strategic Decision-Making and Performance Evaluation in the SIM ERP Simulation Game: Insights into Marketing, Finance, and Operations Management

Junhan Wang*

Xi'an Jiaotong-Liverpool University, Xi'an 215400, Shaanxi, China

***Corresponding author:** Junhan Wang, kamkahia03@gmail.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Within the context of the SIM ERP simulation game, this report provides an analysis of the author's experiences and decisions, with a particular emphasis on the strategic decisions the author took in the areas of marketing, financial management, and manufacturing, as well as an evaluation of the influence those choices had on the overall success of the company. Among the important factors that are investigated in this study are marketing techniques such as budget allocation and market segmentation, as well as financial decision-making, which encompasses plans for loan repayment and liquidity management. In addition, the report provides a reflection on the lessons that were learned from mistakes, such as overly aggressive production planning and inadequate communication between departments. In the context of strategic management, the findings emphasize the significance of making decisions based on evidence, being flexible, and exercising financial restraint respectively. Through the use of the simulation, the necessity of continuously evaluating and adjusting plans in response to changing market conditions was brought to light even more. The conclusion of this analysis is that it offers useful insights into the difficulties of corporate decision-making and provides guidance for improving future strategic planning in business contexts that are comparable to those that have been examined.

Keywords: Marketing; SIM ERP simulation game; Financial operations management

Online publication: March 10, 2025

1. Introduction

An immersive atmosphere was created by the SIM ERP simulation game to model real-world business management. This business management simulation required players to make important decisions across a variety of functions, such as production, marketing, and finance. The purpose of this report is to examine the strategic decisions that the author made during the simulation, with a particular emphasis on how those decisions impacted the success of the organization.

Several important decisions included the management of marketing expenditures, the establishment of product prices, and the maintenance of financial stability through the repayment of loans. In this report, the overall strategy of the game, the decision-making procedures that were utilized, and the lessons that were learned from both successful and poor choices are all detailed throughout.

To get things started, an examination of the initial market conditions and sales data was carried out to provide direction for decisions concerning marketing expenditures and price strategies. Utilizing manufacturing capacities, market demands, and financial commitments, the objective was to find a middle ground between short-term profitability and long-term sustainability. This was accomplished by striking a balance between the two. In the following portions of this report, the study will go into the author's role and strategy in the game, as well as conduct an in-depth analysis of the decision-making process and the results of that process. For the purpose of enhancing future strategic decisions, the reflection on the performance will first emphasize both the author's strengths and faults, and then it will proceed to make recommendations. In the final portion, the study will demonstrate how the simulation helped the author build skills in supply chain management by connecting the experiences the author had during the simulation to the theoretical knowledge gained during the course.

2. SIM ERP simulation game report

This study analyses the author's SIM ERP simulation game experiences and decisions, focusing on the strategic choices and their effects on the company's success. In the next section, the study explains how the game's marketing and finances are managed, including the overall strategy and milestone decisions. The report will also assess the author's performance, stressing the author's advantages and disadvantages and providing guidelines for the next strategic decisions [2].

To guide judgments, the author first examined the initial market and sales data of the game. To guarantee both short-term profitability and long-term survival, the approach included manufacturing, price, marketing, and financial planning. The report will be presented as follows: Introduction and goals are in Parts 1 and 2. The author's involvement and strategies are covered in Part 3. Part 4 describes the decision-making process and round records. The author's performance and lessons are discussed in Part 5. Simulation relates to course content in Part 6. This curriculum helped the author become a supply chain manager, as seen in Part 7.

3. Role description and strategy

The SIM ERP game required the author to handle the company's marketing and finances. Marketing budgets, price plans, and debt repayments were the author's main duties. The author balanced sales growth with long-term financial stability and coordinated with the manufacturing team to optimize output and inventory management [1].

The study applied a flexible and dynamic marketing plan. The author began with meager marketing budgets to see how they would affect various markets. Competitive analysis and sales performance drove the budget to change. The aim was to establish a significant market presence while yet being frugal with money. Changing with rivals and market conditions, the marketing plan likewise altered [2].

Financial management included careful debt repayment to ensure the corporation had enough cash to cover expenses. The company's operating liquidity was protected by "just-in-time" repayment, which was made when cash was surplus. This method sought to preserve a high credit rating and lower long-term interest rates [2].

In summary, the author's duty was to ensure that marketing plans matched production and sales estimates and that financial liquidity supported corporate operations without excessive debt.

4. Decision-making process and specific operations

Throughout the game, the author was tasked with the management of both the financial and marketing aspects [3]. To guarantee the company's liquidity and market competitiveness, a systematic approach to operations was adopted. The following section provides a comprehensive account of the decisions and operations undertaken in both the financial and marketing domains.

4.1. Financial aspects: Borrowing and repayment

In the SIM ERP game, there is no need to borrow money proactively. However, any funds borrowed automatically are reflected in the financial reports. Participants in the game received an initial loan of €8 million at the start [4]. The financial management plan revolved mostly around the repayment of this loan.

The repayment strategy for the loan is as follows. Given the low sales revenue in the initial stages, the cash flow in the bank account was insufficient to repay the entire loan within a short period. A strategy of small, frequent repayments was adopted, whereby a portion of the loan was repaid whenever cash flow allowed, thus ensuring that the bank account maintained a positive cash flow. In practice, the repayment strategy was to repay 5% of sales revenue on a daily basis over a period of five days until the loan was fully repaid. This strategy enabled the company to maintain a stable cash flow and circumvent the potential issue of cash shortages resulting from overly aggressive repayment [5].

The following section will address the pertinent factors influencing credit rating and interest rates. Game credit depends on the payback ability relative to the loan balance. A simple, tiered approach is used by banks to determine credit ratings. After paying off all debts, the greatest credit rating is AAA+ [8]. For net debt under €1 million, the credit grade is AA+. Interest rates and financing expenses depend on the rating. Higher credit scores mean lower loan interest rates and financing costs. The author's goal was to repay loans on time to keep the company's cash flow high and avoid credit deterioration owing to excessive debt.

4.2. Financial operations

Every round, the company's cash situation was evaluated utilizing financial reporting and cash flow forecasting instruments, including the F.01 financial statement and ZFF7B liquidity planning. Regular assessment of these reports guaranteed coverage of operational expenses and loan payback [7].

An oversight in the initial process required equity payback as part of the loan repayment. This action damaged the company's credit rating, making loans difficult. This mistake highlighted the need for financial vigilance.

The following figures show the financial statements and the specific operation pages for debt repayment, increasing conversion time, and increasing production capacity (**Figures 1–4**).

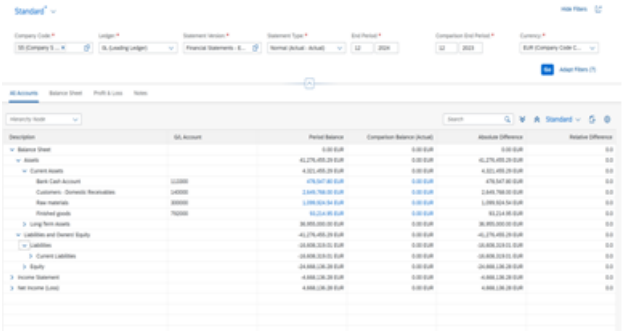


Figure 1. Financial statements

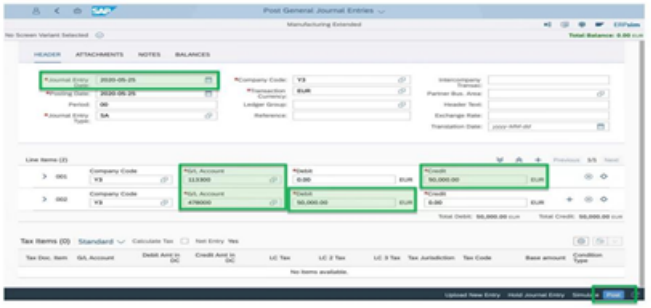


Figure 2. Debt repayment

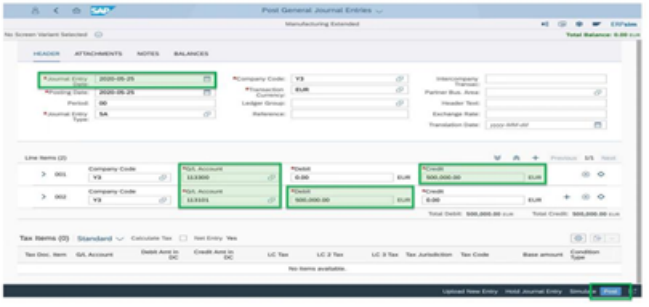


Figure 3. Set up

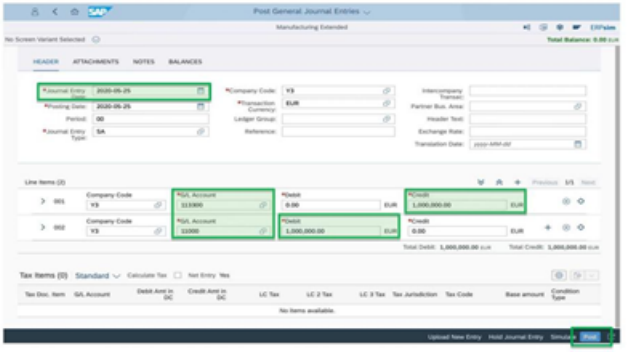


Figure 4. Capacity

4.3. Marketing aspects

4.3.1. Initial testing phase: Gradual investment

To ascertain the optimal marketing strategy, an initial investment was made in smaller amounts. In the initial stages of the marketing campaign, the budget was set at €50–100 per day, with the effects on sales monitored over a period of 2–3 days. This approach permitted an analysis of the impact of marketing on sales without excessive expenditure.

4.3.2. Management of the marketing budget

Using a market-sized budget allocation approach, daily marketing expenditure was limited to 1%–5% of the market size [6]. The budget changed depending on the size of the market (convenience stores, grocery stores, and large supermarkets):

DC12: Grocery Store: around €360,000/week

Convenience Store (DC14) Market: around €12 000/week

Large DC10 Supermarket Market: around €90,000 every week

This information helped to monitor total marketing spending and evaluate investment possibilities across several markets, therefore avoiding the early depletion of funds resulting from too ambitious marketing in the first phases.

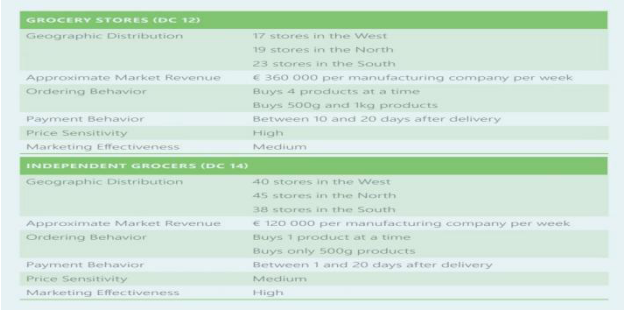
The following chart shows the market characteristics of all distribution channels, helping the author make the most appropriate marketing choices (**Figures 5** and **6**).



Table 5.1: Market Characteristics for All Distribution Channels (DC)

HYPERMARKETS (DC 10)	
Geographic Distribution	3 stores in the West 2 stores in the North 7 stores in the South
Approximate Market Revenue	€ 90 000 per manufacturing company per week
Ordering Behavior	Buys 3 products at a time Buys only 1kg products
Payment Behavior	20 days after delivery
Price Sensitivity	Very High
Marketing Effectiveness	Low

Figure 5. The market characteristics of hypermarkets



GROCERY STORES (DC 12)	
Geographic Distribution	17 stores in the West 19 stores in the North 23 stores in the South
Approximate Market Revenue	€ 360 000 per manufacturing company per week
Ordering Behavior	Buys 4 products at a time Buys 500g and 1kg products
Payment Behavior	Between 10 and 20 days after delivery
Price Sensitivity	High
Marketing Effectiveness	Medium
INDEPENDENT GROCERS (DC 14)	
Geographic Distribution	40 stores in the West 45 stores in the North 38 stores in the South
Approximate Market Revenue	€ 120 000 per manufacturing company per week
Ordering Behavior	Buys 1 product at a time Buys only 500g products
Payment Behavior	Between 1 and 20 days after delivery
Price Sensitivity	Medium
Marketing Effectiveness	High

Figure 6. The market characteristics of grocery stores

4.4. Changing investment depending on the reaction of the market

Tracking sales trends and assessing marketing in many regions was made possible by ZMARKET statistics—e.g., total sales and sales income for every product in every region. Sales data guided changes in the marketing budgets for every product and location. Some convenience store products showed great sales potential, according to findings. The market share soared as the budget for this market rose [7]. The analytical process is as follows.

First, use the ZVC2 report to assess sales performance. Comparing the data will reveal the best-performing products per region.

Step 2: Analyze regional and distribution center sales with ZVA05. The data in this study helped the author discover places with stronger product demand, indicating the need for future investment.

Step 3: Compare the ZMARKET market share data to examine sales volume and pricing trends in different regions to modify marketing strategy.

Step 4: Use the ZCK11 report to determine cost and pricing space to keep prices competitive and pay production costs.

Step 5: Forecast cash flow and marketing spending using the ZFF7B liquidity planning tool to keep the marketing

budget within the company's financial capabilities [8].

When adjusting the author's marketing strategy, the author uses sales orders to quickly find the top-selling products in each region and ZVA05 to quickly check the product's sales channels and order volume and implement the best strategy.

Tables 7–9 indicate product sales channels; if DC10, lower marketing investment. The qty data can also help determine safety stock to guarantee each round has merchandise to sell. This tests team members' communication skills, which can boost efficiency.

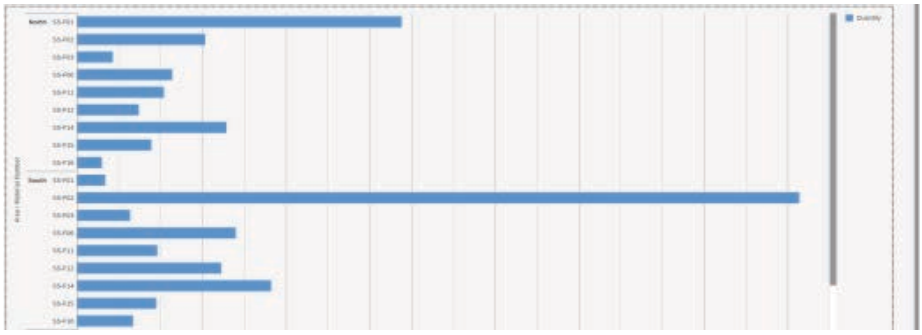


Figure 7. Product sales channels



Figure 8. Stock data



Figure 9. Team member's communication skills

4.5. Marginal effect and adjustment strategy

The game showed that marketing investments had marginal effects. Once a product was established, marketing investment did not enhance sales. It was a resource misallocation [9]. It was vital to avoid excessive investment in

products that had already penetrated markets and reallocate the budget to untapped markets to avoid this issue. This method increased marketing ROI without wasting resources.

Combining a capacity for flexibility with a good decision-making process turned out to be quite helpful. The author constantly changed the marketing budget in line with market data as the game developed, progressively spending more in markets with less competition or more demand. Moreover, regular contact with other team members guarantees that manufacturing and marketing plans complement each other, hence optimizing market share and product visibility.

5. Reflection and evaluation

5.1. Impact of decisions on company performance

The decisions made during the course of the game had a significant impact on the company's performance, both positive and negative. The transition from a make-to-stock (MTS) to a make-to-order (MTO) production strategy resulted in a reduction in inventory accumulation, thereby enhancing cash flow and profit margins. Furthermore, an increase in marketing expenditure resulted in an enhancement of market share, particularly in regions characterized by a paucity of competition. However, missteps, including the repayment of equity instead of debt and the mismanagement of pricing, resulted in a decline in credit rating and sales revenue [10].

Notwithstanding these setbacks, the author contends that the flexible adjustment strategy implemented in subsequent rounds facilitated the company's recovery [11]. It was possible to obtain improved performance in the next rounds by always changing the plans in reaction to sales data, market conditions, and financial situations. The main lessons in financial management are the need for caution while returning loans and the avoidance of too high repayments in uncertain cash flow.

In retrospect, what actions would the author undertake differently? A more cautious approach to inventory and production planning would have been beneficial. In retrospect, it appears that the initial production strategy was excessively aggressive, resulting in an unwarranted accumulation of inventory. A more conservative approach to production in the initial stages of the venture could have circumvented this issue [12].

Early-stage marketing should have seen more aggressive spending. Given the strong initial demand for some products, it would have been wise to increase marketing spending earlier on, especially for things with great future growth potential. A better use of resources in the first phases of the project could have helped to reach a larger market share.

Improved teamwork within departments was another difficulty since poor communication between them led to differences in the production and marketing strategies. Better general performance would have come from more coordinated functional teams.

One of the most challenging aspects of the game was the need to manage the trade-off between short-term profitability and long-term financial stability. The management of cash flow was of paramount importance to achieve an equilibrium between loan repayments and investment in production and marketing. Furthermore, the competitive dynamics between teams resulted in a constantly evolving environment, necessitating the continual adjustment of pricing and marketing strategies [13].

This analysis yields the following main findings: Effective strategic management requires data-driven decision-making. The necessity for data-driven decision-making was the biggest epiphany. The overall performance improved due to informed pricing and marketing modifications made possible by ZMARKET and ZVA05.

Adaptability and responsiveness: The game demonstrated the necessity for flexibility and the capacity to adapt

strategies in response to changing conditions. The efficacy of a given strategy may vary from one round to the next; thus, it is crucial to conduct continuous evaluation and adjustment.

Financial prudence: The game underscored the significance of financial prudence, particularly in the context of loan management. Small, consistent repayments facilitate the maintenance of liquidity without compromising future growth opportunities.

6. ERP knowledge-based decision-making

During the SIM ERP simulation, the course knowledge guided the author in making decisions in marketing and sales, accounting and finance, manufacturing, and materials management.

Using ERP simulation, market segmentation, pricing, and advertising strategies based on marketing course material, sales trends, and market share across product lines and geographies were demonstrated. This made data-driven marketing budget allocation possible to best use resources. For example, budget allocation based on market size-based accuracy of marketing resources by market potential. This approach guarantees market penetration without waste of resources. The author can also modify marketing strategies to fit market trends, competitive dynamics, and demand.

Financial data interpretation and classification in accounting. Ideas in financial management on debt and liquidity inspire the author. Paying on time helps the author to pay off debt while keeping the company's cash flow intact, thus preventing over-indebtedness and sustaining a decent credit score. The accounting module discovered that credit rating and company financing expenses vary depending on loan payback date. Frequent little paybacks kept the business running. Financial statements and cash flow projections offer appropriate plans based on current financial data, therefore lowering the overinvestment risk [14].

Production and materials management modules illuminated the optimal management of these two major domains. The production module made the author think more about inventory management, especially production mode selection. The author switched from "make to stock" (MTS) to "make to order" (MTO), which reduced inventory backlogs, improved market response, and increased cash flow. Production scheduling and materials management expertise allowed adequate production capacity and material acquisition, preventing overproduction and resource waste [15].

7. Key lessons and approach suggestions

A complete simulation analysis yields some valuable lessons for strategic decision-making.

Decisions based on data: The simulation showed that data analysis is essential to decision-making. ZMARKET, ZVA05, and ZFF7B reports help understand market dynamics in real time and alter the strategy plan. This data-driven decision-making method has helped the author comprehend market dynamics and realize the benefits of using data to make decisions. It will also motivate the author to use this evidence-based approach for any future investment decisions.

Strategic decision-making requires adaptability and flexibility. In the simulation, market and corporate financial volatility required the author to adjust the author's plan. This shows how adaptability and flexibility are crucial to strategy creation. In future business decisions, the author will focus more on the need to periodically evaluate and alter strategy to respond quickly to market changes and stay competitive.

Coordination among several departments: The simulation also emphasized interdisciplinary interaction. Sometimes, the departments of marketing, manufacturing, and finance fail to coordinate, therefore wasting resources and producing uneven decisions. Future projects will call for better communication and coordination between other departments to match the team to a shared objective and increase operational effectiveness, therefore avoiding this

problem.

Financial prudence is essential to good management. A cautious financial mindset is increasingly important in financial management. Loan management must address short-term cash flow and long-term financial viability. In the future, the author will balance loan payback and company growth with smart financial management. This requires avoiding excessive debt and supporting the company financially.

The SIM ERP simulation clarified for the author strategic decision-making, cross-functional teamwork, and data analysis in corporate management. From adaptable marketing and sales plans to careful small loan repayments in financial management and sensible inventory control in manufacturing, every choice advances the business toward sustainability and health. This approach helped the author to confirm the author's ERP expertise and spot the author's shortcomings in team communication, resource allocation, and market responsiveness.

Data-driven decision-making will be the first priority; the author will also change with the times and enhance departmental cooperation and communication. Furthermore, influencing the author's future choices will be wise fund utilization and solid financial management. This simulation has helped the author in the profession by clarifying business operations and guiding the author in balancing short-term profitability with long-term stability.

Disclosure statement

The author declares no conflict of interest.

Reference

[1] Alhawamdeh HM, Alsmairat MAK, 2019, Strategic Decision Making and Organization Performance: A Literature Review. International Review of Management and Marketing, 9(4): 95–99.

[2] Alkaraan F, Northcott D, 2013, Strategic Investment Decision-making Processes: The Influence of Contextual Factors. Meditari Accountancy Research, 21(2): 117–143.

[3] Bhushan N, Rai K, 2004, Strategic Decision-Making, in Strategic Decision Making. Springer, London.

[4] Chowdhury IUZ, Adnan M, Safdar Z, 2023, Strategic Financial Management: Exploring the Interplay between Strategic Orientation and Financial Decision-Making in Corporate Settings. Bulletin of Business and Economics, 12(4): 231–237.

[5] Elbanna S, Naguib R, 2009, How Much Does Performance Matter in Strategic Decision Making? Productivity and Performance Management. Meditari Accountancy Research, 21(2): 117–143.

[6] Grundy T, Johnson G, Scholes K, 2022, Strategic Financial Management, thesis Amity University.

[7] Jankelova N, 2017, Strategic Decision Making and Its Importance in Small Corporations, in Corporate Governance and Strategic Decision Making. IntechOpen, London.

[8] Kelly J, Gennard J, 2007, Business Strategic Decision Making: The Role and Influence of Directors. Human Resource Management Journal, 17(2): 99–117.

[9] Klacmer CM, 2017, Business Owner and Manager's Attitudes Towards Financial Decision-making and Strategic Planning: Evidence from Croatian SMEs. Journal of Contemporary Management Issues, 22(1): 103–116.

[10] Narayanan MP, Nanda VK, 2006, Finance for Strategic Decision Making: What non-financial Managers Need to Know. PublicAffairs, New York.

[11] Papadakis VM, Lioukas S, 1998, Strategic Decision-making Processes: The role of Management and context. Strategic Management Journal, 9(2): 115–147.

[12] Polat C, 2008, Forecasting as a Strategic Decision-making Tool: A Review and Discussion with Emphasis on Marketing Management. European Journal of Scientific Research. European Journal of Scientific Research, 20(2): 302–316.

[13] Puranam P, Vanneste B, 2016, Corporate Strategy: Tools for Analysis and Decision-making. Cambridge University Press, Cambridge.

[14] Slater SF, Zwirlein TJ, 1996, The Structure of Financial Strategy: Patterns in Financial Decision Making. Managerial and Decision Economics, 17(3): 253–266.

[15] Weber BW, Clemons EK, 1990, Strategic Information Technology Investments: Guidelines for Decision Making. Journal of Management Information Systems, 7(2): 9–28.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Study on English Translation of Medical Paper Abstract

Yanyan Huang, Mingzhi Pan*, Mingpei Liang, Linkui Wang, Cailiang Li, Shiwu Yang

Editorial Department of Youjiang Medical Journal, Affiliated Hospital of Youjiang Medical University for Ethnicities, Baise 533000, Guangxi, China

Corresponding author: Mingzhi Pan, panmz615@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Translation can play a good role as a carrier for human communication in different regions, which enables people with different types of languages to re-express and exchange ideas according to the original content. Translation can take one language form and adopt another language to express it, to facilitate the readers of the target text to understand the ideas conveyed by the author and generate good feelings. From the perspective of medical papers' abstracts, English translation activities can facilitate a clear understanding of medical development and a deep understanding of the medical progress in China, and provide reference for the medical industry. This paper starts from the perspective of translating medical thesis abstracts, analyzes the application of fuzzy phenomena in medical papers, and discusses the practice of translating medical thesis abstracts under the background of teleology, aiming at providing a reference for the translation of medical thesis abstracts and ensuring that medical researchers can carry out deep researches.

Keywords: Medical papers; Abstract; English translation

Online publication: March 10, 2025

1. Introduction

In science abstracts, simple words are often used to summarize the main content of science and technology literature design, which plays a very important role in systematically reporting and searching science and technology literature. Among them, medical abstracts are one of the expressions of scientific and technological literature. Good medical abstracts can effectively improve the success rate of paper retrieval and collection, and provide convenience for the publicity of medical research results. To effectively connect with the international medical industry, it is necessary to pay attention to the English translation of medical thesis abstracts so that medical research can be carried out smoothly. From the perspective of English translation of medical abstracts, readers usually involve both domestic and foreign groups. Foreign readers are usually native speakers of English, while domestic readers are mostly well-educated readers, who have high expectations for English translation, which involves professionalism and language. Therefore, translators

of medical paper abstracts need to take translation as their goal, understand the genre of medical paper abstracts according to the knowledge structure of the audience, and then effectively complete the translation strategy setting and translate scientific and reasonable translations.

2. The performance of hedges in English translation of medical abstracts

At the level of medical papers, hedges play a communicative role. Scholar Salager Meyer has adjusted and divided hedges into five categories according to linguistic and medical contents. This paper chooses two categories as cases, namely palliative type and expressive type, and combines the example of paper abstracts of a medical university journal in 2021 to carry out an in-depth discussion, aiming at helping medical researchers understand the relevant translation situation.

2.1. Shields

Shields usually contain modals and semi-auxiliary verbs that describe possibilities, such as appear, seem, etc., cognitive verbs, such as suggest, indicate, etc., and possibility adverbs and derived adjectives, such as probably, possibly, etc. From the perspective of abstracts of medical papers, hedges have a good frequency of use.

Example 1: According to medical research, it shows that the serum folic acid level is positively skewed.

In the case of the medical phrase, it is not difficult to find that the two cognitive verbs involved, show and present, can express the subjective reasoning work carried out by the researcher in light of the new conclusion [1]. From the perspective of Chinese connotation, there are similarities between the two, but it shows that the main expression is to grasp the experimental results according to the medical experiment activities and then get the corresponding conclusions. The relevant medical reasoning has the characteristics of subjectivity, and the objective basis can be used as the guarantee. The translation can adopt “indicate”, “suggest”, and so on. On the other hand, in medical phrases, it mainly express objective display, and display or reveal can be selected as the translation. Based on this, the equivalent translation of two cognitive verbs can be realized.

Example 2: According to the results of medical experiments, it shows that the use of this kind of drug use reminder APP can really improve the dosage and medication rate. Through the experiment, it can provide diversified technical means for the development of clinical research and help to alleviate the burden on medical workers and patients.

In the above examples, it is shown that the two words can directly display the experimental results. Because the author’s subjective inference is not strong enough, in the process of word selection in translation, the author needs to choose an affirmative cognitive verb [2]. Therefore, researchers can use the word “Can” to express the author’s emotion directly. In the process of translating medical abstracts into English, the two words do not necessarily need to be displayed in the translation and can be ignored. In the second sentence of case 2, although the modal verb of definite possibility is not involved, the specific translation process needs to clarify the author’s research on clinical medicine and give suggestions on the promotion of clinical medicine technology, which is one of the functions of demonstrating the possibility modal verbs. Starting from the sentence pattern level, there is a logical connection between the two sentences, in which the expression of experimental results in the former sentence provides the possibility for the promotion and use of advanced medical technology in the latter sentence [3]. Therefore, in the process of English translation, the flexible use of non-predicate verbs can accurately express the logical relations of medical papers, avoid the influence of complex sentence structure, and make the paragraphs clear and rigorously structured.

By adding hedges in the translation, the accurate transmission goal of the text content can be satisfied and the

smooth development of medical research can be facilitated.

2.2. Expressions

Expressive hedges can directly express the author's uncertainty, doubts, and participation, such as "I believe", "to our knowledge", and so on. According to the research practice carried out by scholar Meyers, it can be found the collocation of cognitive verbs and first person single and plural hedges can play the role of polite hedges. The purpose is to carry out in-depth communication and verification before their conclusions are accepted by other scholars and provide convenience for the benign interaction between readers and authors [4].

Example 3: We believe in the face of amblyopia patients of different types, degrees, and ages, formal treatment can be adopted to help them recover their vision to the normal level. However, the synchronous stereoscopic vision function has not been constructed in the medical field and targeted adjustment and visual function training are still needed.

In the text of the above case, there are no relevant hedges that researchers think are similar, but in the specific translation, the translation content can be added, as the researchers believe, and then show the research of medical projects, which is the product of teamwork and can improve the communication and affinity of words.

When researchers need to focus on the content, medical researchers of the country rarely use hedges, translate medical theses published in domestic periodicals, and in the writing and contribution process of international periodical papers, and reveal their own opinions as little as possible [5]. For example 3, it belongs to the non-subject statement, which is more common at the conclusion level of the abstract, although it can highlight the objectivity and rigorous research attitude of medical researchers. However, from another point of view, it also shows that the participation of the research team needs to be improved, and some isolation is inevitable. From the perspective of medical papers, authors should not only pay attention to the innovation of research results, but also carefully put forward judgments, communicate with readers, and invite other researchers to verify and analyze the content.

In short, in the process of translating and writing medical papers, researchers need to master the skills of using hedges, describe the content and methods they want to express intuitively through flexible use and operation, effectively control their own views and conclusions, improve the accuracy and flexibility of the language, and visually display the views of researchers to facilitate readers to have in-depth reference [9].

3. Analysis of English abstract translation of medical papers based on Skopos theory

3.1. Words

The abstract of medical papers often involves a lot of medical terms. These terms have the characteristics of being accurate, concise, and comprehensive, which is mainly affected by the abstract of medical papers, constantly reducing the necessary expression, as much as possible to reduce the delay and show a clear style. Based on this, in the process of translating medical paper abstracts, it is necessary to pay attention to the simplicity of words, avoid unclear expressions, and deviate from the actual content, to facilitate readers to read.

Example 4: Taking ankle-brachial index (ABI) as the basis, combined with Rutherford classification and other indicators, medical evaluation was carried out to judge the effects of different surgical methods.

In the writing of medical abstracts, through and other structural ways to express, are usually used to effectively achieve the goal of research. It is influenced by the Chinese way of thinking. In the actual translation process, the translator often uses the traditional way to translate, takes the same concept as the basis, grasps different kinds of expressions, chooses concise expression forms, effectively simplifies the English translation vocabulary, and makes the abstract of medical papers accurate, concise and comprehensive [6]. In addition, in the common medical paper abstracts,

in addition to the expression of common words, it is also easy to be influenced by Chinese thinking. In the translation process, translators carry out word-to-word translation for medical terms, which not only makes the translation appear stiff but also easily brings a layman's impression to readers.

3.2. Sentence structure

Starting from the sentence structure level of medical thesis abstracts, English usually regards vocabulary as the unit of syntactic structure, in which grammatical components play an independent role in the sentence. For example, a complete sentence pattern needs the subject and predicate, in which the various elements of the sentence are connected by way of connectives, keywords, and prepositions, and are constrained by grammar. However, the Chinese habit is obviously the opposite. In Chinese, characters belong to the smallest syntactic unit, in which the structure of characters is clear and they have strong independence. Therefore, in the process of sentence formation, they can be freely combined and flexible characteristics can be implemented. Among them, the syntactic correlation of Chinese is usually demonstrated by word order and semantics. The main reason is that Chinese does not have strict morphological changes, and the differentiation of word classes is not obvious. Therefore, in the process of translating medical papers, translators need to take objective theory as the basis, pay attention to the differences between English and Chinese sentence patterns, and then translate the translation which is convenient for readers to read.

First, pay attention to the modifiers of nouns. Influenced by the syntactic structure of Chinese, translators who use Chinese as their mother tongue are usually accustomed to using the combination of adjectives and nouns in the process of using a variety of adjectives to improve their modifiers. This setting of syntactic structure can show that adjectives can modify nouns, complete the left extension of information, and add multiple modifiers before nouns. At the same time, modifiers can be added on both sides of the English center words, which can break the length limitation compared with the corresponding modifiers, and the posterior modifiers have a broader space and freedom of expansion [7]. When there are multiple adjectives in a sentence to modify one or more nouns, it is easy to confuse the relationship between attributive and central words. Therefore, in the English translation of medical abstracts, it is necessary to attach importance to the relationship between attributive and central words and show them clearly and clearly.

Second, solve the problem that translation may be top-heavy. Chinese attaches great importance to parataxis and is not strict enough in the structure of actual sentences, while English attaches great importance to hypotaxis and requires sentence structure to meet grammatical standards. In English sentence structure, the two key principles are the end center and the center of gravity. To implement these principles effectively, it is necessary to pay attention to the backwardness of the original subject. When the backwardness is complete, it can not only emphasize the subject of the sentence but also make the sentence structure more symmetrical. In the above contents, there are obvious differences between Chinese and English. In the translation of medical abstracts into English, the first problem to be solved is top-heavy.

The Skopos theory provides a new reference for the translation of medical abstracts into English. Translators need to combine translation objectives, grasp the knowledge structure and habits of readers, adjust translation strategies, and consider the differences between Chinese and English in terms of words and sentences [8]. In this regard, translators should not only have a good grasp of medical knowledge and deepen their understanding of the writing styles of domestic and foreign journals but also have a solid theoretical foundation in both Chinese and English, to help readers grasp readability information. Through in-depth efforts, the quality of English translation of medical paper abstracts can be promoted as soon as possible, so that Chinese medical papers will have a higher international competitiveness.

4. Conclusion

To sum up, in the process of translation of medical abstracts into English, there are some common techniques with traditional translation, but it also has unique characteristics. In the face of the differences in translation content, there are differences in translation requirements and emphases in practice. Therefore, in medical translation work, it is necessary to be careful and cautious, not only through the repeated use of professional English dictionaries but also through the reading of original English documents in subsequent learning. Through the grasp of Skopos theory and ambiguity phenomenon, translation can be carried out smoothly, helping students to understand the professional field, deepen the mastery of professional knowledge, and effectively transfer medical knowledge. At the same time, in the submission of medical journals, it is necessary to grasp different language characteristics, combine them with cultural background, understand the use of hedges norms, and effectively improve the accuracy of translation [10]. Based on this, the improvement of the cross-cultural level of medical researchers can realize the docking with international medical technology in the subsequent wave of globalization.

Funding

2024 Publication Research Series Project Number: GUI Ke (Ed.) [2024]T-q04
Project category: Youth Cultivation project
Project name: Problems in Translation of English Abstracts of Medical Journals and Countermeasures

Disclosure statement

The author declares no conflict of interest.

References

[1] Hu XJ, Jin LG, Ye NH, et al., 2024, A Study on the English Translation of Abstracts of Medical Papers Under the Relevance-Adaptation Model. Medical Language and Culture Studies, 2023(1): 65–74.

[2] Si Yue, Wang LL, 2023, Differences on Space-time Thinking Perspective Medical Paper Translation, This Paper Explores. Journal of English Square, 2023(7): 7–11.

[3] Liu MR, 2020, A Study on the Selection of Personal Pronouns in the Translation of Medical Abstract from English to Chinese under the Guidance of German Functionalist Translation Theory. Which College Journal, 33(6): 120–122.

[4] Ge X, 2019, Ambiguities in Translation of Medical Abstracts. Journal of Hefei University of Technology (Social Sciences Edition), 33(6): 97–102.

[5] Liang W, 2018, Translation of Abstracts of Medical Papers from the Perspective of Receiving Aesthetic Readers' Attention. On Science and Education Wenhui (Ten-day), 2018(1): 180–182.

[6] Li L, Fan WQ, 2017, Thinking Mechanism of Multi-level Reconstruction in Translation of Scientific Abstracts: A Case Study of Medical Abstracts. The Chinese Translation of Science and Technology, 30(3): 53–56.

[7] Zeng LJ, 2023, The Chinese Translation Method of English Post-modifier, thesis, Beijing Foreign Studies University.

[8] Wang JJ, 2021, Translation of a Medical Paper Abstract from a Teleological Perspective. English Square, 2021(6): 45–47.

[9] Fu TT, Ma JW, Shao WJ, et al., 2024, Analysis of Translation Problems and Writing Methods of Medical Papers. Science and Technology Communication, 16(1): 73–76 + 80.

[10] Li DX, Luo J, 2024, Translation Strategy of English Medical Review from the Perspective of Teleology. English Square (Academic Research), 2024(10): 28–31.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Exploring the Path of Inheritance, Innovation, and IP Development for Midu Lantern

Ruiji Shengchuan[1]*, Yichun Zhangluo[2]

[1]School of Music and Dance, Guangzhou University, Guangzhou 510006, Guangdong, China

[2]Tianjin Chengjian University, Tianjin 300380, China

Corresponding author: Ruiji Shengchuan, 33c99rj-4@gzhu.edu.cn

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Midu Lantern, an important genre of Yunnan lanterns, has a national-level intangible cultural heritage and possesses profound historical and cultural significance along with unique artistic charm. Through analyzing the historical origins, artistic characteristics, and current inheritance status of Midu Lantern, this paper explores strategies for its preservation, innovation, and IP-based development path. The study suggests that Midu Lantern should innovate and develop while preserving its traditional characteristics, based on inheriting traditional skills and combining modern technology with market demands. By creating an IP image, developing cultural and creative products, and organizing cultural activities, the popularity and influence of Midu Lantern can be enhanced, realizing its sustainable development in contemporary society.

Keywords: Midu Lantern; Inheritance and innovation; IP-based development; Cultural inheritance

Online publication: March 10, 2025

1. Introduction

Midu Lantern, a significant representative of Yunnan lanterns, boasts a long history, rich cultural connotations, and distinctive artistic appeal [1]. Originating in the Tang Dynasty and forming during the Ming and Qing Dynasties, it has evolved into a cultural treasure in the Midu region and even the entire Yunnan area [2]. Beloved by the masses for its elegant melodies, exquisite performances, diverse dance forms, and unique folk cultural connotations, Midu Lantern faces challenges of inheritance and market competition in the rapidly developing modern society. Therefore, how to preserve, innovate, and promote the IP-based development of Midu Lantern has become an urgent issue to address.

2. Overview of Midu Lantern

2.1. Historical origins

The origins of Midu Lantern can be traced back to the Tang Dynasty [3]. Historical records indicate lantern performances

in the Midu region during that period. In the Ming and Qing Dynasties, Midu Lantern gradually developed into a unique style of local opera, absorbing musical, dance, and folk cultural elements from local ethnic groups like the Yi and Bai, forming a rich and colorful artistic form [4]. In 2008, Midu Lantern was listed in the second batch of national intangible cultural heritage protection lists by the State Council, becoming an essential component of traditional Chinese culture [5].

2.2. Artistic characteristics

2.2.1. Diversified performance forms

Midu Lantern performances mainly include small singing, big singing, and excerpted plays. Small singing focuses on singing, with a bright rhythm and beautiful melody; big singing incorporates dance and performance elements based on small singing, making the form more diverse and colorful; excerpted plays are theatrical performances with complete storylines, vividly showcasing the characters and emotional worlds through the exquisite performances of actors.

2.2.2. Unique musical singing style

The musical singing style of Midu Lanterns is dominated by Zheng and Yu modes, with a beautiful melody, bright rhythm, and strong local characteristics [6]. Its singing style integrates elements of Central Plains music, Jiangnan tunes, and local ethnic music, forming a unique musical genre. Simultaneously, Midu Lantern singing emphasizes rhythm variations and melody fluctuations, expressing different emotions and artistic conceptions through changes in sound pitch, strength, and speed.

2.2.3. Graceful dance moves

The dance moves of Midu Lanterns possess unique artistic charm. These moves integrate dance elements from the Han, Yi, and Bai ethnic groups, resulting in a rich and varied dance form. Midu Lantern dance moves emphasize bodily coordination and rhythmic sense, expressing different emotions and artistic conceptions through variations in body posture, gestures, and steps. Additionally, these dance moves involve certain technical skills, such as walking on stilts, playing with dragon lanterns, and lion dancing, which not only enhance the performance's visual appeal but also reflect the folk art characteristics of Midu Lanterns.

2.2.4. Rich folk cultural connotation

Midu Lantern is an essential component of the folk culture in the Midu region, containing rich folklore connotations [7]. Midu Lantern performances are often combined with local festivals, temple gatherings, and other folklore activities, becoming an important way for people to express blessings and pray for peace. Simultaneously, the lyrics and performance content of Midu Lanterns reflects the local people's lifestyle, emotions, and values, exhibiting strong local flavor and cultural heritage.

2.3. Current inheritance status

Despite its profound historical and cultural heritage and unique artistic charm, the inheritance of Midu Lanterns faces challenges and difficulties in the rapidly developing modern society. The specific manifestations are as follows.

2.3.1. Limited Inheritance Subjects

The inheritance of Midu Lanterns mainly relies on a few professional actors and folk artists, resulting in limited inheritance subjects [8]. Simultaneously, due to the limited number of professional actors and folk artists, their inheritance capabilities and levels vary, making it difficult to meet the needs of Midu Lantern inheritance, wider promotion, and dissemination.

2.3.2. Traditional inheritance methods

Midu Lantern inheritance is primarily transmitted through apprenticeship and oral tradition [9]. Although this inheritance method ensures the traditional skills and cultural connotations of Midu Lanterns are passed down, it also suffers from issues such as low inheritance efficiency and narrow inheritance scope. Meanwhile, due to the fast-paced development of modern society, this traditional inheritance method has become difficult to adapt to the diverse needs of the times, requiring innovation and reform.

2.3.3. Weak market competitiveness

In the modern cultural market competition, Midu Lanterns face competition from various cultural forms such as movies, television, and the internet, resulting in weak market competitiveness. Simultaneously, due to limited funds for external promotion, the popularity and influence of Midu Lanterns are relatively limited nationwide, making it difficult to attract more external audiences and investors' attention.

3. Strategies for the inheritance and innovation of Midu Lanterns

3.1. Strengthening the cultivation of inheritance subjects

3.1.1. Enhancing school education

Schools are important fronts for inheriting Midu Lanterns, and educational work related to Midu Lanterns should be strengthened. In school education, especially in basic education, courses related to Midu Lanterns should be offered to allow students to understand and become familiar with the historical origins, artistic characteristics, and cultural connotations of Midu Lanterns. This will cultivate their interest and love for Midu Lanterns, thereby enhancing cultural confidence. Simultaneously, students should be organized to participate in Midu Lantern performances and practical activities at fixed locations and times to improve their performance skills and practical abilities.

3.1.2. Cultivating folk artists

Folk artists are a crucial force in the inheritance of Midu Lanterns, and their cultivation and support should be strengthened. Annual training sessions, seminars, and other activities should be organized to enhance the performance skills and creative abilities of folk artists. Additionally, a digital archive of folk artists should be established to record and preserve their skills and representative works, providing sustainable talent support for the inheritance and development of Midu Lanterns.

3.1.3. Encouraging young people to participate

Young people are the future and hope of Midu Lantern inheritance. Local governments and relevant academic associations should encourage young people to participate in the inheritance and innovation of Midu Lanterns. By organizing diverse cultural activities that appeal to young people at fixed times every year, more local and external young people can be attracted to focus on Midu Lanterns. Simultaneously, more performance opportunities and development spaces should be provided for young people, allowing them to leverage their advantages and expertise in the process of inheriting and innovating Midu Lanterns.

3.2. Innovating inheritance methods

3.2.1. Utilizing modern technological means

Modern technological means provide new opportunities and platforms for the inheritance and innovation of Midu

Lanterns. Technologies such as Virtual Reality (VR) and Augmented Reality (AR) can be utilized to enrich the experience and effects of Midu Lantern performances and displays. For instance, VR technology can immerse audiences in the performance scene of Midu Lanterns, enhancing their sense of participation and experience.

3.2.2. Conducting cross-border cooperation

Midu Lanterns should closely cooperate with other art forms and cultural industries to expand their inheritance and development space. For example, collaborations can be established with dance, music, and other art forms to create more diverse and enriching new artistic works. Simultaneously, cooperation can be sought with cultural industries such as tourism, film and television, and animation to develop a series of cultural products and tourism projects featuring Midu Lanterns.

3.2.3. Promoting cultural innovation

Based on inheriting the traditional skills of Midu Lanterns, cultural innovation should be continuously promoted to inject new vitality and connotation into Midu Lanterns. While preserving traditional characteristics, innovations and reforms can be made to the performance forms, musical singing styles, dance moves, and other aspects of Midu Lanterns, taking into account the needs and aesthetic concepts of modern society. This will result in the creation of Midu Lantern works that better align with contemporary aesthetic characteristics. Simultaneously, Midu Lanterns can be combined with hot topics and cultural themes in contemporary society to produce a batch of Midu Lantern works with significant meaning for the times.

3.3. Strengthening brand building

3.3.1. Creating a brand image

The brand image is a crucial aspect of Midu Lantern brand building, and emphasis should be placed on creating a brand image that reflects the characteristics of Midu Lanterns. This can be achieved by designing unique brand logos, clothing, props, and other elements to create a visual effect that embodies the essence of Midu Lanterns. Simultaneously, brand activities and promotional materials can be organized to enhance the brand awareness and influence of Midu Lanterns.

3.3.2. Reinforcing brand promotion

Brand promotion is a vital means of building the Midu Lantern brand, and efforts should be intensified in this regard. Television, newspapers, the internet, and other media platforms can be utilized for extensive promotional coverage of Midu Lanterns. Additionally, organizing Midu Lantern cultural festivals and participating in domestic and international traditional cultural exchange activities can expand the popularity and influence of Midu Lanterns.

3.3.3. Protecting brand intellectual property

Protecting brand intellectual property is a critical aspect of Midu Lantern brand building, and efforts should be made to strengthen this protection. This can be achieved by applying for trademarks, patents, and other forms of intellectual property protection for Midu Lanterns. Simultaneously, it is essential to strengthen the management and supervision of the Midu Lantern brand to prevent brand infringement and counterfeiting.

4. Exploring the IP path of Midu Lantern

4.1. Clear IP positioning

4.1.1. Cultural positioning

As an art form with a profound historical and cultural heritage, the IP positioning of Midu Lantern should highlight its cultural characteristics. By combining the cultural connotations of Midu Lantern with the values of modern society, a cultural IP with contemporary characteristics can be created. For example, themes such as love, friendship, and family in Midu Lantern can be integrated with the emotional needs of modern society to create cultural works that evoke emotional resonance.

4.1.2. Regional positioning

Midu Lantern is a cultural treasure of the Midu region, and its IP positioning should emphasize regional characteristics. By combining the Midu Lantern with natural scenery, folk culture, and other elements of the Midu area, a cultural IP with regional features can be forged. For instance, elements like the rural scenery and the Ancient Tea Horse Road in Midu can be integrated with Midu Lantern to produce cultural works that reflect the region's uniqueness.

4.1.3. Artistic positioning

Midu Lantern, with its beautiful singing, exquisite performances, rich dance forms, and unique folk culture connotations, possesses high artistic value. Its IP positioning should accentuate these artistic qualities. By merging the artistic charm of Midu Lantern with modern artistic design concepts, a culturally valuable IP can be shaped. For example, elements of Midu Lantern's singing, acting, and dance can be combined with modern music, dance, theater, and other art forms to create culturally significant works.

4.2. Developing IP products

4.2.1. Cultural and creative product development

Cultural and creative products are crucial carriers for the IP development of Midu Lantern. A series of cultural and creative products featuring Midu Lantern can be developed, such as clothing, accessories, toys, stationery, and water bottles. These products not only satisfy consumers' aesthetic needs but also spread the cultural connotations of Midu Lantern to a broader audience.

4.2.2. Digital product development

Digital products represent a significant trend in the IP development of Midu Lantern. Digital products featuring Midu Lantern, such as mobile games, anime, movies, and other digital content, can be created. These not only cater to consumers' entertainment needs but also promote and disseminate the cultural essence of Midu Lantern more widely.

4.2.3. Tourism product development

Tourism products are vital for the IP advancement of Midu Lantern. Tourism products that highlight Midu Lantern, such as cultural tourism routes, attractions, and performances (both online and offline), can be developed. These not only meet tourists' needs but also spread the cultural message of Midu Lantern to the outside world.

4.3. Forging the IP industry chain

4.3.1. Creation and production

The creation and production phase is the foundation for the IP development of Midu Lantern. Efforts should be

intensified in creating and producing Midu Lantern works. Professional creative teams can be invited and organized to conduct field research, deeply exploring more cultural and artistic features of Midu Lantern, and creating works that reflect contemporary characteristics and artistic value. Simultaneously, copyright protection for Midu Lantern works should be strengthened to prevent theft and infringement.

4.3.2. Brand promotion

Brand promotion is a critical aspect of Midu Lantern's IP advancement. Multi-channel brand promotion efforts should be intensified. Television, newspapers, the internet, and other media platforms can be utilized for publicity and reporting on Midu Lantern. Additionally, organizing Midu Lantern cultural festivals and participating in domestic and international cultural exchange activities can expand the popularity and influence of Midu Lantern both domestically and internationally.

4.3.3. Market sales

The market sales segment is a vital aspect of Midu Lantern's IP progress. Market sales efforts for Midu Lantern should be bolstered. A comprehensive marketing system can be established, enhancing sales channel development for Midu Lantern products. Simultaneously, consumer demand analysis should be strengthened to develop Midu Lantern products that cater to different age groups, improving the products' market competitiveness.

4.4. Enhancing IP operation and management

4.4.1. Talent cultivation

Talent is a crucial pillar for the IP advancement of Midu Lantern. Efforts should be made to cultivate talents in IP operation and management. Training courses, seminars, and advanced studies can be organized to enhance the professional quality and business capabilities of IP operation and management talents. Simultaneously, efforts should be made to attract and cultivate more outstanding talents to join the team for the IP development of Midu Lantern.

4.4.2. Brand management

Brand management is a vital aspect of Midu Lantern's IP progress. Management efforts for the brand should be intensified. A comprehensive brand management system can be established, strengthening the management of trademarks, patents, copyrights, and other aspects of the brand. Additionally, brand image building, promotion, and publicity should be enhanced to increase brand awareness and influence.

4.4.3. Risk management

Risk management is a crucial part of Midu Lantern's IP advancement. Risk assessment and management during the IP development process should be strengthened. A comprehensive risk assessment system can be established to conduct periodic evaluations and continuous analysis of potential risks during the IP development process. Simultaneously, risk warning and response measures should be strengthened to timely adopt effective measures to address risks and minimize risk losses.

5. Conclusion

As an integral part of traditional Chinese culture, the Midu Lantern possesses a profound historical and cultural heritage and unique artistic charm. In the rapidly developing modern society, Midu Lantern faces challenges such as

inheritance difficulties and market competition. Therefore, it is imperative to strengthen the inheritance, innovation, and IP development of Midu Lantern. Measures such as enhancing the cultivation of inheritance subjects, innovating inheritance methods, strengthening brand building, clarifying IP positioning, developing IP products, forging the IP industry chain, and reinforcing IP operation and management should be taken to promote the sustainable development of Midu Lantern in contemporary society. Simultaneously, continuous protection and inheritance of the Midu Lantern should be strengthened, allowing this unique traditional culture to continue to radiate new vitality and dynamism in the new era.

Funding

Guangzhou Municipal Bureau of Education 2024 College Research Project: Phase I Research Results of the Innovative Research on Folk Art Education in Guangzhou Colleges and Universities under the Background of Digital Transformation (Project No. 2024312462)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Li G, 2017, Intangible Cultural Heritage Application and Cultural Reconstruction — Taking Yunnan Midu Lantern as an Example. Journal of Dali University, 2(7): 75–79.

[2] Yang JS, 2015, On the Mountain Song Elements in Midu Lantern Music. Northern Music, 2015(7): 11.

[3] Zhang H, 2011, Inheritance and Development of Midu Lantern. Ethnic Music, 2011(4): 30.

[4] Li ZH, 1995, A Preliminary Study on Midu Lantern Music. National Art Studies, 1995(1): 59.

[5] Peng ZF, 1994, Brief Exploration of the Origin of Midu Folk Songs and Lanterns. National Art Studies, 1994(1): 33.

[6] Wang GX, 1994, The Performance Form of Midu Lantern. Ethnic Music, 1994(4): 53.

[7] Hu RM, 2013, A Brief Discussion on the Protection and Inheritance of Yunnan Lantern Opera. Ethnic Music, 2013(1): 21.

[8] Li CY, 2005, Investigation Report on Folk Lantern Art in Mizhi Township, Midu County, Dali. National Art Studies, 2005(4): 76.

[9] Wen LZH, Li Y, Wei SS, 2013, For the Source of Living Water — A Preliminary Exploration of the Source of the Famous Song “Little River Flowing”. Ethnic Music, 2013(2): 10.

Publisher’s note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Integrating Functional Principal Component Analysis with Generalized Regression Neural Networks for Enhanced Forecasting of New Energy Vehicle Market Trends

Long Chen*, Yong Wang, Qianhao Cheng, Shuxian Shen, Ying Wang

Anqing Normal University, Anqing 246133, Anhui Province, China

Corresponding author: Long Chen, 3464842084@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: With the rapid development of the new energy vehicle (NEV) industry, it has become a critical component of modern productivity, offering immense potential for economic growth and environmental benefits. However, accurately predicting NEV trends, such as sales volume and the annual installed capacity of power batteries, remains challenging due to the high dimensionality of data and the limitations of existing predictive methods. In view of these challenges, this paper proposes a novel prediction method that combines Functional Principal Component Analysis (FPCA) and Generalized Regression Neural Network (GRNN) to forecast NEV sales and power battery installation trends. By employing FPCA to reduce the dimensionality of nine key variables and using GRNN to incorporate seven influencing factors, such as ownership and total energy consumption, the study constructs a robust predictive model. The GRNN model is further optimized using cross-validation, achieving a high level of accuracy. It is hoped that the proposed FPCA-GRNN method, which has demonstrated superior performance compared to traditional approaches such as BP neural networks and multiple linear regression, will serve as a valuable tool for predicting NEV development trends and provide guidance for industry growth and policy-making in the NEV sector.

Keywords: Functional principal component analysis; Generalized regression neural network; Legendre polynomials; Multiple linear regression prediction

Online publication: March 10, 2025

1. Introduction

In the context of globalization, new energy vehicles (NEVs) have emerged as a promising solution to address energy and environmental challenges. By reducing reliance on fossil fuels and fostering environmental awareness, NEVs play a pivotal role in enhancing energy security, driving industrial upgrades, and promoting technological innovation. As a cornerstone of sustainable economic and social development, NEVs have garnered significant attention globally. To support their growth, governments worldwide have implemented a range of policies, such as setting ambitious sales targets, offering purchase subsidies, restricting traditional fuel vehicles, and expanding charging infrastructure. These

initiatives have effectively lowered costs, improved accessibility, and spurred innovation across the NEV industry chain.

In China, the world's largest NEV market, industrial progress is particularly vital to the reform and sustainable development of the global automotive industry. Recent data highlights the remarkable growth of China's NEV sector, driven by technological advancements, increasing market demand, and improvements in the industry chain. Research focused on forecasting the development trends of NEVs is essential for optimizing industry strategies and guiding policymaking. Accurate predictions of sales volume and battery installation capacity are key to promoting advanced productivity and achieving high-quality economic growth [1].

Despite the significant strides made in NEV development, challenges remain in forecasting future trends due to the high dimensionality of relevant data and the limitations of existing predictive models. This study aims to address these gaps by proposing a novel prediction method that combines Functional Principal Component Analysis (FPCA) and Generalized Regression Neural Network (GRNN). By leveraging these advanced methodologies, this research provides a comprehensive framework for accurately forecasting NEV sales and battery installations, offering valuable insights to support industrial and policy decision-making.

2. Functional principal component analysis

2.1. FPCA principal component analysis

Functional principal component analysis (FPCA) is a statistical method for analyzing functional data, where functions are treated as the basic units of data rather than traditional individual data points [2]. FPCA aims to identify major patterns of variability within the data in function space, maximizing the interpretation of data variability by linearly combining the original data. Similar to principal component analysis (PCA), FPCA identifies principal components that are orthogonal to each other, which allows for dimensionality reduction. FPCA works by calculating the covariance matrix of the data and its eigenvalues and eigenvectors. The principal components that explain the most variability are then selected for effective data fitting and dimensionality reduction. In addition, correlation analysis using SPSS was conducted to examine the relationships between key factors and market indicators, providing valuable insights into the factors influencing market trends. Use selected principal components to reconstruct raw functional type data. Select the most important principal components to explain most of the variance in the data. This is usually achieved by retaining principal components that explain more than a certain threshold of variance. Functional principal components normalized data are shown in **Figure 1** and principal components and target variables in **Figure 2**.

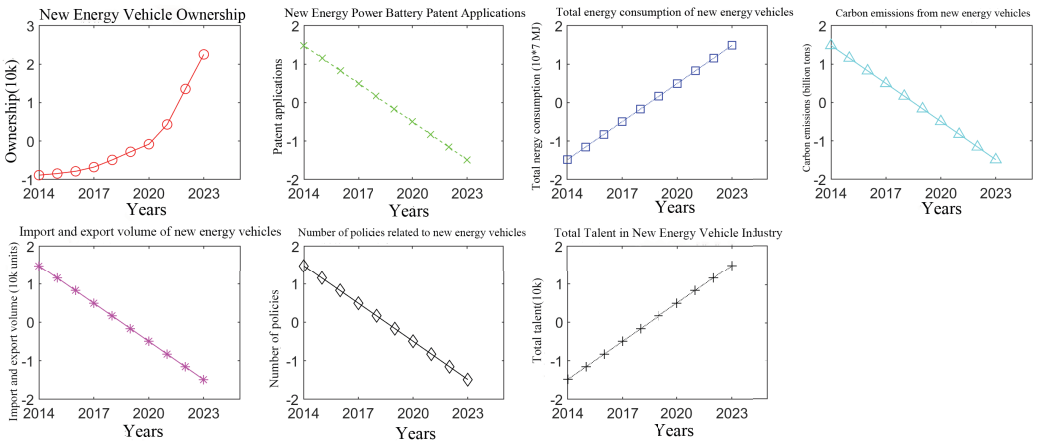


Figure 1. Function principal component normalized data image

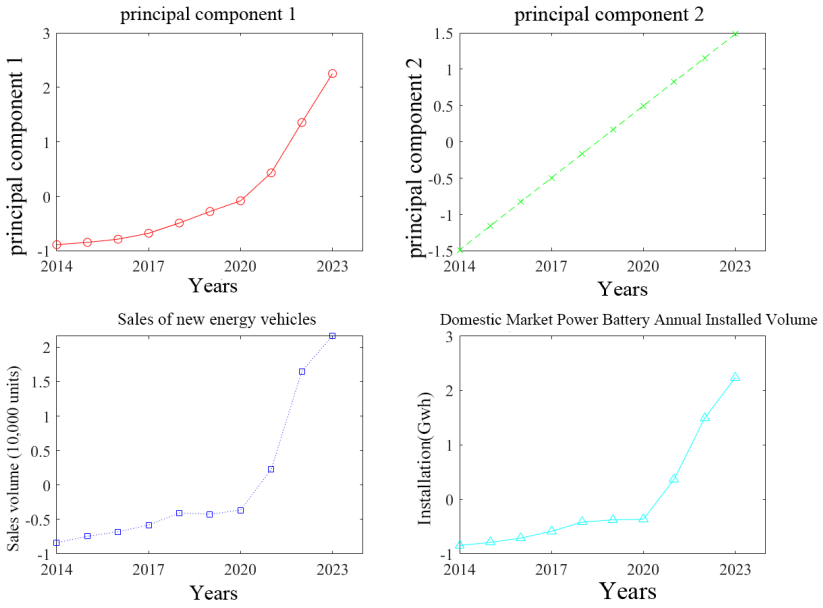


Figure 2. Trends in principal components and target variables

2.2. Calculating Legendre polynomials

This paper uses the Legendre function expansion method, where the Legendre functions are orthogonal polynomials, resulting in a symmetric matrix$W$. The resulting symmetric matrix$W$ is a unit matrix [3]. If other non-orthogonal basis functions are used, it is unavoidable to calculate each elementW_{ij} in the matrix$W$. If the order increases, the computation becomes more complicated. Each element W_{ij} of the matrix$W$ is inevitably computed, and if the computational effort is large as the order increases, it is fitted as shown in *Figure 3*.

$$f(x) = 0.0072771 - 44.0098x_1 + 88719.8687x_2 \\ -59617172.2584x_3 - 2.7022 \times 10^{-8}x_4 + 3.7497 \times 10^{-11}x_5$$

The Legendre multinomial equation is obtained as follows.

$$P_l(x) = \sum_{j=0}^{\left[\frac{l}{2}\right]} (-1)^j \frac{(2l-2j)}{2^l j!\,(l-j)!\,(j-2j)!} x^{l-2j}$$

$$\left[\frac{l}{2}\right] = \begin{cases} \frac{l}{2}, l = 2n \\ \frac{l-1}{2}, l = 2n+1 \end{cases} \quad (n = 0,1,2,\cdots)$$

$$P_0(x) = 1, P_1(x) = x, P_2(x) = \frac{1}{2}(3x^2-1), P_3(x) = \frac{1}{2}(5x^3-3x), P_4(x) \\ = \frac{1}{8}(35x^4 - 30x^2 + 3)$$

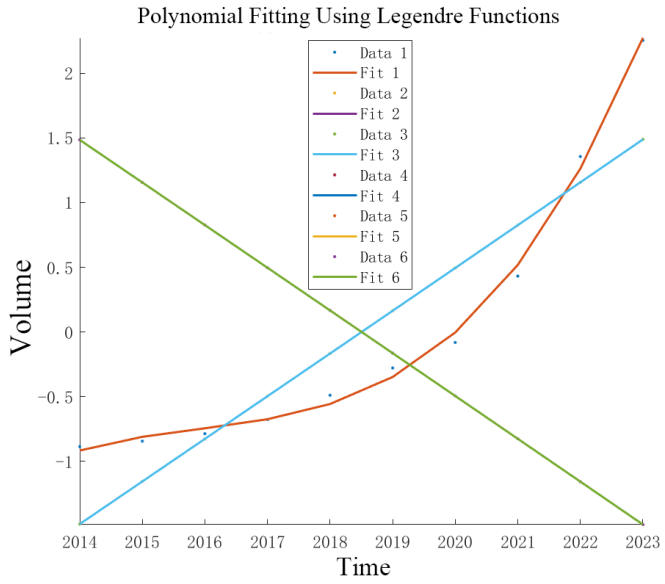


Figure 3. Legendre polynomial function fitted image

2.3. FPCA analysis results

FPCA retains as much information as possible from the original variables by extracting a small number of uncorrelated principal components. It achieves this by calculating the correlation or covariance matrix of the sample data and selecting the eigenvectors corresponding to the largest eigenvalues for dimensionality reduction. In this study, SPSS was used to conduct a correlation analysis of the seven factors influencing the annual installed capacity of power batteries and the sales volume of new energy vehicles in the domestic market. The results of the correlation analysis are summarized in the correlation coefficient matrix presented in **Table 1**.

Table 1. Matrix of correlation coefficients of observed variables

	Retention (10,000 units)	**Battery patent applications (pieces)**	**Total energy consumption (10*7 MJ)**	**Total carbon emissions (billion tonnes)**	**Import and export volume (10,000 units)**	**Number of relevant policies (number)**	**Total number of talents (10,000)**
Retention (10,000 units)	1.000						
Battery Patent applications (pieces)	0.916	1.000					
Total energy consumption (10*7 MJ)	0.930	0.941	1.000				
Total carbon emissions (billion tonnes)	0.729	0.854	0.874	1.000			
Import and export volume (10,000 units)	0.981	0.878	0.865	0.672	1.000		
Number of relevant policies (number)	0.461	0.526	0.504	0.737	0.526	1.000	
Total number of talents (10,000)	0.853	0.963	0.954	0.886	0.799	0.539	1.000

There is a strong correlation between several influencing factors. For instance, the correlation coefficient between import and export volume and retention volume is 0.9810. Additionally, the correlation coefficients between total talent volume and patent volume and between total talent volume and energy consumption are 0.9633 and 0.9538, respectively. To avoid the complexity and overfitting caused by these high correlations, FPCA is used to reduce the dimensionality of the new energy market development factors. This process converts the high-dimensional data into

a low-dimensional principal component dataset. The principal components retain most of the original information and have low correlation, simplifying the neural network inputs and improving both the training process and model generalization ability. Thus, FPCA effectively addresses the problem of variable correlation in new energy market prediction. The principal component analysis reveals that the eigenvalues of the first three components decrease sharply, dominating the explanatory power. In contrast, the eigenvalues of the subsequent three components decrease more gradually and remain small. Therefore, to simplify the model while retaining the main information, it is more appropriate to extract the first two factors as principal components for analysis. These two principal components can then be used to construct the calculation expression by treating their eigen contributions as coefficients, with the corresponding influencing factors as independent variables.

$$\begin{aligned} 0.127F_1 =& -0.2269x_1 - 0.0332x_2 + 0.4253x_3 + 0.4593x_4 + 0.5391x_5 \\ & + 0.5145x_6 + 0.0157x_7 \\ 0.974F_2 =& \ 0.5552x_1 - 0.7567x_2 - 0.2281x_3 + 0.1589x_4 + 0.0673x_5 \\ & + 0.1694x_6 + 0.0931x_7 \\ -0.003F_3 =& -0.2727x_1 - 0.1035x_2 - 0.0222x_3 - 0.0893x_4 - 0.0314x_5 \\ & - 0.0249x_6 + 0.9512x_7 \end{aligned}$$

Where: F_1, F_2, and F_3 are principal component eigenvectors; x_1, x_2, x_3, x_4, x_5, x_6, and x_7 are standardized data.

2.4. Summary of the chapter

In this chapter, FPCA is applied to the weight analysis and correlation modeling of nine variables related to new energy vehicles. The principal components are extracted through dimensionality reduction, providing key data such as sales volume and vehicle loading volume. Next, the data are standardized, and a standardization matrix is established to analyze the cumulative contribution and correlation coefficients. The correlation coefficient graph and feature vector are then generated. The trends of the principal components are visualized, and Legendre polynomials are used for computational fitting, which effectively addresses the orthogonality and recurrence relationships in FPCA. Finally, using the two extracted principal component eigenvectors and the standardized data, principal component expressions are constructed to derive the functional relationships of FPCA.

3. Prediction by multiple linear regression

3.1. Establishing a functional equation for predicting the target variable from the raw data

According to the respective new energy vehicle ownership (10,000 units), annual patent applications for new energy power battery is as follows.

(10*7 MJ), total energy consumption of new energy vehicles (10*7 MJ), total carbon emissions of new energy vehicles (billion tons), import and export volume of new energy vehicles (10,000 units), number of relevant policies promulgated for new energy vehicles, total number of talents in the new energy vehicle industry, etc., respectively. Import and export volume of new energy vehicles (10,000 units), number of relevant policies enacted for new energy vehicles, total number of talents in the new energy vehicle industry (10,000)（The seven data on new energy vehicles as independent variables are analyzed and forecasted, and the annual installed capacity of power battery (Gwh) in the domestic market is analyzed and forecasted. The annual installed battery volume (Gwh) and the sales volume of new energy vehicles (10,000 units) are used as dependent variables, and the MLR is used to build a model for new energy vehicles [4].

The prediction model for new energy vehicles is established by adopting MLR, and the functional equations of the

prediction model are as follows.

Predictive function equation for the first dependent variable:

$$Y_{i+1} = -1.615 \times 10^{-14} - 2.5345 \times 10^{-18} \times X_1 - 2.4432 \times 10^{-14} \times X_2 \\ -5.839 \times 10^{-17} \times X_3 - 4.3043 \times 10^{-16} \times X_4 + 2.9383 \times 10^{-14} \times X_5 \\ -7.7578 \times 10^{-16} \times X_6 - 3.6123 \times 10^{-16} \times X_7$$

Predictive function equation for the second dependent variable

$$Y_{i+1} = 8.9877 \times 10^{-15} - 4.0552 \times 10^{-17} \times X_1 + 2.0523 \times 10^{-13} \times X_2 \\ -8.6084 \times 10^{-15} \times X_3 + 1.7659 \times 10^{-15} \times X_4 - 7.1382 \times 10^{-13} \times X_5 \\ +2.2609 \times 10^{-14} \times X_6 + 2.2458 \times 10^{-14} \times X_7$$

3.2. Establishing the principal component data predictive target variable function equation

According to our FPCA on the existing data of new energy vehicles, the study extracted the two dependent variables that have more influence on the annual installed capacity of power battery (Gwh) and the sales volume of new energy vehicles (10,000) in the domestic market. The study extracted two independent variables that have a greater influence on our domestic market, namely, the annual installed capacity of power batteries (Gwh) and the sales volume of new energy vehicles (10,000 units).

The MLR method is used again to establish a prediction model for new energy vehicles. The prediction function equations are as follows.

The prediction function equation for the first dependent variable:

$$Y_i + 1 = -1.6009 \times 10^{-14} - 2.5345 \times 10^{-18} \times X_1 - 2.4432 \times 10^{-14} \times X_2$$

Predictive function equation for the second dependent variable:

$$Y_i + 1 = 8.9877 \times 10^{-15} - 4.0552 \times 10^{-17} \times X_1 - 2.2966 \times 10^{-13} \times X_2$$

The first dependent variable is sales volume, and the second dependent variable is the production of electric batteries according to the (raw data). Since the confidence interval set in conducting the linear regression is 95%, the two independent variables are more significant below the significance level of 0.05.

3.3. Analysis of results

According to data from China's new energy vehicle market between 2010 and 2020, several key factors are considered: new energy vehicle ownership (in 10,000 vehicles), the annual installed capacity of power batteries (in GWh), the number of patent applications for new energy power batteries (in pieces), the total energy consumption of new energy vehicles (in 10^7 MJ), and the sales volume of new energy vehicles (in 10,000 units). Other factors include the carbon emissions of new energy vehicles (in 100 million tonnes), import and export volumes (in 10,000 units), the number of relevant policies, the total number of talents in the new energy vehicle industry (in 10,000), and the number of new energy vehicle industry organizations (in 10^7 MJ). Using these variables, the established multiple linear regression (MLR) prediction equation indicates that the target variables—sales volume and electric battery production—are expected to show an upward trend.

4. Analysis of new energy vehicle market forecasting results based on BP neural network and generalized regression neural network

To address local minima and slow convergence in BP neural networks (BPNN), the study proposes a prediction model based on the generalized regression neural network (GRNN). Using data from China's new energy vehicle market (2014-2023), the GRNN and chaotic BP models predict market trends, aiding policy and strategy development. Traditional forecasting methods like regression, gray modeling, and Markov forecasting often lack accuracy and exhibit significant lag, requiring qualitative corrections [5].

While BPNN struggles with small samples and noisy data, GRNN offers better approximation, faster learning, and greater accuracy, especially with limited data. Thus, GRNN is used to build a prediction model for new energy vehicle trends based on historical data.

4.1. BP neural network prediction

The fitness value of the individual in this case is represented by the BPNN prediction value, making the accuracy of BP prediction crucial for determining the optimal location. The optimization function is nonlinear, with two input parameters and one output parameter. Thus, the construction of an effective BP network is essential for identifying the optimal position [6].

For this optimization function, the BP network structure is designed as 2-5-1. It uses 10 sets of input-output data from the nonlinear function, randomly selecting 9 sets for training and reserving 1 set for testing. This approach allows for the evaluation of the BP network's fitting performance. The BP training process is shown in **Figure 4**.

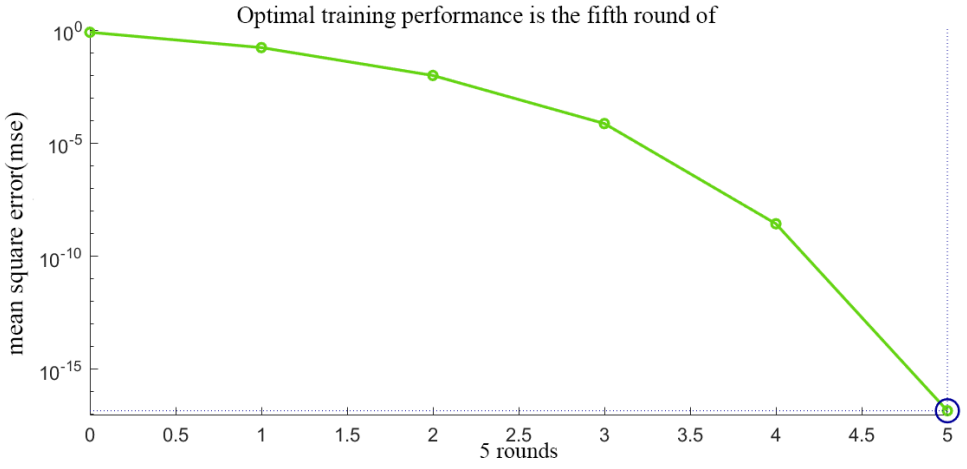


Figure 4. BP network performance graph

To eliminate scale and order of magnitude differences, the data were first standardized using MATLAB. The input set is the processed data, and the output set is the new energy vehicle data for prediction.

The input set is the processed data, and the output set is the new energy vehicle data for prediction. Generally, 80% of the data is used to train the network, and 20% is used for testing (**Figure 5**).

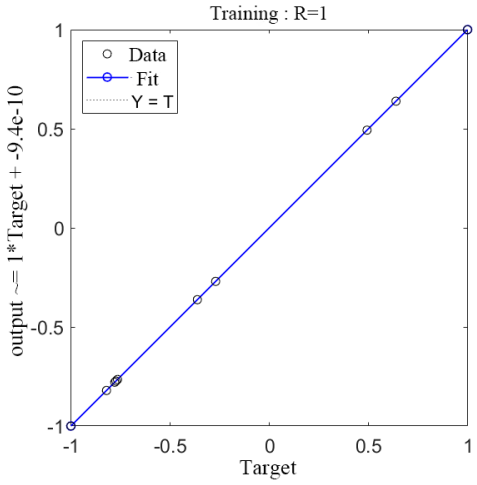


Figure 5. BP network predictive regression results plot

In this example, the number of neurons in the input layer is 3, so the number of neurons in the hidden layer is set to 7, from which a 3:7:1 network structure is formed. The network structure of 3:7:1 is formed. The training process of BPNN (**Figure 6**) shows that the BP network reaches the optimal training effect after 5 times of training, and its mean square error is 8.2322e^{-25}, 1.4497e $^{-17}$.

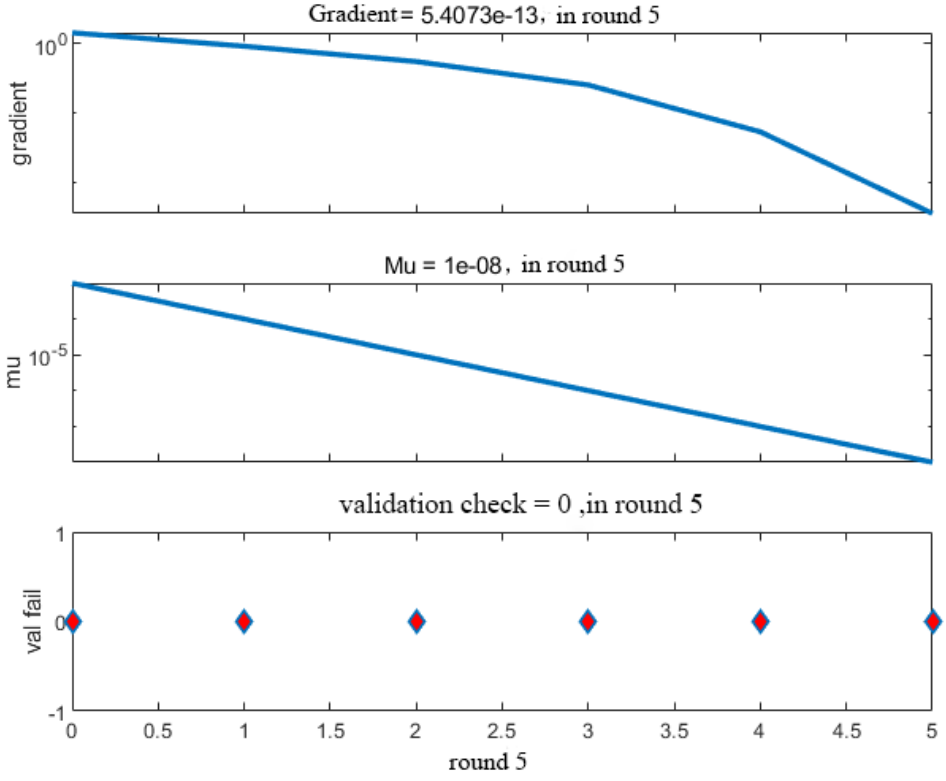


Figure 6. BP network training fit state diagram

4.2. GRNN projections

Under the Matlab2021a environment, Matlab language was used to write the algorithm calculation program, and the

Matlab neural network toolbox was applied to construct two kinds of prediction models: the GRNN-based new energy vehicle data prediction model (GRNN model) and the general chaotic BP prediction model (BP model), and to carry out prediction comparison experiments. The sample data were processed into a normalized time series with mean 0 and amplitude 1 according to the formula.

$$y_i = \left[x_i - \frac{1}{n} \sum_{j=1}^{m+1} x_i \right] / [max(x_i) - min(x_i)]$$

Given the limited sample size, the GRNN prediction model employs cross-validation for training and iterative validation to determine the optimal spread parameter [7]. The BP prediction model is structured with an 8-17-1 architecture, with training parameters set to 100 iterations, a target error of 0.0001, and a learning rate of 0.001.

To analyze the development of the new energy vehicle market, nine key indicators are selected as inputs for the GRNN model: ownership, battery patents, energy consumption, sales volume, carbon emissions, import and export volumes, number of policies, and total number of talents. The installed capacity and sales volume of power batteries serve as outputs. The model is trained using data from 2014 to 2022, while data from 2023 is used for testing. The prediction results are presented in **Table 2**.

4.3. Analysis of results

The MLR prediction model uses data from the previous year to estimate the following year's values, while the GRNN model applies cross-validation, using the first nine years of data to predict the final year. The GRNN model was trained nine times, generating nine prediction errors. A comparison of the errors in **Tables 2** and **3** shows that the GRNN model was used to predict the number of battery-loaded vehicles based on the original dataset.

The GRNN model achieved an average relative error of 2.23% in predicting battery loading, outperforming both the BP model and the multivariate linear regression (MLR) model. Its simple structure and single spread parameter contribute to fast and accurate predictions, making it well-suited for forecasting new energy vehicle data.

A comparison between the original data and the predicted data after FPCA dimensionality reduction indicates that predictions using the original data are more accurate than those after dimensionality reduction. As shown in **Table 3**, the GRNN model demonstrates higher prediction accuracy than both the BP and MLR models. Given the small sample size, this result is acceptable, as GRNN exhibits lower error when handling limited data. For the GRNN model, the choice of the spread parameter significantly affects performance: a smaller spread value enhances approximation to the sample, whereas a larger spread value smooths the approximation. In this experiment, setting the spread parameter to 1.4 produced the best prediction results, as illustrated in **Figure 7**.

Table 2. Comparison of prediction errors for battery loadings by three prediction methods

	Year/number of times	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average value
Raw data	MLR	9.42	13.28	10.43	15.75	4.47	10.85	8.66	10.23	10.09	10.38
	BP	15.14	8.03	43.40	24.07	77.31	13.81	25.65	4.77	19.23	25.71
	GRNN	7.01	7.01	7.14	7.06	7.00	16.80	7.01	11.43	7.14	8.62
Downscaled data	MLR	158.96	188.56	166.22	156.35	136.68	231.63	320.80	179.29	140.48	186.55
	BP	155.17	191.60	153.69	168.05	150.68	226.63	142.03	156.58	143.35	167.14
	GRNN	134.93	139.68	220.61	144.60	139.68	150.89	155.35	156.86	134.93	153.06

Table 3. Comparison of forecasting errors of sales volume by three forecasting methods

	Year/number of times	2015	2016	2017	2018	2019	2020	2021	2022	2023	Average Value
Raw data	MLR	25.28	35.37	27.54	38.81	38.11	25.82	27.09	38.00	25.89	30.21
	BP	32.35	47.89	45.05	31.38	63.72	30.21	18.87	45.28	12.23	33.30
	GRNN	25.63	25.63	25.86	25.74	25.63	33.22	25.64	35.54	25.86	27.64
Downscaled data	MLR	288.26	290.63	380.65	290.54	305.51	290.96	350.21	310.25	280.52	309.72
	BP	328.58	387.71	277.65	336.69	288.63	337.10	273.63	286.98	327.30	316.03
	GRNN	273.58	294.60	364.90	279.44	294.60	291.64	328.02	303.11	273.58	300.39

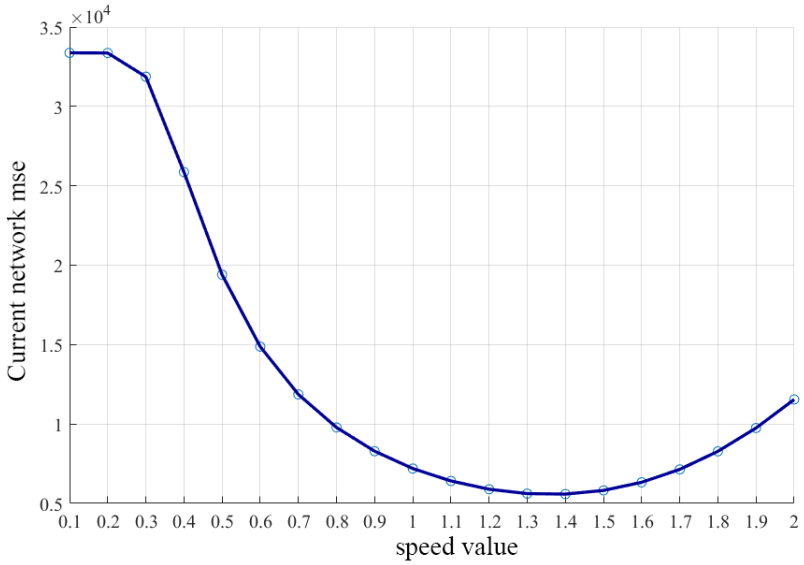


Figure 7. Variation curves of MSE value for networks with different spread values

4.4. Summary of the chapter

To address the issues of local minima and slow convergence in BPNN prediction, a prediction model based on GRNN is proposed. This model is applied to forecasting new energy vehicle data and compared with the BPNN model. Computational results demonstrate that the GRNN model exhibits good convergence, high accuracy, and strong practicality, making it a reliable tool for predicting new energy vehicle trends.

Compared with the BPNN model, the GRNN model offers several advantages: a simpler structure, the need to adjust only a single spread parameter, faster prediction speed, and the elimination of complex mathematical computations. These characteristics enhance its applicability and make it a promising approach for new energy vehicle prediction.

5. Summary and prospects

This study presents a comprehensive predictive analysis of new energy vehicle (NEV) market trends by integrating functional principal component analysis (FPCA) with multiple linear regression (MLR), back-propagation neural network (BPNN), and generalized regression neural network (GRNN). CiteSpace software was used to identify key terms and variables relevant to the study, while path analysis diagrams helped determine loading volume and sales

volume as primary research variables. During data analysis, FPCA was applied to reduce the dimensionality of high-dimensional data, effectively extracting the dataset's main features.

Building on this foundation, the MLR model was used for year-by-year prediction of the target variable. Additionally, BPNN and GRNN were employed to fit data from the first nine years, using the final year's data as a test set to forecast future market trends. By comparing the prediction errors of the three models, the one with the smallest error was selected as the final predictive tool [8]. This approach enables accurate forecasting of NEV market developments, providing a scientific basis for decision-making by policymakers, enterprises, and investors.

Future research can be expanded in several directions: (1) regularly updating data and iterating models to maintain prediction accuracy, (2) identifying and incorporating additional influencing factors within the NEV market, (3) exploring model fusion techniques such as ensemble learning to enhance predictive robustness, (4) conducting refined analyses of niche or regional markets, (5) performing comparative studies between the Chinese market and international counterparts to broaden the global perspective, (6) leveraging system dynamics simulations to support decision-making, and (7) investigating the environmental and social impacts of the NEV industry on sustainability. These efforts will deepen our understanding of the factors shaping the NEV market development and provide precise references for informed decision-making.

Disclosure statement

The authors declare no conflict of interest.

Reference

[1] Nosyk PN, Bacho R, 2024, Strategic Development Trends in the Automotive Industry of Ukraine. Engineering Proceedings, 79(1): 71.

[2] Feng J, Shi H, Ma D, et al., 2025, Supervised Functional Principal Component Analysis Under the Mixture Cure Rate Model: An Application to Alzheimer's Disease. Statistics in Medicine, 44(3–4): e10324.

[3] Fukushima T, 2018, Fast Computation of Sine/cosine Series Coefficients of Associated Legendre Function of Arbitrary High Degree and Order. Journal of Geodetic Science, 8(1): 162–173.

[4] Li R, Yang J, Cao Z, et al., 2025, A Multiple Linear Regression Model Calculates the Anterior Neck Skin Surface Area in Chinese Individuals: Implications for Neck Resurfacing and Reconstruction. Journal of Plastic, Reconstructive & Aesthetic Surgery, 2025(102): 363–372.

[5] Liu L, Wang G, Lan Y, et al., 2024, Predictive Model of Granular Fertilizer Spreading Deposition Distribution Based on GA-GRNN Neural Network. Drones, 9(1): 16.

[6] Ye J, Cai S, Zhang S, et al., 2025, Space Utilization Analysis of Classrooms for Individual Studies via Back Propagation Neural Network. Journal of Building Engineering, 2025(102): 111946.

[7] Yao D, Shen J, Hou J, et al., 2024, Online Vehicle Velocity Prediction Based on an Adaptive GRNN with Various Input Signals. International Journal of Automotive Technology, 2024(99): 1–13.

[8] Wang Z, Niu S, Fu C, et al., 2024, Advancing Data-driven Sustainable Design: A Novel NEV Form Design Approach in China's Market. Journal of Cleaner Production, 2024(461): 142626.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Micro-Ethnography Study: Effect of Home Habitus, and Western Cultural Capital on Foreign Students' Small Group Discussion Experience

Di Yuan*

Faculty of Education, Tianjin Normal University, Tianjin 300387, China

***Corresponding author:** Di Yuan, yuandi0449@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: This study explores the learning experiences of an international student, as a special case, in small group discussions within American classrooms. Utilizing Bourdieu's capital theory, the research investigates how past experiences influence current educational experiences, highlighting disparities in cultural, linguistic, and knowledge capital between international and domestic students. The study identifies power dynamics affecting international student's participation and learning outcomes. It emphasizes the need to consider international students holistically, with their unique backgrounds shaping their ways of learning and participating within and outside of the academic setting. The findings challenge the uncritical acceptance of Western-centric cultural, linguistic, and knowledge capital in multicultural educational settings, advocating for a more inclusive approach that acknowledges and values diverse student backgrounds.

Keywords: Habitus; Cultural capital; International students

Online publication: March 10, 2025

1. Introduction

The number of international students continues to increase. However, unlike K-12 educational settings where research and cross-cultural theories on teaching and learning strategies are available, almost no empirical research and very little theoretical work have been done on cross-cultural adult or collegiate classroom learning [1–3]. Most of the existing research focuses on describing foreign students' disadvantaged situation from linguistic, cognitive, and psychological perspectives, not from a perspective that analyzes the power dynamic in the classroom [4–5]. Many studies are examining international students from what they are experiencing "here and now" chronotope, barely considering what they have experienced before entering the classroom or the U.S. [6].

The primary goal of this study was to understand what the learning experience of international students in small group discussions was and what affected their current learning experience. Especially, how their past life and learning

shaped and reshaped their current learning experience. This study invited one Japanese female student to share her learning experiences in small group discussions in an American classroom to discover the power dynamic in an American classroom that affected her current learning experience. Based on the capital theory, the study examined whether foreign students' past life and learning negatively influenced their current learning experience because they did not share the same culture/ knowledge/ linguistic capital with the domestic students and American teachers [7]. By conducting this qualitative research, the study would suggest that international students should be considered as "whole persons" with past experience and expect their learning style and strategy in dynamic ways. Meanwhile, the study would like not only to reveal the "unthinking acceptance" of Western-centric cultural/linguistic/knowledge capital in multicultural classrooms but more importantly, to question and challenge in various ways that these "capitals" are affecting international students in everyday living [7].

2. Literature review

Most of the articles the author has read about international students situating international students as foreign learners with language, cognitive, and psychological barriers [4]. Linguistic scholars consider international students as second language learners [8–9]. Universities language specialists should establish language and learning support mechanisms for English as a second language (ESL) postgraduate learners so that ESL learners would find a legitimate way to acquire academic language and academic language communication skills [10]. Studying in a second language was one of the greatest challenges for international students [11]. They revealed the needs of the foreign student population for university language support and even advocated for administrators and policymakers to provide language preparations for international students even before they came to the States.

While language issues might be the most plausible reason why international students are experiencing struggles in academic and everyday life, it cannot be the exclusive factor. Other psychological factors are alongside the language factor. A great deal of research on the international student population highlights the difficulties such as interpersonal problems with American students, loss of support, and alienation [4]. Participants in the study offer an interesting point by saying that culture has a greater effect than English-language speaking problems [12].

3. Theoretical framework

While there are various perspectives to view this specific population, the framework that the author applying for this study is capital theory [7]. Heavily influenced by Marxism, Bourdieu's work is primarily concerned with the dynamics of power in society, and especially the diverse and subtle ways in which power is transferred and social order gets maintained within and across generations. As one of the most important terms in Bourdieu's work, habitus is produced by the structure of a determinate type of conditions of existence, through the economic and social necessity [7]. Habitus then becomes in turn the basis of perception and appreciation of all subsequent experience.

Sometimes, habitus will also be entitled as collective history or unthinking acceptance [13]. The author would like to explore international students' home habitus and postulate that the reason why international students are facing "barriers" in American classrooms is because they do not share the same habitus with domestic students and American teachers. In other words, they share different conditions of existence and different definitions of the impossible, the possible, and the probable.

As further indicated the work of education is not clearly institutionalized as a specific or autonomous practice, but it is a whole group and a whole symbolically structured environment, without specialized agents or specific moments,

which exerts an anonymous and pervasive pedagogic action [7]. When pedagogic action bears the responsibility to be the mediating tool to transfer habitus, power maintains its status quo, and the education field is again divided into the dominant and dominated groups. Within this pedagogical action, the elite group imposes its cultural dominance as the legitimate definition of educational culture [7]. This study explored how this Japanese student performed in a Western-centered learning environment, how her past habitus affected her current learning experience, and how she negotiated with specific forms of dominance within her small group.

4. Methodology

4.1. Participants

The participant is a Japanese female, named Yuki (pseudonym) who is a student at Northeastern University in the U.S. It is her first year in PhD program but not the first year in the U.S. Every time before the small group and whole group discussion, Yuki will tell everyone else that her English is not good and she struggles because of this. Thus, she would rather stay silent, Yuki is from the "high context" culture, which means information is internalized within the individual and situation and is not necessarily part of the social discourse [14]. It was revealed that Japanese students felt comfortable with silence [12].

In the first stage of my inquiry, the author did 125-minute small group discussion observations with Yuki. The author suggested Yuki participate in a small group that included domestic and international students. During the observation, the author took field notes about small group discussion content and physical gestures. After the observation, the author transcribed verbal and physical information as preliminary data and then processed the data. After observation, the author continued and documented my analytic memo to ensure that the author was on track of not missing important information. Then, the author conducted three private interviews with Yuki. Interviews were structured and organized in a sequence of three stages: history before coming to the U.S., history in the U.S., and personal experience in small group discussions. The whole process lasted three months with the first month collecting the observation data and interviewing, and the second and third months analyzing the data and writing the paper.

4.2. Research questions

In terms of the research questions, the author investigated the following ones.

1. What is the learning experience of Yuki in small group discussions in an American classroom?
2. How does "habitus" affect Yuki's current learning experience in small group discussions?
3. During the small group discussion, how do cultural capital, knowledge capital, and language capital influence Yuki's learning experience and how will she reflect on them?

4.3. Data analysis

4.3.1. Past learning experience

Yuki's undergraduate major in Japan was English education. Her professors encouraged her and her classmates to speak in English in class. English was a language that had already dominated the way of communication in her Japanese classroom which was a non-English speaking country's classroom. The fact that English was preferred in Japanese classrooms cannot be simply explained as Yuki's major being English education, but it could also be traced back to the colonial time when the English language possessed the dominant status globally. Even before Yuki entered the U.S., it was already rooted that English was a preferred speaking language in academic settings, both in Japan and in the U.S. As she said,

Not only because of the advantageous international communication status of English, the more a language or its culture was attractive, the more learners were motivated to acquire it [15]. The reason why she wanted to study in the U.S. was influenced by her advisor who talked about how wonderful American life was. When Yuki told her advisor about the idea of studying in the U.S., her advisor encouraged her to do so. Through her interaction with other Japanese, such as her academic advisor who would be quite influential to her academic identity and could direct her academic path, Yuki developed her own idea about what her study in America would be like.

However, after coming to the U.S., Yuki had to adjust her learning style while discussing in a small group. Her past learning experience in Japan was that the purpose of students discussing in a small group was to get correct answers. Yuki and her group members would prepare for the answer and then share the correct answer in front of the whole group and the teacher. This was a normal process of small group discussions in Asian countries, such as China or Japan. However, small group discussions in the U.S. were to build on ideas. Each member of the group offered their ideas, exchanged opinions, and built them on each other. Yuki's past learning experience, which was preparing for the correct answer, was not what Western learning constructivists advocated.

This disadvantaged her as she entered a low-context country like the American discussion was one of the most important ways to learn knowledge in the American classrooms, especially when America was a country where silence and unspoken negotiations were not preferred. Even for some American students who did negotiate in the discussion, Yuki felt excluded from the negotiating process because she was not familiar with American negotiation rules.

4.3.2. Past life experience

In Japan, because of the endless negotiations and the social requirements of being polite, Yuki sometimes felt that she was not speaking what she really thought at all. From this perspective, staying in the U.S. made her feel more real and true to herself and others. Meanwhile, Yuki thought it was stressful to live in Japan because of the population density, house prices, and unfair social pressures on Japanese females (i.e. quitting after getting married). Thus, Yuki did not want to go back to Japan anymore. She planned to stay in the U.S. and not go back to Japan by looking for and getting a job.

After finishing her Master's degree at an American university, she went directly to Thailand because she did not want to be in Japan. She told me that she felt jealous about refugees who got American citizenship and she said she wanted to be a refugee if she could get a green card and stay in the U.S. This really surprised the author because the author once thought that Japan was a developed country, highly educated, and very considerate to its citizens so that Japanese people might be living satisfactorily. After listening to her own life and learning experience, the author once again realized the value of learning people's past experiences and not making over-generalizations. As she further expressed,

40 "But here (America), I in ehhh, small group discussion, I can, I feel I can say what I want to say (rising)."

42 "So, I feel very comfortable speaking any of my opinions (in the U.S.)."

28 "yeah, anyway..then… I finished my master's here and then I went to Thailand to teach at a Japanese school and worked there."

5. Current capitals: Language, culture, and knowledge

After coming to the U.S., the first barrier that Yuki perceived was still the language barrier. She said repetitively about her worries about her English incompetency. Compared to English writing, she was more concerned about her English speaking. She explained,

18: “Then, I came here, umm, I already knew, my English is not enough (Japanese style nodding), but I was ummm, I attended ELI, English language institute before just studying my master program here.”

52: “So but probably unconsciously they know I am not a native speaker. Their English is more comprehensible, not to me, but to other native speakers.”

64: “I mean, maybe because I am not good at speaking English. I think I am more confident in writing English (rising)”

69: “Yeah, but for me, ummmm, this is my second time studying in the U.S., but still I am very struggling with speaking English.”

82: “But I do not know how American students think about my speaking (rising).”

As Bourdieu proved within the pedagogical action, the elite group imposed its cultural dominance as the legitimate definition of educational culture. International students who do not share the possession of dominant culture might be disadvantaged in academia while international students tried much harder to succeed in the U.S. tertiary educational system. As Yuki said,

77: “Then probably they knew that I do not know. So, they just do not try to explain what it is to me. I know it is so annoying (to explain to me every time). It is cultural stuff. Like something on TV, kind of. Even if I do not watch the TV, maybe I never know.”

78: “So, yeah. I understand how they feel. I cannot blame them. But, yeah, sometimes, I feel a little bit isolated from that kinda conversation.”

115: “I hope they can explain a little bit more about the cultural stuff.”

116: “I know it is fine to talk about culture. But, if people do not understand, sometimes I do not understand what they are talking about. Then I feel a little bit isolated. So, I want them to explain what it is.”

From an academic perspective, people should not define that a certain form of knowledge is better or more valuable than other forms. However, it is also the academic reality that in many of the American higher education level classrooms, most curriculums concentrate on European and North American educational philosophy and history. Thus, the dominant and appropriate way of expressing and exchanging knowledge and ideas exists in everyday U.S. classes. However, Yuki did not know exactly how to express her knowledge, how to interrupt the discussion, and how to change a topic in an American way. Because of her non-Western communication skills, she relied heavily on the discussion board forum and the English academic writing format where she could get heard and be equal with her American counterpart.

6. Discussion

Yuki was quite sensitive about eye contact during the small group discussion with American classmates. She wished that when American students were talking in small groups, they could look at her too, not only looking at other American students. This comment from Yuki appeared more than ten times. Whenever native speakers did not look at her, she thought that maybe it was because she was not a native English speaker that her English was neither good nor intelligible. The consequence was that she felt ignored, isolated, and unequal. Toward the end of the interview, Yuki said: “I get used to it.” the author assumed she was not used to being ignored, but only not to stick to the idea of “looking at me.”

Compared to how small group discussion was performed in Japan, she preferred the American way of small group discussion because she could “be honest and real” to herself and others rather than negotiate with others stressfully and consciously. In American small group discussions, when she was in a group with someone she felt comfortable with, she would be even more relaxed and willing to talk. On the other hand, it was often the case that she was ignored and

isolated because of her lack of confidence, disempowered language status, Western versus Eastern cultural barrier, language barrier, and unawareness of communication skills in American classrooms.

In any multicultural and multinational classroom, whether it was reasonable to equalize international students' being different as deviant, not knowing Western cultural and linguistic capital being their fault, and the willingness to further education in the U.S. would deprive students' power of getting their true voices heard by the domestic students and American teacher.

In this study, Yuki's perceptions and actions should not be explained from "here and now", but also discussed on a macro level. For example, globalization made English a dominant language all around the world so that individuals in non-English speaking countries felt they were obliged to learn well in English. Yuki did not want to go back to her own country which pushed her to be more tolerant while being "ignored" in the small group discussion. Quoting Yuki's own words, "If I can stay here, I am willing to be a refugee."

7. Conclusion

As the study showed, it should be analyzed thoroughly when international students are silent and inactive. Other factors should also be taken into account, such as what they have experienced, what their habitus was, and what the possible power distance and capital they possessed, compared to the domestic students and American teachers in American classrooms. As Yuki said at the end of one interview, despite all the challenges presented in small group discussions, studying in the U.S. was a satisfying experience, not only for academic purposes but also on a personal level of everyday life.

Summing up, people should engage international students in small group discussions in the context of acknowledging the value they bring to every conversation. Many international students were seeking to construct their knowledge in a new culture, which was quite different from their home context in which they accomplished most of their learning [16]. Understanding international students does not only mean understanding them by where they are and who they are, but also about where they were and who they were.

Funding

This research was funded by the Tianjin Science and Technology Popularization Project "Development and Application of Teenagers' Scientific Inquiry Experimental Courses Based on Maker Thinking" (Project No.: 23KPZDRC00080).

Disclosure statement

The author declares no conflict of interest.

References

[1] Banks JA, Banks MC, 2004, Multicultural Education: Issues and Perspectives (5th ed.). John Wiley & Sons, New Jersey.

[2] Bennett C, 2006, Comprehensive Multicultural Education: Theory and Practice. Allyn & Bacon, Boston.

[3] Chavez AF, 2007, Islands of Empowerment: Facilitating Multicultural Learning Communities in College. International Journal of Teaching and Learning in Higher Education, 19(3): 274–288.

[4] Mori SC, 2000, Addressing the Mental Health Concerns of International Students. Journal of Counseling &

Development, 78(2): 137–144.

[5] Perrucci R, Hu H, 1995, Satisfaction with Social and Educational Experiences among International Graduate Students. Research in Higher Education, 36(4): 491–508.

[6] Bakhtin MM, 1981, The Dialogic Imagination. University of Texas Press, Austin.

[7] Bourdieu P, 1977, Outline of a Theory of Practice (Vol. 16). Cambridge University Press, Cambridge.

[8] Davies A, Hamp LL, Kemp C, 2003, Whose Norms? International Proficiency Tests in English. World Englishes, 22(4): 571–584.

[9] Tsui ABM, 2007, Complexities of Identity Formation: A Narrative Inquiry of an EFL Teacher. TESOL Quarterly, 41(4): 657–680.

[10] Fenton-Smith BB, Humphreys PP, 2015, Language Specialists' Views on Academic Language and Learning Support Mechanisms for EAL Postgraduate Coursework Students: The Case for Adjunct Tutorials. Journal of English for Academic Purposes, 2015(20): 40–55.

[11] Ren J, Bryan K, Youngkyoung M, et al., 2007, Language Preparation and the First Year Experience: What Administrators and Policy Makers Should Know. Florida Journal of Educational Administration & Policy, 1(1): 11–24.

[12] Kim SS, Ates BA, Grigsby YY, et al., 2016, Ways to Promote the Classroom Participation of International Students by Understanding the Silence of Japanese University Students. Journal of International Students, 6(2): 431–450.

[13] Bourdieu P, Passeron JC, 1977, Reproduction in Education, Culture and Society. Sage, London.

[14] Olaniran BA, 2009, Culture, Learning Styles, and Web 2.0. Interactive Learning Environments, 17(4): 261–271.

[15] Krashen SD, 1982, Principles and Practice in Second Language Acquisition. Pergamon Press, New York.

[16] Miranda M, 2009, Creating the Successful Community College Student: Using Behaviorism to Foster Constructivism. The Community College Enterprise, 15(1): 21–38.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research Status and Hotspots of Movement Economy: A Visual Analysis based on VOSviewer

Yuxiao Tan*

International Football Academy, Tongji University, Shanghai 200092, China

***Corresponding author:** Yuxiao Tan, 2032078@tongji.edu.cn

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: *Objective*: The more economical the energy consumption of the human body during exercise, the better the exercise effect, that is, the higher the movement economy (ME). This study applied VOSviewer to conduct a visual analysis of the research hotspots and trends of ME in recent years, with the aim to reveal the pattern and possible mechanism of energy metabolism during exercise. *Method*: This study screened 3149 relevant papers in the Web of Science Core Collection database before June 30, 2022, and used the VOSviewer for bibliometric and visual analyses. The extracted data included publication journals, countries, high-frequency keywords, etc. *Result*: The results showed that the United States had the largest number of papers in the field of ME. Medicine and Science in Sports and Exercise was the journal with the most publications and citations. Scholar Andrew M. Jones exhibited great influence in this field. The research on ME presented interdisciplinary characteristics, mainly focusing on five hotspots, including nutrition and metabolism related to exercise energy consumption, biomechanical factors affecting ME, physiological performance, the impact of special environment on ME, and exercise injury and recovery related to ME. *Conclusion*: The visual study of the movement economy is of great significance to the improvement of the rationality of sports technology. The analysis results provide a novel perspective for researchers to perform related research in the future and also confer a reference for finding potential collaborators and research cooperation institutions.

Keywords: Movement economy; Running economy; Energy consume; Visualization analysis; VOSviewer

Online publication: March 10, 2025

1. Introduction

Generally, the more reasonable the use of physical strength, the more economical the energy consumption of the human body and the better the motion effects, that is, the higher the movement economy (ME). ME is known as an important determinant of aerobic exercise performance [1]. ME has acquired increasing attention in endurance sports events (such as long-distance running, triathlon, and swimming) and mixed sports (such as football and basketball), and has been accepted as a pivotal indicator for predicting sports performance by athletes and coaches [2]. ME is typically defined as

the energy/oxygen cost for a given submaximal-intensity exercise [3–4]. Since direct measurement of ME is difficult, ME is traditionally measured as the submaximal oxygen uptake (VO_2) at a given running velocity. Hence, ME is also often referred to as running economy (RE). This study applied VOSviewer to conduct visual analysis on the research hotspots and trends of ME in recent years, with the aim to reveal the law and possible mechanism of energy metabolism during exercise, thereby conferring a deeper and richer understanding of the scientific nature of sports training and national fitness.

2. Materials and methods

2.1. Data sources

Based on the Web of Science Core Collection database and visualization software VOSviewer, this study focused on the highly cited papers and hot papers in the field of ME research and performed visual analysis on the research hotspots of ME in recent years by using bibliometrics. The relevant papers were extracted from the Web of Science Core Collection and the search terms were set as follows: "Movement Economy", "Energy Consume", "Oxygen Consume", and "Running Economy", taking OR as the connecting word and connecting "Exercise" with AND. The final retrieval execution time was 30th June 2022. The selected literature types were "Articles" and "Review Articles." The main discipline categories selected were "Sports Science" and "Physiology." After screening, a total of 3149 valid papers were finally obtained.

2.2. Data processing

The papers retrieved from the Web of Science Core Collection database were exported in the format of "Full Records and Cited References" with tab separators, and then, the data were imported into the VOSviewer software for keyword co-occurrence analysis and co-citation analysis. Thereafter, the keywords of different clusters were exported to Excel. The synonyms, singular and plural numbers, and abbreviations of the keywords were merged to ensure the accuracy of the clustering analysis results. For example, the keywords "Oxygen cost", "O_2 uptake kinetics", and "O_2 cost" were replaced with "Aerobic performance".

3. Result

3.1. Annual publication and co-citation analysis

The number of published and cited foreign papers in the field of ME increased year by year (**Figure 1**). The number of publications reached the highest of 239 in 2019, and the cited frequency reached the highest of 11794 in 2021. The average cited frequency of each paper was 32.87. As of June 30, 2022, a total of 3149 valid papers were retrieved, including 2880 research articles (91.46%) and 269 review articles (8.48%). The ranking of highly cited articles is shown in **Table 1**. Through co-citation analysis, it was found that there were a large number of high-quality studies on ME in the 1980s. In the early years, the research on ME mainly focused on running performance. The most frequently cited paper was Running Economy and Distance Running Performance of Highly Trained Athletes published in Medicine and Science in Sports and Exercise in 1980 by American scholars Douglas L. Conley and Gary S. Krahenbuhl, which was cited 232 times, mainly discussing the relationship between RE and running performance of well-trained long-distance runners. In the past decade, the research focus on ME has gradually diversified, and many studies have begun to explore the relationship between nutrition diet, energy metabolism, and ME. Among all researchers, Jones Andrew M. had great influence in this field, with 24 relevant studies and 1820 citations.

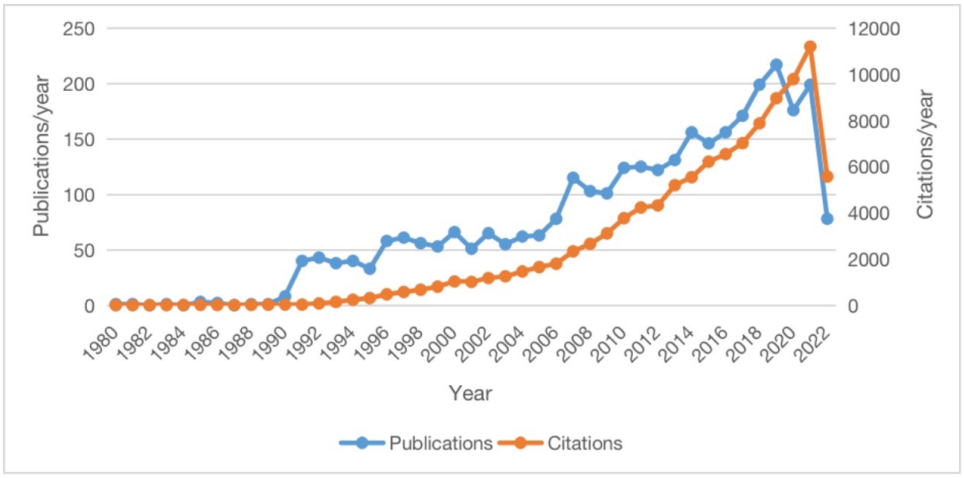


Figure 1. Publication and citation of papers on the movement economy

Table 1. Highly cited papers on the movement economy

Title	Country	Year	Author	Journal	Citation
Running economy and distance running performance of highly trained athletes	America	1980	Douglas L. Conley and Gary S. Krahenbuh	Medicine And Science in Sports and Exercise	232
Factors affecting the running economy in trained distance runners	Australia	2004	Philo U. Saunders, David B. Pyne,	Sports Med	230
Relationship between distance running mechanics, running economy, and performance	America	1987	Keithr. Williams and Peter R. Cavanagh	American Physiological Society	162
Psychophysical bases of perceived exertion	Sweden	1982	Gunnar A.V. Borg	Medicine And Science in Sports and Exercise	145
The effect of stride length variation on oxygen uptake during distance running	America	1982	Peter R. Cavanagh and Keith R. Williams	Medicine And Science in Sports and Exercise	113
Relationship between distance running mechanics, running economy, and performance	America	1987	Keithr. Williams and Peter R. Cavanagh	American Physiological Society	107

3.2. Analysis of country/region and affiliated institution

In the VOSviewer software, the screening threshold of the number of country publications was set to 5 times. Cluster analysis showed that 83 countries had published papers on ME, and only 50 countries reached the set threshold (**Figure 2**). The country with the largest number of papers was the United States (1036, 32.90%) (**Table 2**), and these studies mainly came from the economically developed regions in Europe and America. China had 62 published papers (1.97%) and only ranked 17th in the number of research results. The publication institutions were mainly various universities (**Figure 3**, **Table 3**), such as the Australian Institute of Sport, University of Copenhagen, Loughborough University, University of Granada, and McMaster University. The number of papers and citations on ME in Europe and the United States was much higher than that in other regions, and researchers from different countries cooperated with each other, showing the characteristics of cluster distribution with the United States as the center.

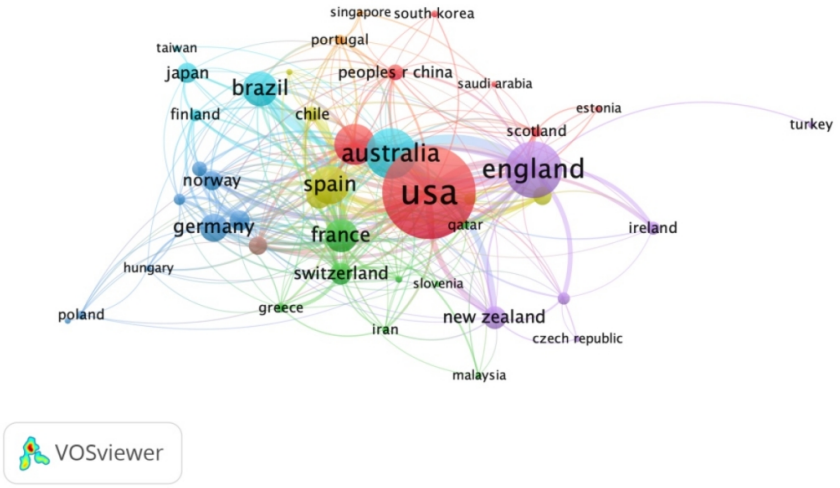


Figure 2. Country distribution of hot research in VOSviewer

Table 2. Ranking of country publications on movement economy

Rank	Countries	Documents	Citations
1	America	1036	36896
2	England	442	16449
3	Australia	341	10980
4	Canada	272	8514
5	France	198	7160
6	Spanish	184	4686
7	Chile	167	1953
8	Germany	132	3422
9	Italy	131	5539
10	Netherlands	100	2620

Table 3. Ranking of organizations on movement economy

Rank	Organizations	Documents	Citations
1	Norwegian University of Science and Technology	39	5049
2	Australian Institute of Sport	58	2666
3	University of Copenhagen	47	2445
4	University of Colorado	39	2354
5	University of Exeter	27	2131
6	University of Rome Tor Vergata	9	2121
7	University of Jyvaskyla	39	1990
8	University of Connecticut	21	1964
9	Liverpool John Moores University	39	1866
10	RMIT University	15	1860

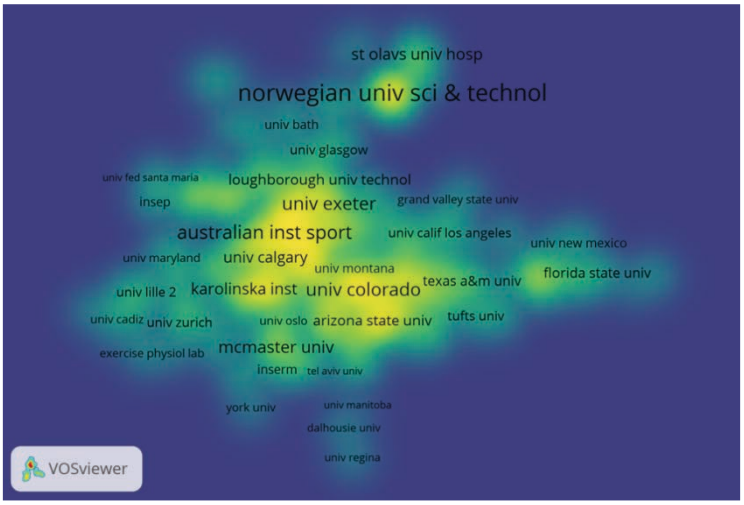


Figure 3. Institution distribution of hot research in VOSviewer

3.3. Analysis of publications

Based on the VOSviewer analysis of the publication sources of relevant literature, the top 10 journals with the most published literature in the field of ME are shown in **Table 4**. The Medicine and Science in Sports and Exercise had published the largest number of papers in the field of ME, with a total of 350 papers (8.45%). ME-related papers were mainly published in the journals of physiology, sports science, and nutrition under the medical category.

Table 4. Ranking of publications on movement economy

Publication Titles	Record Count	Percentage
Medicine and Science on Sports and Exercise	350	11.15%
Journal of Strength and Conditioning Research	212	6.75%
European Journal of Applied Physiology	161	5.13%
Journal of Applied Physiology	137	4.36%
International Journal of Sport Nutrition and Exercise Metabolism	130	4.14%
Journal of Sports Sciences	123	3.92%
International Journal of Sports Medicine	112	3.57%
Applied Physiology Nutrition and Metabolism	101	3.22%
Sports Medicine	101	3.22%
Frontiers in Physiology	100	3.19%

3.4. Keyword co-occurrence and cluster analysis

ME-related papers involved 52 research fields, as shown in **Table 5**. The top 5 research fields included Sports Sciences, Physiology, Nutrition Dietetics, Neurosciences, and Endocrinology Metabolism. Through cluster analysis and statistics of keywords in VOSviewer software, a total of 11544 keywords were obtained, and furthermore, keywords with a frequency of more than 5 times were screened and 1252 keywords reached the standard critical value. After merging and screening, the 10 keywords with the highest frequency were “running economy”, “metabolism”, “endurance”, “skeletal muscle”, “strength”, “fatigue”, “oxygen consumption”, “carbohydrate”, “energy consumption”, and “leg stiffness.”

Numerous ME-related papers focused on the characteristics of basic metabolism such as oxygen consumption and energy consumption and primarily explored the relationship between the rationality of technical action and ME (**Figure 4**). Consequently, 6 clusters were obtained through cluster analysis of keywords, as shown in **Table 6**. Different clusters were displayed in different colors. The node size indicated the occurrence frequency of keywords, and the connection between nodes indicated the correlation between various keywords. Through cluster analysis, the major hot research fields of ME are summarized in **Figure 5**.

Table 5. Hot research fields of movement economy

Rank	Field	Article number	Percentage	Rank	Field	Article number	Percentage
1	Sport science	2538	76.49%	6	Orthopaedic	71	2.41%
2	Physiology	1198	41.57%	7	Endocrinology metabolism	66	2.04%
3	Nutrition	409	13.71%	8	Rehabilitation	65	1.97%
4	Neuroscience	147	4.95%	9	Hospitality leisure sport tourism	65	1.74%
5	Psychology	73	3.95%	10	Engineering biomedical	56	1.51%

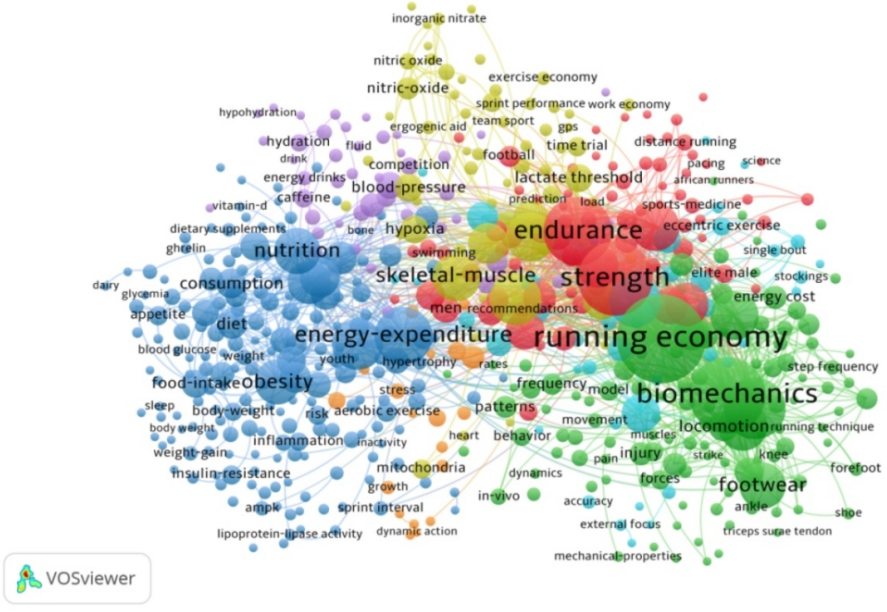


Figure 4. Co-occurrence network diagram of keywords related to movement economy

Table 6. High-frequency keywords of various clusters of movement economy

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Energy expenditure	Biomechanics	Strength	Intensity	Recovery
Body composition	Gait	Endurance	Aerobic performance	Induced muscle damage
Metabolism	Footwear	Resistance	Hypoxia	Perceived exertion
Nutrition	Running	Maximal oxygen-uptake	Efficiency	Adaptation
Carbohydrate	Fatigue	Oxygen-uptake	Lactate threshold	Eccentric exercise
Obesity	Stiffness	Power	Blood-pressure	Soreness

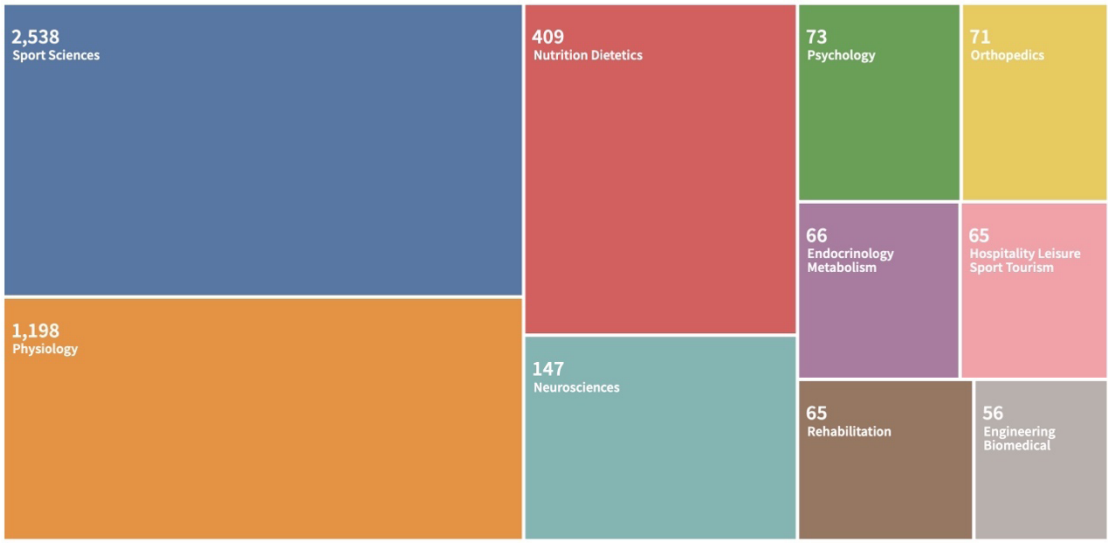


Figure 5. Major hot research fields of ME

3.4.1. Nutrition and metabolism in the process of energy consumption during exercise

In cluster 1, i.e. the red cluster plate, the top 6 co-occurrence keywords with the highest frequency were "energy consumption", "body composition", "metabolism", "nutrition", "carbohydrate", and "obesity", indicating that energy consumption and nutrition metabolism during exercise were the hot research topics in ME. On the one hand, the human body provides energy for metabolism by ingesting various nutrients in food such as carbohydrates, and on the other hand, it consumes energy through physical activities. Different dietary nutrition arranges, such as ketogenic diet or high-sugar and low-fat diet, cause different metabolic reactions and further affect the energy supply of physical activities, specifically manifested as changes in body mass (BM), basal metabolic rate (BMR), body fat rate (BF%), and other indicators. Higher BF% and higher BM produce more energy metabolism consumption during exercise, leading to lower ME. In previous studies on marathon races, Giovanni Tanda et al. pointed out that the lower BF% was usually related to better endurance running performance, but the race performance was mainly related to the amount of training in the case of BF% < 15% [5–6]. Meanwhile, Maciejczyk M et al. indicated that for athletes with similar BM and different body composition ratios, athletes with higher BF% had lower RE and consumed more energy [7]. BM is one of the important determinants of ME, and 94% of ME differences can be explained by BM [8]. The increase in BM is usually accompanied by an increase in BMR, which leads to more energy consumption. Under the same exercise intensity, the energy metabolism cost can be reduced and ME can be improved by adjusting the nutrition strategy to control the BM. In previous research on the relationship between body composition and ME, it was found that the subjects with lower body mass index (BMI) had lower energy costs in the exercise of the same intensity, suggesting a higher ME [9]. Notably, Merry A. Bestard et al. also revealed that a high-sugar and high-fat diet did not affect swimming economy at 50-70% VO_{2max}. Hence, ME may also be affected by exercise intensity and exercise items in addition to nutrition intake and body composition.

3.4.2. Biomechanical factors affecting ME

In cluster 2, i.e. the green cluster plate, the co-occurrence keywords with the highest frequency were "biomechanics", "gait analysis", "footwear", "running", "fatigue", and "stiffness", mainly focusing on the biomechanical factors of

ME during running. ME is also known as RE, and 54% of RE changes can be explained by biomechanical factors [10]. Among the biomechanical factors that affect ME, the endogenous factors include gait (step length, frequency, stride length, etc.) and lower limb stiffness, etc., and the exogenous factors include the type of shoes, the time of touching the ground, and the running site, etc. Gait retraining is often used to treat common running-related injuries (RRI) and to improve performance. In general, the longer the stride, the shorter the time of touching the ground, leading to a higher energy metabolism cost [11]. Morgan. et al. found that 3 weeks of training to reduce step length can improve RE in 9 subjects [12]. However, due to the large individual differences (endurance, running experience, etc.), different gait and stride patterns may combine to produce similar ME. At present, no research has clearly pointed out the most economical running gait [13–14]. Generally, subjects have a higher ME when they exercise at their preferred stride. On this basis, moderate adjustment of stride can effectively improve ME [15]. When fatigue occurs, the gait of subjects is adjusted with the changes in space-time parameters, kinematics, and dynamics.

In addition, some exogenous factors can also affect ME, such as environmental factors (temperature, wind speed, etc.) and wearable devices. Different types of running shoes can obviously affect the running performance but do not exert a significant improving effect on the athletic ability of subjects. The reason may be that wearing running shoes externally affects a series of biomechanical factors such as plantar pressure, gait frequency, and muscle activity, but does not change the subjects' athletic ability. In two studies by Joe P. Warne and Fabrice Vercruyssen et al., it was found that the running performance of the subjects wearing minimalist style running shoes was higher than that of the subjects wearing traditional running shoes, but the ME of the subjects themselves was not improved [16–17]. It is indicated that the difference in ordinary running shoes has little impact on ME. When the athletes reach the fatigue state after a short-distance cross-country race, there is no significant difference in the ME of athletes wearing different kinds of running shoes [17]. Therefore, improving RE requires barefoot training or wearing barefoot running shoes for training. Compared with running with shoes, barefoot running can produce greater vertical stiffness, which increases the total amount of exercise and contributes to the improvement of RE. Warne et al. showed that after 4 weeks of barefoot simulation training, the athletes in the barefoot test group exhibited higher vertical stiffness and leg stiffness than those in the shoe-wearing test group. The greater the leg stiffness, the higher the storage and release efficiency of elastic potential energy, implying that the type of shoes is one of the external factors affecting ME [18].

3.5. Physiological manifestation and influencing factors of ME

In cluster 3, i.e. the blue cluster plate, the main keywords were "strength", "endurance", "resistance training", "maximum oxygen uptake", "oxygen uptake", and "power." ME represents the complex interaction of physiological and biomechanical factors [19]. The research hotspots in cluster 3 mainly focused on various physiological indicators, the impact of changes in physical qualities (such as strength and endurance) on ME, and common training methods to improve ME. Aerobic physiological indicators are often used to measure the performance of long-distance running. A high maximum oxygen uptake (VO_{2max}) is a prerequisite for good performance in middle and long-distance running. VO_{2max} is defined as the maximum rate of oxygen absorption and utilization during vigorous exercise [20]. VO_{2max} is primarily affected by congenital genetic factors, so it is difficult to improve ME by elevating VO_{2max} through training [21]. For long-distance runners with equivalent athletic ability, ME is often considered to be a better performance predictor than VO_{2max} [10, 22]. There are three methods commonly used to quantify ME: oxygen uptake per unit time (VO_2, ml/kg/min), oxygen consumption costs at a given submaximal velocity (EO_2, ml/kg/m), and aerobic energy cost (E_{aer}, J/kg/m) [5, 23–24]. Aerobic energy cost is generally considered more reliable. The energy equivalent generated by oxygen consumption during exercise depends on the metabolic substrate (relative content of sugar, fat, and protein) and exercise

intensity. Aerobic exercise and anaerobic exercise alternate under different exercise intensities, resulting in incomplete oxidation of some substrates. Hence, it is considered more accurate to calculate aerobic energy consumption through the respiratory exchange rate (RER) [25].

ME is closely related to aerobic endurance, which can be improved through endurance and strength training. Danielle et al. found that after 10 weeks of strength and endurance training, the 2km running performance of athletes was improved [24]. Endurance training and strength training produce different forms of adaptation. Endurance training mainly improves VO_{2max} by increasing cardiac output, mitochondrial density, enzyme concentration and activity, and capillary density, while strength training mainly activates the nerve muscle, stimulates the muscle fiber to be more hypertrophy, makes the muscle fiber more coordinated, and thereby increases the maximum strength [26]. Simultaneous strength and endurance training has no negative impact on endurance, but diversified adaptation reduces strength improvement, known as the "interference effect". Kenji Doma et al. pointed out that strength and endurance training at the same time could enhance endurance adaptation to a greater extent and improve ME [27]. However, strength training tends to cause exercise fatigue. Insufficient fatigue recovery exerts adverse effects on the performance of subsequent endurance training. Therefore, it should be prudent to combine resistance training with endurance training. Moreover, simultaneous strength training and plyometrics training has a positive effect on neuromuscular metabolic adaptation and running performance. Plyometrics training is also one of the important training methods to improve ME [28–31]. Plyometrics training can increase tendon stiffness, make muscle elastic potential better stored and released, enhance muscle power, and increase ME. A meta-analysis by Balsalobre Fernández C et al. revealed that 2–3 times of strength training [including 2–4 times of 40%–70% one repetition maximum (1RM) resistance training and plyometrics training] per week for 8–12 weeks can improve the RE of long-distance runners [32]. Short-term resistance training and plyometrics training can improve RE and running performance by enhancing neuromuscular metabolic adaptation [33].

3.6. Effects of special environment on ME-related physiological indexes

In cluster 4, i.e. the yellow cluster plate, the high-frequency keywords were "intensity", "aerobic performance", "hypoxia", "efficiency", "lactate threshold", and "blood pressure", indicating that the hotspots of this plate mainly focused on the impact of changes in human skeletal muscle, aerobic capacity, and blood composition on ME under different environmental sports conditions, such as high pressure and hypoxia. Reasonably changing the training and living environment while performing routine training (such as strength and endurance training) can effectively improve the sports performance of subjects. Compared with normoxia training, altitude/hypoxia training is considered to improve the performance of athletes in sea-level sports [34–35]. People at a high altitude are found to have higher muscle movement efficiency (ratio of mechanical power to metabolic energy consumption) than people at sea level [36]. Training in the high altitude/hypoxia environment contributes to improving the endurance performance and submaximal exercise efficiency of athletes at sea level. The common hypoxia training methods are living high training low (LHTL) and living high training high (LHTH). After several weeks of hypoxia training, the aerobic performance indexes such as VO_{2max} and hemoglobin content can be improved [37–38]. Park et al. found that 4 weeks of LHTL significantly enhanced the ME and metabolism (HR, VO_2, VCO_2, and blood lactate concentration) of subjects, and also improved the performance of 3000-meter and 5000-meter time trials [39]. The influence mechanism of hypoxia training on ME may be that the altitude/hypoxia environment increases carbohydrate consumption [40]. Katayama et al. suggested that the body's utilization of carbohydrates was increased when exercising in a moderate hypoxia environment compared with exercising in a normoxia environment with the same relative intensity [18, 41]. The body changes from lipid oxidation to carbohydrate oxidation, reducing O_2 and energy consumption, improving the mechanical efficiency of exercise,

and eventually enhancing ME [42]. Also, metabolic adaptation to altitude/hypoxia environment may enhance muscle hemodynamic function, and mean arterial blood pressure is one of the important physiological predictors of male marathon performance [39, 43]. On the contrary, some scholars believe that LHTL cannot improve athletic performance. Clark et al. found that there was no significant change in ME, lactate metabolism index, and pH value of athletes [fraction of inspiration O_2 (FIO_2), 16.27%] after 20 consecutive nights of normobaric hypoxia exposure. The reasons for the different results may be related to the altitude and the length of exposure. Therefore, Levine et al. held that an altitude of not more than 3000 meters, a residence time of at least 18 days, and an exposure time of at least 12 hours per day could positively affect ME during LHTL. Alexandra M. Coates et al. pointed out that most basic physiological indicators, such as lactate threshold and VO_{2max}, could better reflect running performance. However, such physiological indicators only predict the running performance within a distance of 50 kilometers. With the increase in the running distance, the correlation between the changes in traditional physiological indicators and the performance of running is significantly reduced [44].

3.7. Exercise injury and recovery related to energy consumption

In cluster 5, i.e. the purple cluster plate, the main keywords were “recovery”, “exercise-induced muscle damage”, “perceived exertion”, “adaptation”, “centrifugal exercise”, and “muscle pain.” Exercise-induced muscle damage is prone to occur after unsuitable exercise or intensive centrifugal exercise, and muscle fiber damage has adverse effects on ME. Therefore, the Borg Rating of Perceived Exertion (RPE) scale is usually used to monitor the perceived exertion during exercise, which enables the athletes to adjust the exercise intensity through the perceived response and thereby effectively reduces the occurrence of muscle injuries [45–46]. Long-term high-intensity exercise also induces fatigue in the central nervous system and peripheral nerves and muscles, accompanied by increased RPE. The accumulation of exercise fatigue triggers exercise injuries. When fatigue occurs, the energy consumed by the body increases and muscle soreness appears, resulting in the decrease of ME. Hence, reducing exercise fatigue and injury can effectively improve ME [44].

The accumulation of fatigue effect also limits the development of optimal endurance in training [47]. Kenji Doma et al. believed that delayed-onset muscle soreness (DOMS) caused by resistance training was one of the factors affecting endurance performance when resistance and endurance training were performed simultaneously [47]. DOMS, one of the common muscle damages, often occurs after high-intensity centrifugal exercise of skeletal muscle, accompanied by the symptoms of inflammation, edema, and muscle function damage [48–49]. Exercise in the period after the occurrence of DOMS leads to changes in the muscle activation mode and the increased recruitment of type II fiber. As a result, more movement units must be activated to generate the same strength, resulting in significantly increased energy consumption per unit of time. William et al. further pointed out that human muscle damage caused changes in biomechanics such as stride length, increased proportion of anaerobic energy consumption, and decreased ME [50]. Low-intensity exercise in the early stage, such as low-intensity resistance exercise two weeks before training, can induce small-scale muscle damage. After repeated muscle damage exercise, the symptoms and signs of muscle damage caused by subsequent high-intensity exercise are weakened, which can reduce the incidence of muscle damage [27, 51–52].

4. Conclusion

Through the visual and bibliometric analyses of 3149 ME-related papers in the Web of Science Core Collection database, it is found that the research popularity on ME has been increasing year by year, and the upward tendency has

leveled off in the past two years. The researches mainly come from universities in economically developed regions such as Europe and the United States, and the research links among countries are relatively close, showing a cluster distribution centered on the United States. At present, there are few studies related to ME in China.

ME-related researches present interdisciplinary characteristics involving multiple disciplines such as physiology, nutrition, and neuroscience, mainly focusing on five hotspots, including nutrition and metabolism related to exercise energy consumption, biomechanical factors affecting ME, physiological performance, the impact of special environment on ME, and exercise injury and recovery related to ME.

The current researches on ME primarily aim at periodic sports events, such as running and swimming. More non-periodic sports should be taken into consideration in future research, which is of great significance to the improvement of the rationality of sports technology. The analysis results provide a novel perspective for ME-related research in the future and also confer a reference for finding potential collaborators and research cooperation institutions.

Disclosure statement

The author declares no conflict of interest.

References

[1] Schücker L, Fleddermann M, de Lussanet M, et al., 2016, Focusing Attention on Circular Pedaling Reduces Movement Economy in Cycling. Psychology of Sport and Exercise, 2016(27): 9–17. https://doi.org/10.1016/j.psychsport.2016.07.002

[2] Shaw AJ, Ingham SA, Fudge BW, et al., 2013, The Reliability of Running Economy Expressed as Oxygen Cost and Energy Cost in Trained Distance Runners. Applied Physiology, Nutrition, and Metabolism, 38(12): 1268–1272. https://doi.org/10.1139/apnm-2013-0055

[3] Schücker L, Anheier W, Hagemann N, et al., 2013, On the Optimal Focus of Attention for Efficient Running at High Intensity. Sport, Exercise, and Performance Psychology, 2(3): 207–219. https://doi.org/10.1037/a0031959

[4] Schücker L, Knopf C, Strauss B, et al., 2014, An Internal Focus of Attention Is Not Always as Bad as Its Reputation: How Specific Aspects of Internally Focused Attention Do Not Hinder Running Efficiency. Journal of Sport and Exercise Psychology, 36(3): 233–243. https://doi.org/10.1123/jsep.2013-0200

[5] Knechtle B, Tanda G, 2015, Effects of Training and Anthropometric Factors on Marathon and 100 km Ultramarathon Race Performance. Open Access Journal of Sports Medicine, 2015(6): 129–136. https://doi.org/10.2147/OAJSM.S80637

[6] Bale P, Bradbury D, Colley E, 1986, Anthropometric and Training Variables Related to 10km Running Performance. British Journal of Sports Medicine, 20(4): 170–173. https://doi.org/10.1136/bjsm.20.4.170

[7] Maciejczyk M, Więcek M, Szymura J, et al., 2015, Physiological Response during Running in Athletes with Similar Body Mass but Different Body Composition. Science & Sports, 30(4): 204–212. https://doi.org/10.1016/j.scispo.2015.02.005

[8] Lundby C, Montero D, Gehrig S, et al., 2017, Physiological, Biochemical, Anthropometric, and Biomechanical Influences on Exercise Economy in Humans. Scandinavian Journal of Medicine & Science in Sports, 27(12): 1627–1637. https://doi.org/10.1111/sms.12849

[9] Lundby C, Montero D, Gehrig S, et al., 2017, Physiological, Biochemical, Anthropometric, and Biomechanical Influences on Exercise Economy in Humans. Scandinavian Journal of Medicine & Science in Sports, 27(12): 1627–

1637. https://doi.org/10.1111/sms.12849

[10] Williams KR, Cavanagh. PR, 1987, Relationship between Distance Running Mechanics, Running Economy, and Performance. Journal of Applied Physiology, 63(3): 1236–1245. https://doi.org/10.1152/jappl.1987.63.3.1236

[11] Chapman RF, Laymon AS, Wilhite DP, et al., 2012, Ground Contact Time as an Indicator of Metabolic Cost in Elite Distance Runners. Medicine & Science in Sports & Exercise, 44(5): 917–925. https://doi.org/10.1249/MSS.0b013e3182400520

[12] Morgan D, Martin P, Craib M, et al., 1994, Effect of Step Length Optimization on the Aerobic Demand of Running. Journal of Applied Physiology, 77(1): 245–251. https://doi.org/10.1152/jappl.1994.77.1.245

[13] Moran MF, Wager JC, 2020, Influence of Gait Retraining on Running Economy: A Review and Potential Applications. Strength & Conditioning Journal, 42(1): 12–23. https://doi.org/10.1519/SSC.0000000000000511

[14] Lussiana T, Gindre C, Hébert-Losier K, et al., 2017, Similar Running Economy with Different Running Patterns Along the Aerial-Terrestrial Continuum. International Journal of Sports Physiology and Performance, 12(4): 481–489. https://doi.org/10.1123/ijspp.2016-0107

[15] Connick MJ, Li FX, 2014, Changes in Timing of Muscle Contractions and Running Economy with Altered Stride Pattern during Running. Gait & Posture, 39(1): 634–637. https://doi.org/10.1016/j.gaitpost.2013.07.112

[16] Warne JP, Moran KA, Warrington GD, 2015, Eight Weeks Gait Retraining in Minimalist Footwear has no Effect on Running Economy. Human Movement Science, 2015(42): 183–192. https://doi.org/10.1016/j.humov.2015.05.005

[17] Vercruyssen F, Tartaruga M, Horvais N, et al., 2016, Effects of Footwear and Fatigue on Running Economy and Biomechanics in Trail Runners. Medicine & Science in Sports & Exercise, 48(10): 1976–1984. https://doi.org/10.1249/MSS.0000000000000981

[18] Mukai K, Ohmura H, Takahashi Y, et al., 2021, Four Weeks of High — intensity Training in Moderate, but not Mild Hypoxia Improves Performance and Running Economy More than Normoxic Training in Horses. Physiological Reports, 9(4): e14760. https://doi.org/10.14814/phy2.14760

[19] du Plessis C, Blazevich AJ, Abbiss C, et al., 2020, Running Economy and Effort after Cycling: Effect of Methodological Choices. Journal of Sports Sciences, 38(10): 1105–1114. https://doi.org/10.1080/02640414.2020.1742962

[20] Bassett DR, 2000, Limiting Factors for Maximum Oxygen Uptake and Determinants of Endurance Performance. Medicine and Science in Sports and Exercise, 32(1): 70–84. https://doi.org/10.1097/00005768-200001000-00012

[21] Schücker L, Fleddermann M, de Lussanet M, et al., 2016, Focusing Attention on Circular Pedaling Reduces Movement Economy in Cycling. Psychology of Sport and Exercise, 2016(27): 9–17. https://doi.org/10.1016/j.psychsport.2016.07.002

[22] Saunders PU, Pyne DB, Telford RD, et al., 2004, Factors Affecting Running Economy in Trained Distance Runners. Sports Medicine, 34(7): 465–485. https://doi.org/10.2165/00007256-200434070-00005

[23] Dolci F, Hart NH, Kilding A, et al., 2018, Movement Economy in Soccer: Current Data and Limitations. Sports, 6(4): 124. https://doi.org/10.3390/sports6040124

[24] Trowell D, Fox A, Saunders N, et al., 2022, Effect of Concurrent Strength and Endurance Training on Run Performance and Biomechanics: A Randomized Controlled Trial. Scandinavian Journal of Medicine & Science in Sports, 32(3): 543–558. https://doi.org/10.1111/sms.14092

[25] Kipp S, Byrnes WC, Kram R, 2018, Calculating Metabolic Energy Expenditure Across a Wide Range of Exercise Intensities: The Equation Matters. Applied Physiology, Nutrition, and Metabolism, 43(6): 639–642. https://doi.org/10.1139/apnm-2017-0781

[26] Barnes KR, Kilding AE, 2015, Running Economy: Measurement, Norms, and Determining Factors. Sports Medicine: Open, 1(1): 8. https://doi.org/10.1186/s40798-015-0007-y

[27] Chen TC, 2003, Effects of a Second Bout of Maximal Eccentric Exercise on Muscle Damage and Electromyographic Activity. European Journal of Applied Physiology, 89(2): 115–121. https://doi.org/10.1007/s00421-002-0791-1

[28] Mikkola J, Rusko H, Nummela A, et al., 2007, Concurrent Endurance and Explosive Type Strength Training Improves Neuromuscular and Anaerobic Characteristics in Young Distance Runners. International Journal of Sports Medicine, 28(7): 602–611. https://doi.org/10.1055/s-2007-964849

[29] Paavolainen L, Häkkinen K, Hämäläinen I, et al., 1999, Explosive-strength Training Improves 5-km Running Time by Improving Running Economy and Muscle Power. Journal of Applied Physiology, 86(5): 1527–1533.

[30] Saunders PU, Telford RD, Pyne DB, et al., 2006, Short-term Plyometric Training Improves Running Economy in Highly Trained Middle and Long Distance Runners. Journal of Strength and Conditioning Research, 20(4): 947–954.

[31] Ramírez-Campillo R, Alvarez C, Henríquez-Olguín C, et al., 2014, Effects of Plyometric Training on Endurance and Explosive Strength Performance in Competitive Middle- and Long-Distance Runners. Journal of Strength and Conditioning Research, 28(1): 97–104. https://doi.org/10.1519/JSC.0b013e3182a1f44c

[32] Balsalobre-Fernández C, Santos-Concejero J, Grivas GV, 2016, Effects of Strength Training on Running Economy in Highly Trained Runners: A Systematic Review with Meta-Analysis of Controlled Trials. Journal of Strength and Conditioning Research, 30(8): 2361–2368. https://doi.org/10.1519/JSC.0000000000001316

[33] Lum D, 2016, Effects of Performing Endurance and Strength or Plyometric Training Concurrently on Running Economy and Performance. Strength & Conditioning Journal, 38(3): 26–35. https://doi.org/10.1519/SSC.0000000000000228

[34] Gore CJ, Hahn AG, Aughey RJ, et al., 2001, Live High: Train Low Increases Muscle Buffer Capacity and Submaximal Cycling Efficiency: Hypoxia Increases Efficiency and Muscle Buffering. Acta Physiologica Scandinavica, 173(3): 275–286. https://doi.org/10.1046/j.1365-201X.2001.00906.x

[35] Sinex JA, Chapman RF, 2015, Hypoxic Training Methods for Improving Endurance Exercise Performance. Journal of Sport and Health Science, 4(4): 325–332. https://doi.org/10.1016/j.jshs.2015.07.005

[36] Saltin B, Kim CK, Terrados N, et al., 2007, Morphology, Enzyme Activities and Buffer Capacity in Leg Muscles of Kenyan and Scandinavian Runners. Scandinavian Journal of Medicine & Science in Sports, 5(4): 222–230. https://doi.org/10.1111/j.1600-0838.1995.tb00038.x

[37] Bonetti DL, Hopkins WG, 2009, Sea-Level Exercise Performance Following Adaptation to Hypoxia: A Meta-Analysis. Sports Medicine, 39(2): 107–127. https://doi.org/10.2165/00007256-200939020-00002

[38] Millet GP, Roels B, Schmitt L, et al., 2010, Combining Hypoxic Methods for Peak Performance. Sports Medicine, 40(1): 1–25. https://doi.org/10.2165/11317920-000000000-00000

[39] Park HY, Kim S, Nam SS, 2017, Four-week "Living High Training Low" Program Enhances 3000-m and 5000-m Time Trials by Improving Energy Metabolism during Submaximal Exercise in Athletes. Journal of Exercise Nutrition & Biochemistry, 21(1): 1–6. https://doi.org/10.20463/jenb.2017.0060

[40] Levine BD, 2002, Intermittent Hypoxic Training: Fact and Fancy. High Altitude Medicine & Biology, 3(2): 177–193. https://doi.org/10.1089/15270290260131911

[41] Katayama K, Goto K, Ishida K, et al., 2010, Substrate Utilization during Exercise and Recovery at Moderate Altitude. Metabolism, 59(7): 959–966. https://doi.org/10.1016/j.metabol.2009.10.017

[42] Brocherie F, Millet GP, Hauser A, et al., 2015, "Live High–Train Low and High" Hypoxic Training Improves Team-Sport Performance. Medicine & Science in Sports & Exercise, 47(10): 2140–2149. https://doi.org/10.1249/

MSS.0000000000000630

[43] Green HJ, Roy B, Grant S, et al., 2000, Increases in Submaximal Cycling Efficiency Mediated by Altitude Acclimatization. Journal of Applied Physiology, 89(3): 1189–1197. https://doi.org/10.1152/jappl.2000.89.3.1189

[44] Coates AM, Berard JA, King TJ, et al., 2021, Physiological Determinants of Ultramarathon Trail Running Performance. International Journal of Sports Physiology and Performance, 16(10): 1454–1461.

[45] Abbiss CR, Peiffer JJ, Meeusen R, et al., 2015, Role of Ratings of Perceived Exertion during Self-Paced Exercise: What are We Actually Measuring? Sports Medicine, 45(9): 1235–1243. https://doi.org/10.1007/s40279-015-0344-5

[46] Swart J, Lindsay TR, Lambert MI, et al., 2012, Perceptual Cues in the Regulation of Exercise Performance — Physical Sensations of Exercise and Awareness of Effort Interact as Separate Cues. British Journal of Sports Medicine, 46(1): 42–48. https://doi.org/10.1136/bjsports-2011-090337

[47] Doma K, Deakin GB, Bentley DJ, 2017, Implications of Impaired Endurance Performance following Single Bouts of Resistance Training: An Alternate Concurrent Training Perspective. Sports Medicine, 47(11): 2187–2200. https://doi.org/10.1007/s40279-017-0758-3

[48] Nosaka K, Newton M, 2002, Repeated Eccentric Exercise Bouts Do Not Exacerbate Muscle Damage and Repair. Journal of Strength and Conditioning Research, 16(1): 117–122.

[49] Rawson ES, Gunn B, Clarkson PM, 2001, The Effects of Creatine Supplementation on Exercise-Induced Muscle Damage. Journal of Strength and Conditioning Research, 15(2): 178–184.

[50] Braun WA, Dutto DJ, 2003, The Effects of a Single Bout of Downhill Running and Ensuing Delayed Onset of Muscle Soreness on Running Economy Performed 48 h later. European Journal of Applied Physiology, 90(1–2): 29–34. https://doi.org/10.1007/s00421-003-0857-8

[51] Hermens HJ, Freriks B, Merletti R, et al., 1999, European Recommendations for Surface ElectroMyoGraphy. Roessingh Research and Development, Netherlands.

[52] Brown SJ, Child RB, Day SH, et al., 1997, Exercise-induced Skeletal Muscle Damage and Adaptation Following Repeated Bouts of Eccentric Muscle Contractions. Journal of Sports Sciences, 15(2): 215–222. https://doi.org/10.1080/026404197367498

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research and Design on Building Digital Immersive Exhibitions in Museums — Taking the "24 Solar Terms Exhibition at the China National Film Museum" as an Example

Chaoyi Huang[†], Yuxi Chen[†], Xuanyao Zhang[†], Yanting Mo*

School of Design, Beijing Institute of Technology, Beijing 100081, China

[†]These authors are co-first authors

***Corresponding author:** Yanting Mo, 1491995164@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: With the rapid development of technology, digital immersive exhibitions have become a new trend in museum exhibitions. This article explores the application of digital immersive technology in museum exhibitions, particularly its role in showcasing intangible cultural heritage. Taking the "24 Solar Terms Exhibition at the China National Film Museum" as a case study, this article analyzes the current situation, design, and technological implementation of immersive exhibitions, and discusses their value in enhancing audience experience, cultural education, and innovative development of museums. Through practical cases, this article demonstrates how to combine modern technology with traditional culture to create an exhibition experience that is both educational and engaging. The research results indicate that digital immersive exhibitions can effectively enhance cultural heritage and educational effectiveness, while also enhancing the brand image and social influence of museums.

Keywords: Digital immersive exhibition design; 24 solar terms culture; Interactive experience

Online publication: March 10, 2025

1. Introduction

This study analyzed the literature published in the past 5 years using VOS software (**Figure 1**). At present, immersive exhibitions in museums are showing a trend of diversification, innovation, and technological development. Due to the development of technologies such as AR and VR in recent years, new forms of exhibition innovation have been promoted, and the experience of visitors visiting exhibitions has also been enhanced, making the presentation of museum exhibitions more vivid, intuitive, and with a stronger sense of participation from visitors. In terms of application cases, many museums have successfully applied these advanced technologies to exhibitions. For example, in

its exhibition plan for 2024, the Shanghai Museum will launch multiple special exhibitions, including the "Starry China — Sanxingdui Jinsha Ancient Shu Civilization Exhibition", which will fully utilize digital technology and immersive display methods to bring audiences a new viewing experience [1]. Dunhuang has also utilized relevant technologies, using immersive techniques to support the sustainable development of Dunhuang's cultural heritage [2].

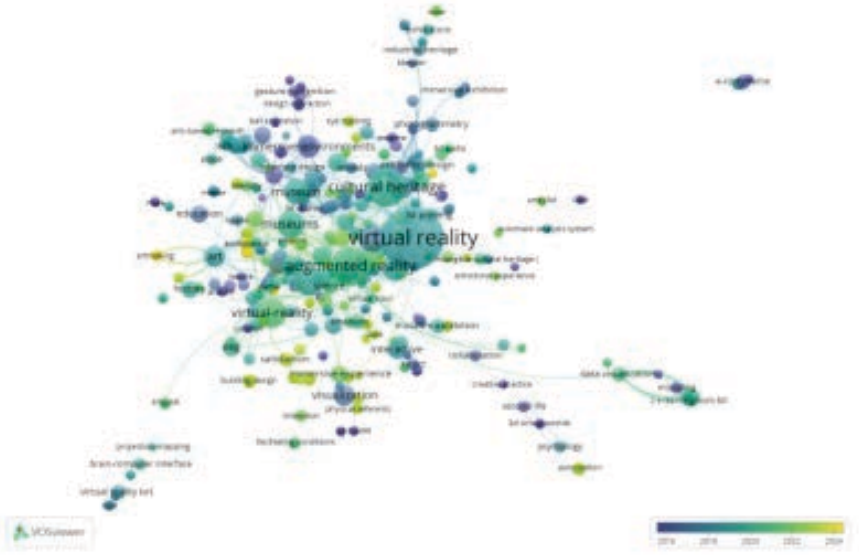


Figure 1. Keyword relationship graph of immersive exhibition-related research

From the current published papers, it can be seen that around 2020, there was a significant amount of publications related to virtual reality technology and museums. However, there have been many problems in actual exhibition practice due to the high number of visitors to museums, VR and other devices are usually unable to meet the needs of all tourists and require long waiting times. Therefore, many museums have gradually begun to downplay the role of VR in exhibitions. However, tourists still need more innovative experiences. According to the research conducted by Thompson, the overwhelming majority of visitors exhibit a stronger preference for the space-surround environment [3]. Therefore, museums are constantly exploring, and the immersive experience surrounded by large screens undoubtedly has certain advantages in efficiency and cost (**Figure 2**). As described by Wickens, several characteristics of space-surround environments parallel the key features of "virtual reality" [4]. For instance, a museum can utilize dynamic displays, such as films and videos, which are capable of depicting scientific phenomena more accurately than static images [5]. In recent years, immersive art exhibitions set in museums have experienced vigorous development. The Frameless Museum in London immerses audiences in works by Monet, Van Gogh, and Cézanne through large-scale projections. Similarly, Milan Expo's Japan Pavilion "Harmony" uses digital technology to recreate rice fields' vitality. TeamLab further enhances immersive art with interactive spaces like "Yatagarasu", blending cultural storytelling and aesthetic innovation in transformative experiences.

technical means	advantage	disadvantage
Multi screen surround	1. Enhance spatial and immersive experience through multi angle visual display. 2. Display large-scale scenes and complex historical events. 3. Viewers can freely choose their viewing angles, improving their autonomy in visiting. 4. Suitable for showcasing dynamically changing content.	1.High equipment and space requirements, 2.with a large initial investment. Maintenance and updates are relatively complex 3. There are certain limitations on the spatial positioning and movement of the audience
Virtual Reality (VR)	1. Provide an immersive experience, allowing visitors to immerse themselves in historical or cultural scenes 2. Can reproduce scenes that cannot be visited in person 3. Enhance the fun of education and learning through simulation and interaction 4. Easy to update and modify content, keeping the exhibition fresh	1.High quality equipment and maintenance costs 2.May cause dizziness and discomfort for users. 3. Strong dependence on technology, once the device malfunctions, it may affect the overall experience. 4. There may be barriers to entry for visitors who are not familiar with urgent technology
Augmented Reality (AR)	1. Combining real and virtual information to provide a highly interactive visiting experience. 2. It can be accessed through mobile phones or tablets, making it easy to popularize and use 3. It can achieve real-time information updates and displays, improving the timeliness of exhibitions. 4. It helps attract young audiences and expand the audience of museums	1. The technical implementation is complex and requires precise positioning and image recognition 2. Information security issues, such as privacy breaches and data protection 3. The user interface and experience design requirements are high, and improper design may affect the visiting experience. 4. The dependence on devices is high, and there may be differences in experience between different devices

Figure 2. Analysis of the advantages and disadvantages of immersive exhibition technology

At present, there are still some shortcomings in the exhibition of intangible cultural heritage in museums. Many intangible cultural heritages exist in festivals and customs, and there are few specific actual items that can be displayed in exhibitions. Even if there are some exhibits related to festival customs, it is difficult for the audience to feel the cultural atmosphere.

Taking the 24 solar terms as an example, as an important intangible cultural heritage of China, how can exhibitors still make people feel the cultural atmosphere of intangible cultural heritage when they no longer need to cultivate in cities today? This is a topic that requires researchers to explore in-depth, and they need to combine the 24 solar terms with modern technology and innovate display methods.

2. Feasibility analysis of enhancing immersive exhibition experience

2.1. Technical support on software: Scene restoration technology

Use a FARO 3D laser scanner to scan the exhibition hall with multi-point control. A dedicated person selects suitable points and angles for accurate and complete spatial data (**Figure 3**). After the initial scan, post-process point cloud data in professional software (denoise, register, stitch). Finally, Use Twinmotion to simulate scenarios for virtual presentations, modeling, setting materials, and adding lighting and adjusting materials for video production visualization (**Figure 4**).

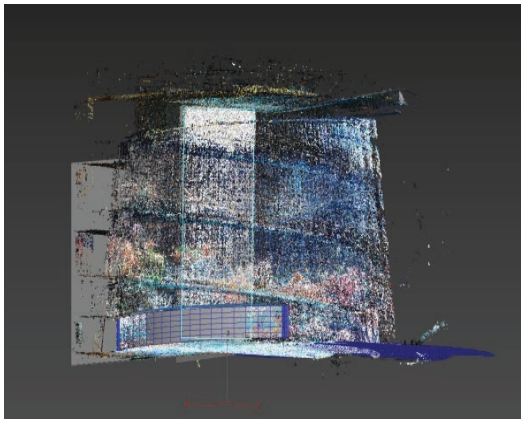


Figure 3. Point cloud generated by scanning with a FARO 3D laser scanner



Figure 4. Use Twinmotion simulation scenarios for virtual presentations

2.2. Animation production technology

Open AE settings parameters to create a 24 solar term engineering file. Hand-drawn materials for the 24 solar terms were imported into AE engineering files, and placed on different layers. Create animation effects by adding keyframes through attributes such as movement, rotation, and scaling, adding rich content such as special effects and sound effects, and finally rendering the output animation.

2.3. Collaboration between museums and universities

At present, the cooperation between museums and universities is showing a trend of deepening integration, resource sharing, and mutual benefit at the policy level. Museums can fully leverage their cultural resources and educational functions, while universities can utilize the advantages of talent cultivation to enhance their practical abilities, jointly promote the protection, inheritance, and innovation of intangible cultural heritage, and improve the professionalism of

high-level talent cultivation.

Both parties can jointly plan and implement museum-school cooperation projects, such as holding themed exhibitions, academic seminars, and other activities, which not only enrich campus cultural life but also enhance the social influence of the museum (**Figure 5**). In an open learning environment, students can be exposed to more new knowledge and ideas, stimulate their curiosity and creativity, put theory into practice, and lay a solid foundation for their future career development.

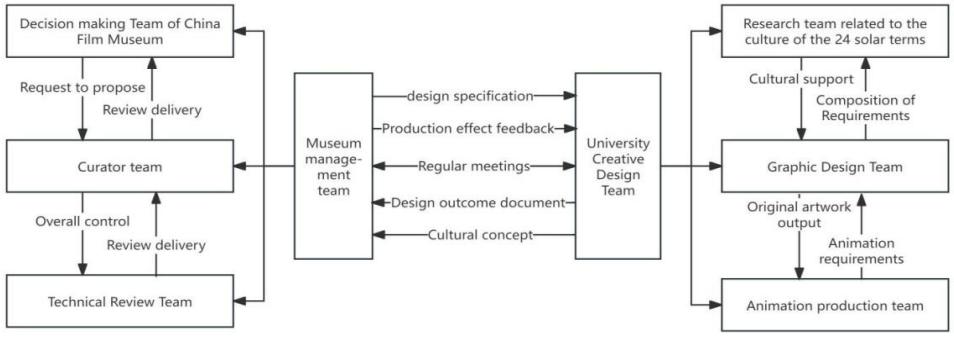


Figure 5. Flowchart of collaboration between museums and universities

3. Design practice of immersive exhibition

3.1. Immersive cultural experience

The Central Hall of the China Film Museum utilizes multiple sensory stimuli, including visual, auditory, tactile, etc., to create a comprehensive sensory environment that allows the audience to feel truly immersed in the environment presented by the exhibition. This atmosphere allows the audience to have a more intuitive understanding of the history and cultural background of the 24 solar terms, an intangible cultural heritage. At the same time, it provides them with a unique emotional experience. For example, during the Rain Festival, the audience feels like they are surrounded by lanterns on a small river at night, and during the Qingming Festival, they feel like they are in the cultural atmosphere of a small bridge flowing water in the Jiangnan region, truly experiencing the unique charm of traditional Chinese culture (**Figure 6**).



Figure 6. The main visual image of the immersive exhibition during twenty-four solar terms

People living in modern cities no longer need to cultivate, so how to protect and inherit the 24 solar terms culture, which is an intangible cultural heritage based on agricultural civilization, is a very challenging task. If it only shows

the characteristics of traditional agricultural culture, it may not arouse the interest of the audience and cannot meet the cultural needs of people today. However, through immersive experiential exhibitions, cultural heritage can be displayed more attractively, thereby expanding the breadth and depth of cultural inheritance. Viewers can gain a deeper understanding of the history and significance of cultural heritage, while also experiencing the charm and value of culture. This experiential approach not only helps to enhance public awareness and respect for cultural heritage but also stimulates their interest and sense of responsibility for cultural protection and inheritance.

3.2. User experience experiments before and after design

To verify the authenticity of the effect, the researchers took the form of a questionnaire survey to test the immersive effect. This research questionnaire was designed based on users' experiences before, during, and after the exhibition, comprising a total of 17 questions. The survey primarily focused on the differences in experience and sense of immersion among on-site audiences before, during, and after the exhibition. A total of 128 questionnaires were distributed. The survey results indicate the following.

The sensory experience at the China Film Museum received high recognition from the audience, with a significant improvement in immersion. As shown in **Table 1**, 44.43% of the audience rated the visual and animation effects as "excellent, highly impressive," while 35.15% considered them "quite impressive, with strong visual impact."

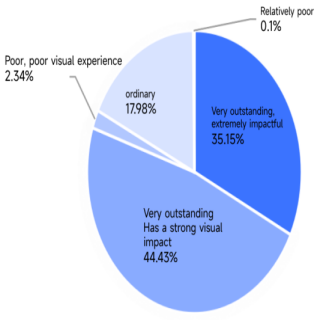


Table 1. Audience perception of visual effects

Additionally, by comparing the immersive experience of the "Twenty-Four Solar Terms" exhibition with other themed exhibitions in the museum, data on the differences in immersion before and after the experience were obtained. The results show that the audience's sense of immersion increased after the experience, as detailed in **Table 2**.

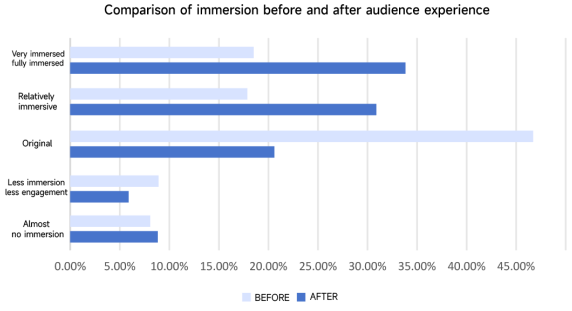


Table 2. Comparison of audience immersion before and after the experience

The communication of solar term culture was clear, leading to an enhanced cultural identity among the

audience. After the experience, the audience's understanding of solar term culture improved due to the clear information provided by the exhibition. Specifically, 28.9% of the audience found the displayed solar term information "very clear and easy to understand" (**Table 3**). Post-experience, the audience's awareness, and recognition of solar term culture also improved.

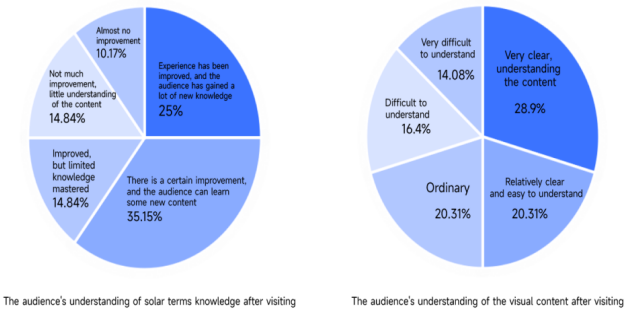


Table 3. Audience's understanding of solar term culture after the experience

The "Twenty-Four Solar Terms Immersive Exhibition" at the China Film Museum has achieved significant improvements in terms of immersion, visual experience, cultural dissemination, and audience identity.

4. Retrospect and prospect

This article explores the application of digital immersive exhibitions in museums and their positive impact on cultural heritage and education through in-depth research and design practice of the "24 Solar Terms Exhibition" at the China Film Museum. The researchers have found that by combining modern technology with traditional cultural connotations, not only can the audience's experience and participation be enhanced, but also the breadth and depth of cultural inheritance can be effectively expanded, the level of social education can be improved, and the innovative development of museums can be promoted.

In the future, museums should continue to explore how to better utilize digital technology to create more diverse and interactive exhibition forms, to meet the cultural needs of the public and enhance social educational value. At the same time, museums should also pay attention to the protection and innovative display of intangible cultural heritage, to revitalize traditional culture in modern society. Through these efforts, museums will be able to better fulfill their social functions, become cultural bridges connecting the past and future, tradition and modernity, and make greater contributions to promoting cultural diversity and the progress of human civilization.

In short, digital immersive exhibitions have opened up new paths for the future development of museums. The researchers look forward to seeing more innovative practices and breakthroughs, making museums a more vivid, open, and interactive cultural space, and allowing the brilliance of cultural heritage to shine on a broader future.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Tan XL, 2024, Discussion on the Exhibition Planning of "Exploring the Ancient Shu Civilization: Sanxingdui and Jinsha". Museum, 3(3): 99–104.

[2] Zhang R, Pan Y, 2024, Immersive Narrative Interactive Games in Dunhuang Online Museum: A New Approach to Promote Sustainable Development of Cultural Heritage. Proceedings of the Korean Society of Industrial Engineers Spring Joint Conference, 2024(5): 709–716.

[3] Thompson DR, 1993, Considering the Museum Visitor: An Interactional Approach to Environmental Design, thesis, The University of Wisconsin-Milwaukee.

[4] Wickens CD, 1992, Virtual Reality and Education. 1992 IEEE International Conference on Systems, Man, and Cybernetics, 842–847.

[5] Harvey ML, Loomis RJ, Bell PA, et al., 1998, The Influence of Museum Exhibit Design on Immersion and Psychological Flow. Environment and Behavior, 30(5): 601–627.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Opportunities and Challenges for Innovative Design of Traditional Tie-dyeing Techniques in the Era of Self-media

Zhongxiang Feng*, Yang Liu

Tianjin University of Technology and Education, Tianjin 300222, China

Corresponding author: Zhongxiang Feng, 15335586095@163.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: With the popularization of self-media, traditional tie-dyeing techniques in China have gained wider opportunities for dissemination and innovation. However, current self-media platforms face problems such as information overload, intense competition, and the inability of some products and processes to maintain traditional characteristics, which pose significant challenges to the dissemination and innovation of traditional tie-dyeing techniques. The article provides a detailed discussion and analysis of the opportunities and challenges brought by self-media to traditional tie-dyeing techniques, providing new references for innovative design of traditional tie-dyeing techniques in the era of self-media.

Keywords: Self-media era; Traditional tie-dyeing technique; Innovative design; Opportunity; Challenge

Online publication: March 10, 2025

1. Overview of the development of traditional tie-dyeing techniques and contemporary innovative design

1.1. The historical context of the tie-dyeing process

Tie-dyeing is one of China's precious intangible cultural heritages and an important category in traditional arts and crafts, with rich cultural connotations and artistic value. According to historical research, tie-dyeing technology began to be applied to fabric dyeing in ancient China during the Qin and Han dynasties and was then known as tie and tie-dyeing. It has a history of about 1500 years to this day.

With the evolution of history, tie-dyeing techniques have been inherited and innovated in various dynasties. During the Six Dynasties period, people created deer maw by imitating the patterns of deer maw and created fish roe maw by tying and dyeing [1]. In the Tang Dynasty, the technique of using wooden boards to carve patterns for dyeing and the printing technique of using molds for dyeing emerged. At the same time, wax printing was also very popular, known in ancient times as wax printing, which involved drawing patterns on fabrics with wax and then dyeing them. The

parts covered with wax cannot be dyed, thus presenting patterns [2]. In the Ming Dynasty, over fifty types of dyes were used for dyeing, and specialized dyeing workshops emerged. Nowadays, tie-dyeing has developed various techniques, including bundling, seam dyeing, arbitrary folding, and immersion dyeing, which can produce different artistic effects.

In modern times, Yunnan, Guizhou, Sichuan, and other places in China have been inheriting and developing traditional tie-dyeing techniques. For example, in some cities in Yunnan, such as Zhoucheng, known as the hometown of tie-dyeing, many handicrafts made using tie-dyeing techniques are sold to tourists, such as shawls, scarves, etc., bringing economic benefits to the local area.

1.2. Tie-dyeing technology in contemporary innovative design

The tie-dyeing process usually uses flat fabric as the basis and creates different artistic effects by using various tie-dyeing techniques for dyeing. The works created by traditional tie-dyeing techniques are mostly flat, and the dyes used are mostly plant dyes, usually presenting indigo or cyan, mainly applied to clothing.

In today's society, with the inheritance of tie-dyeing technology, it has also been widely used in various products, enriching the forms of expression of tie-dyeing technology. At the same time, traditional tie-dyeing techniques are also integrated with uniquely shaped crafts and new materials, making the artistic effect of traditional tie-dyeing techniques no longer limited to flat fabrics [3].

1.2.1. The application of tie-dyeing in handicrafts

The combination of tie-dye craftsmanship and earring design endows earrings with a unique charm. Earstuds made of Miao silver material come in various shapes such as square, round, and oval. On the surface of the earring, hand-tie-dyed fabric is cut into small pieces and sealed in the center of the earring. The fusion of tie-dyeing technology and earrings gives earrings an elegant style that is different from metal materials, giving people a new feeling.

The combination of tie-dye craftsmanship and leather crafts design allows users to experience a unique feeling. A handmade tie-dye cultural and creative wristband cleverly combines cowhide and tie-dye fabric together. The shape of the wristband is similar to a watch, with the ring part made of real cowhide and a hard texture, while the main body of the wristband is decorated with tie-dyed fabric, presenting a soft color. The entire wristband gives people a unique feeling of combining rigidity and softness.

1.2.2. The combination application of tie-dyeing process and different materials

Generally speaking, the effect of traditional tie-dyeing on raw fabric usually has high color purity and a strong visual impact. The use of tie-dye for dyeing organza results in relatively low color purity, giving a fresh and elegant feeling. By utilizing the characteristics of organza, which undergoes shrinkage and shape changes at high temperatures, combined with tie-dyeing techniques, various rich effects can be created, further enhancing the artistic expression of tie-dyeing techniques.

Humans have a history of thousands of years in the application of fish skin materials. In today's society, people use discarded non-protected fish skins from the market as artistic carriers. The application of fish skin materials not only allows for the treatment and utilization of discarded fish carcasses, reducing environmental pollution, but also, combined with dyeing techniques, turns these discarded fish skins into works of art. This innovative application not only protects the natural environment but also achieves new breakthroughs and applications in tie-dyeing technology.

2. Opportunities for innovative design of traditional tie-dyeing techniques in the era of self-media

With the development of social platforms and the diversification of information dissemination, many individuals and small groups began to use the Internet platform to create and share their works. By disseminating and exchanging content through relevant platforms, individuals and groups can showcase their creative achievements more widely [4].

In the era of self-media, anyone can create and publish content through self-media platforms. For most people, creating content such as lifestyle vlogs, video content, or publishing news is relatively low-cost and may also generate some revenue. There are various forms of self-media creation, including images, audio, and other forms. Creators can create content according to the different preferences of the public.

In today's society, various self-media platforms have emerged as key opinion leaders in many fields, who play a huge driving role in cultural dissemination in their respective fields. For example, Li Ziqi, Grandpa Amu, and Zhu Tiexiong. In this situation, self-media platforms provide new opportunities for innovative design of traditional tie-dyeing techniques.

2.1. More extensive and efficient channels of dissemination

In the past, traditional methods of information dissemination mainly relied on media such as newspapers, magazines, radio, and news agencies. In contrast, traditional methods of information dissemination require editing, typesetting, and other steps, resulting in slower dissemination speed. Meanwhile, the public can only receive information in one direction and cannot engage in rapid interaction and feedback.

Today, the dissemination of information has become efficient and diverse. The innovative design of the traditional tie-dyeing process can be spread through various self-media platforms. Today, self-media platforms such as Jinri Toutiao, Sohu, Tiktok, Xiaohongshu, Himalaya, etc., can complete the dissemination of information in a short time. At the same time, self-media platforms have interactive commenting functions, allowing creators to receive timely feedback from the public and make corresponding improvements to create more valuable content. This dissemination method has expanded the traditional ways of tie-dyeing technology and improved dissemination efficiency.

The Ninghang wax printing in Danzhai, Guizhou Province is a national intangible cultural heritage project. To publicize the batik craft of Nanjing and Hangzhou, they created an official account on the WeChat platform, and released the production process and related works of batik crafts through Tiktok, Xiaohongshu, and other self-media platforms, so that more people learned about the batik craft of Danzhai.

2.2. More convenient and user-friendly design solutions

Design has always focused on human needs and embodies humanization in the design process. For traditional tie-dyeing techniques, in the process of inheritance, it is necessary to maintain the characteristics of traditional craftsmanship while also innovating design according to the needs of modern people.

Currently, utilizing self-media platforms to promote innovative designs of traditional tie-dye crafts can better interact with users and timely obtain their suggestions and feelings about tie-dye crafts. Self-media platforms have interactivity and timeliness and can respond to user feedback faster.

2.3. More possibilities for innovative inspiration

On self-media platforms, there are many creators with rich cultural heritage and knowledge, who share cultural knowledge in various fields.

Tiktok blogger Jiang Xunqian (September) focused on learning Chinese traditional arts and crafts, and made

ancient arts and crafts with modern materials and methods, realizing design innovation. She also designs and creates based on her own feelings in daily life. Traditional dragon and phoenix candles were essential for weddings in ancient times, and prolonged burning represents long-lasting happiness for couples. Jiang Xunqian uses sweet potatoes as a tool to draw candle patterns when making traditional flower candles. He draws decorative patterns on the candles and adds candle wax. He also incorporated some modern elements into the overall design and innovatively designed the dragon and phoenix flower styles.

Based on the above analysis, the design innovation of traditional tie-dyeing techniques can be approached from both traditional and modern perspectives, as well as from different cultural angles, integrating different fields and characteristic elements together. Based on maintaining traditional cultural characteristics, innovative design is carried out to endow traditional tie-dyeing techniques with new features.

2.4. A broader commercial platform

The self-media platform provides a broader commercial platform for innovative design of traditional tie-dyeing techniques. At present, many cultural products are sold through commercial channels provided by self-media platforms and successfully promote their own culture. Yuelu Academy sells accounting books printed with the academy's rules, bookmarks based on the academy's appearance, and the Four Treasures of the Study through the WeChat store of No. 9 Academy. These products effectively spread the teaching philosophy and cultural connotations of the academy, and bring economic value to Yuelu Academy.

The self-media platform has created a new business model for traditional tie-dyeing techniques, such as online sales and customized services, further expanding the market space of traditional tie-dyeing techniques. At the same time, the retail sales of physical goods on the Internet are also increasing year by year, and the e-commerce platform has attracted a large number of consumers. This innovative development of tie-dyeing technology provides another way.

3. The challenge of innovative design in the traditional tie-dyeing process in the era of three self-media

3.1. Information overload and fierce competition on self-media platforms

Today's self-media platforms, such as WeChat, Weibo, TikTok, etc., have brought together a large number of creators. According to the statistics of the Annual White Paper of Kwai Music in 2022, 350 million creators created more than 13.8 billion works in 2022 alone. Meanwhile, self-media platforms have the characteristic of fast dissemination speed, pushing a large amount of information every day, including news, short videos, advertisements, and other user-created content.

According to a study published in the American magazine Computers in Human Behavior in 2014, more and more news is being delivered to readers through print, broadcast, and interactive means. In today's society, people can access a large number of articles, images, and videos anytime and anywhere. However, in this situation, people must deal with a large amount of irrelevant information from the outside world.

This article reflects that in the self-media environment, the amount of information is extremely large, with a wide and diverse range of sources, making it inevitable for people to face a large amount of irrelevant information. Excessive information may make it difficult for people to filter out valuable content for themselves, and may even have an impact on the brain's information processing ability and cognition. In this situation, the innovative design of the traditional tie-dyeing process needs to stand out on self-media platforms and attract public attention, generating high influence in fierce competition, which is a huge challenge for the traditional tie-dyeing process.

3.2. Maintain a balance between traditional characteristics and adapting to the market

In the era of self-media, the design ideas of creative products continue to emerge, like spring shoots emerging endlessly. In this context, maintaining the traditional characteristics of tie-dyeing technology and carrying out innovative design is also a major challenge [5]. At present, various creative product design ideas are rapidly emerging, like green grass in spring. The public's expectations for design and innovation are constantly increasing, which is also a huge challenge for maintaining the characteristics of traditional tie-dyeing techniques while carrying out innovative design.

Embroidery is a technique of manually embroidering various decorative patterns on fabric. However, with the rise of modern production methods, many traditional embroidery techniques have gradually been replaced by machines. Embroidery, as a unique traditional craft in China, has a unique artistic charm. In recent years, to meet market demand, some businesses have increased their embroidery production and extensively used machine embroidery, such as Hong embroidery. This has resulted in machine embroidery producing more than manual embroidery. There are also many machine embroidery works for sale in the online stores of self-media platforms. Although machine embroidery can improve the production speed of handicrafts, it cannot fully reflect the artistic value and cultural connotation of embroidery works [6].

4. Thoughts on the development of tie-dyeing technology in the era of media

4.1. Analysis of the successful reasons for the dissemination of traditional arts and crafts on self-media platforms

On current self-media platforms, figures such as Jiang Xunqian, Peng Nanfangke, and Shan Bai who are dedicated to spreading traditional arts and crafts can achieve high influence mainly for the following reasons.

Unique themes and styles: Their videos have clear themes and unique personal styles that can attract the audience's attention. For example, Jiang Xunqian showcases traditional Chinese culture in a fresh style, Peng Nanke focuses on spreading agricultural skills and intangible cultural heritage, and Shan Bai focuses on replicating traditional objects such as brush, ink, paper, and inkstone. These unique themes and styles make them stand out among many self-media creators.

Professional content production: Their accounts and series of videos are all very professional, with dedicated personnel overseeing topics, script planning, content presentation, filming techniques, editing skills, and subsequent operation and dissemination. For example, Jiang Xunqian's videos are well produced, with beautiful visuals that can bring viewers aesthetic enjoyment. Peng Nanke uses skilled techniques and cross-temporal production methods to help viewers better understand agricultural skills and traditional culture.

Interaction and communication with the audience: They focus on interaction and communication with the audience, establishing a good relationship with them through replying to comments, private messages, and other means. For example, Jiang Xunqian interacts with fans in the comment section and answers their questions, which makes fans feel her affinity. They also make corresponding adjustments to their videos based on feedback from fans.

In the era of self-media, the inheritance of tie-dye craftsmanship can be inspired by successful cases. Communicators should clarify the theme and shape a unique style, such as exploring the cultural connotations of tie dye and presenting them in different styles to attract audiences. Emphasis on professional content production, covering multiple topics, showcasing the beauty of tie-dyeing through rich forms and exquisite techniques.

4.2. Establishing domain brands and cultivating domain KOLs

In the era of self-media, establishing an independent brand can give a product or enterprise a unique identity, making it stand out in the market. The establishment of a brand can not only enhance its own value and shape a unique image but

also enhance its competitiveness in market competition. At the same time, key area advocates (KOLs) with high visibility can help promote the brand through their own influence, which can help shape the brand's image and reputation [7].

In the era of self-media, to cope with issues such as information overload and fierce competition, innovative design of traditional tie-dyeing techniques can be achieved through brand building. People can use self-media platforms to publish videos introducing traditional tie-dyeing techniques and interact with users to understand their interests and needs. Based on maintaining the characteristics of traditional tie-dyeing techniques, innovative designs are carried out to meet the needs of users. Gradually establish one's own brand, promote tie dye crafts, and thus promote innovation in traditional tie dye craft design. At the same time, it can cultivate key opinion leaders (KOLs) with professional knowledge, promote tie-dyeing techniques, and enhance brand awareness and influence.

5. Summary

In the era of self-media, there are both opportunities and challenges for innovative design of traditional tie-dyeing techniques. By fully utilizing the advantages of self-media platforms, one can establish their own unique brand image. On the premise of maintaining traditional tie-dyeing techniques, innovative designs are carried out according to market and user needs to expand the market space of tie-dyeing crafts. At the same time, cultivating key opinion leaders in the field of tie-dyeing technology provides more possibilities for the inheritance and innovation of tie-dyeing technology. Through these efforts, success can be achieved in the era of self-media and promote the development and innovation of traditional tie-dyeing techniques.

Disclosure statement

The author declares no conflict of interest.

Reference

[1] Wang SQ, Xu YQ, 2013, The Most Beautiful Weaving, Dyeing and Embroidery in China. Hubei Fine Arts Publishing House, Wuhan, 1–2.

[2] Tian ZB, 2024, History of Chinese Arts and Crafts. Business Library, 2014(8): 154–155.

[3] He BR, Wu Y, Liang QH, 2023, Tie-dyeing Technology and Its Innovative Application in Modern Cultural and Creative Design. Liaoning Silk, 2023(4): 65–66.

[4] Zhang YL, Li YH, 2022, A Study on the Communication Path of Nantong Tie-dyeing from the Perspective of New Media. Lianlian, 2022(2): 4–6.

[5] Chen YJ, 2022, Inheritance and Development of Tie-dyeing Craft under the Background of Intangible Cultural Heritage Protection. Western Leather, 44(15): 19–27.

[6] Li F, 2007, A Brief Discussion on the Problems and Development Trends Faced by China's Contemporary Embroidery Industry. Art and Design (Theory), 2007(2): 136–137.

[7] Zhang ZY, 2022, Research on the Construction and Communication of Self-media Brands from the Perspective of Omnimedia: Taking the New World as an Example, thesis, Qingdao University of Science and Technology.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Tourism Culture in Luoshui Town, Shifang, Deyang City from the Perspective of Engineering Design

Jin Hu[1,3]*, Wei Wei[2], Wentao Li[3], Yue Xiao[3]

[1]Chengdu Tailige Environmental Technology Co., Ltd., Chengdu 610200, Sichuan, China

[2]Luzhou Water Resources and Electric Power Survey and Design Institute, Luzhou 646000, Sichuan, China

[3]Sichuan College of Architectural Technology, Deyang 618000, Sichuan, China

***Corresponding author:** Jin Hu, 478428210@qq.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Luoshui Town in Shifang has a beautiful natural environment and a long history and culture, which is a protected area listed as a famous historical and cultural town. A large number of cultural relics and historic sites are here, such as Li Bing mausoleum, Da Peng Temple, Da Wang Temple, Houcheng Zhi, Chuanzhu Temple, Mosque, Yang Family Ancestral Hall, and Li Bing's numerous relics of water control and immortality ascension. The vast majority of tourism introductions are about the legend of Li Bing and the comparison between the Luoshui irrigation project and the Dujiangyan irrigation project, but little research has been done from the perspective of engineering design. To explore the tourism culture of Luoshui town from the perspective of engineering design, the Daoluo water conservancy project in Shifang was studied through a literature search, field investigation, and semi-aerial geophysical prospecting. By comparing its design concept and design form with the Dujiangyan irrigation project, the design characteristics of the Luoshui water conservancy project in Shifang, Deyang were excavated. At the same time, combined with the cultural relics around the water conservancy project, it was judged that the water conservancy project was likely to be built by Li Bing, and Li Bing was also likely to die in Shifang to a large extent.

Keywords: Li Bing; Luoshui town; Hydraulic engineering; Design concept; Tourism culture

Online publication: March 10, 2025

1. Introduction

Luoshui Town in Shifang has a beautiful natural environment and a long history and culture, which is a protected area listed as a famous historical and cultural town. A large number of cultural relics and historic sites are there, such as Li Bing mausoleum, Da Peng Temple, Da Wang Temple, Houcheng Zhi, Chuanzhu Temple, Mosque, Yang Family

Ancestral Hall, and Li Bing's numerous relics of water control and immortality ascension. The vast majority of tourism introductions are about the legend of Li Bing and the comparison between the Luoshui, Shifang irrigation project, and Dujiangyan irrigation project, but little research has been done from the perspective of engineering design. To explore the tourism culture of Luoshui Town from the perspective of engineering design, the authors plan to conduct research and discussion from the perspective of the design concept of the irrigation project and the authenticity of the irrigation project built by Li Bing.

Li Bing (about 302–235 B.C.) was appointed as governor of Shu Prefecture by King Zhao of Qin from 256–251 B.C. [1]. During this period, Li Bing, in line with the Taoist ideas of "Tao follows nature" and "harmony between man and nature", and based on investigating and understanding the causes of floods caused by the Minshan river system, built many irrigation projects in the Minjiang River Basin and Tuojiang River Basin. In addition to Dujiangyan, Li Bing also presided over the construction of other irrigation projects. Such as "When guiding the Luoshui River to flow through the mountains, the Luoshui River may emerge as a waterfall, passing through Shifang and Pidou before branching into a separate river."; "Crossing the Shixi River in the south of the Yangtze River"; "Li Bing further connected the Zawu-Wenjing Rivers, and after passing through Linqiong, the river divided at Mengxi, flowing into the Baimu River."; "Dividing the Yangmo River from the dike" and so on [2–4]. Among them, the Dujiangyan hydraulic engineering project built by him and his son in his early years and the hydraulic engineering project built by him by diverting the Luoshui River and clearing the mountain pass in Shifang in his later years are the most famous.

2. Daoluo water conservancy project and its design concept

Li Bing managed water control in Shifang by "diverting the Luoshui River and clearing the mountain pass." He carved through rocks to widen the ancient waterfall opening and dredged the Luoshui River. In the downstream from the waterfall, he excavated Baihe (Crane) Lake, and then, based on a careful assessment of the terrain, constructed a flat dam to establish the Luokou Weir. On this foundation, he built three weirs (**Figure 1**): the upper weir was called Zhu Weir, the middle section of the weir was called Li Weir, and the left section was known as Fire-burnt Weir, which enters the territory of Mianzhu [5]. 70% of water flows to Shifang while 30% water flows to Mianzhu. This scientific management turned counties like Shifang and Mianzhu abundant in fish and rice with guaranteed harvests regardless of drought or flood, while also effectively mitigating the damage caused by flooding to the forest vegetation and rural farmlands along the banks of the Luoshui River.



Figure 1. A realistic picture of the Daoluo Project (Quoted from: Li Bing and Shifang)

2.1. Governance Process

The record in Records of the Huayang Region: Shu Chronicles states: "(Li Bing) also diverted the Luoshui River to clear the mountain pass. The Luoshui River either emerged from the waterfall outlet, flowing through Shifang, Pidou, and joining another river and converging at Dadu in Xindu." This record indicates that after completing the Dujiangyan hydraulic engineering project, Li Bing came to Shefang to divert the Luoshui River, clear the mountain pass, and manage the Tuojiang River.

The Li Bing Shifang Luoshui River Diversion Project involved two main components: the excavation of the waterfall outlet and the dredging of the Luoshui River bed. The waterfall outlet, located at today's Gaojingguan (elevated scenery), its mountain landscape and water flow are similar to the Baoping Mouth of the Dujiangyan hydraulic engineering project. The excavation of the Baoku Mouth involved opening another canal at Gaojingguan Pass, which primarily shows benefit during the dry seasons of winter and spring to ensure water supply for areas south of the Luoshui River, including Shifang and Guanghan. This canal was anciently known as "Luopeng" or "Luoyan" and is now called Zhulihuoyan Weir (**Figure 2**). The term "Daoluotong Mountain" refers to the excavation through Zhangshan, the front range of the Longmen Mountains at Gaojingguan Pass, which obstructed the flow of the Luoshui River, and the dredging of obstacles that hindered the discharge of the Luoshui River into the Tuojiang River.

In addition, Records of the Huayang Region: Shu Chronicles states that "Mianshui River flows out of Ziyan Mountain, enters Luoshui through Mianzhu, flows eastward through Zizhong, and meets Jiangyang, irrigating rice fields and moistening crops. Therefore, the Shu people call Pi Fan "Gao Fu" (richness) and Mianluo "Jin Wo" (fertile).

This sentence illustrates that while Li Bing led the Luotong Mountain, he also managed the Mianshui River, making it a "fertile land" for irrigating farmland and benefiting the people, turning floods into water conservancy, and promoting the reputation of the Chengdu Plain as the "Land of Abundance."

2.2. Governance Plan and Characteristics

For the Luoshui project, according to the actual situation, the water diversion is different from that of the Dujiangyan irrigation project's 40% and 60% proportions [6]. The proportions are 30% and 70%, 30% to Mianzhu, and 70% to Shifang (**Figure 2**). The reason is that Mianzhu has the Mianyuan River, whose water volume can also provide water for Mianzhu. The fundamental reason lies in the scientific calculation of water consumption.



Figure 2. The realistic picture of the 30% and 70% proportions in the Luoshui Project

"Deep lear the shoal" actually does not mean that the sand is scoured very deep because if it is scoured too deep and the water inflow is too large, it will cause floods; The water is too shallow and the inflow is insufficient, making it difficult to ensure irrigation. Therefore, it actually refers to dredging the sand in the riverbed to a moderate depth during annual maintenance. When Li Bing was harnessing the Dujiangyan Irrigation Project, he came up with the idea of

burying an auspicious animal stone rhinoceros under the river bed. If the stone rhinoceros is slightly obvious, the depth is moderate. The same goes for the Luoshui Project, and to this day there is still a place name for the Chenxi River between Shifang and Guanghan.

When the water flow is scattered, the direction is chaotic, and there is no river channel, it is necessary to open a channel in the sandbar at an appropriate position in the riverbed to divert water and ensure smooth flow, which can reduce flood disasters. When managing rivers, it is also necessary to correctly handle the dialectical relationship between "bend" and "straight." Due to the water flow scouring the convex bank at bends, the result is that the convex bank gradually collapses into the river. Therefore, according to the water potential, the water flow on the opposite beach corner should be intercepted to transform the water flow from curved to straight. The advantage of using this method to manage rivers and ditches is that the river is smooth and easy for drifters to navigate. At the same time, sand and stones are not easily stagnant, which can reduce the amount of excavation work. The Luoshui Project adopts the approach of strengthening the protection at the bay corner (**Figure 3**) and striving to make the river as smooth as possible when dealing with this issue.



Figure 3. A realistic view of strengthening bay corner protection and smooth river diversion in the Luoshui project

The method of guiding Luotong Mountain is based on records and legends, which involves adapting to local conditions, using locally sourced materials, and using fire and water stimulation techniques. That is, through labor, the people organized river workers to pile up wood at the foot of the mountain, burn the mountain, cause the mountain to crack and relax when exposed to heat, stimulate the flow of water, break through the mountain, and lead out the river water gap. To this day, there are still wind tunnel and fire tunnel sites in Gaojingguan, suspected to be remnants from the initial construction of Luokou Weir. This formed the ancient waterfall mouth of Gaojingguan, formerly known as "Luokou Weir."

2.3. Unfinished Luoshui project

Based on our on-site investigation, the authors believe that it is possible for Li Bing to pass away in Shifang. The reason is that his design concept of "pulling the heart at the right moment and cutting the corner at the right moment" was not fully reflected in the Luoshui project in Shifang, or rather half of it was reflected. The real-life picture of the Luoshui Project strengthening bay corner protection and smooth river diversion shown in **Figure 3** indicates that in this project, the diversion design concept for the 7-minute water volume in Shifang was based on the principle of "pumping at the right corner and cutting at the bay corner." However, the 3-minute water volume heading towards Mianzhu did not achieve the completion of this design concept (**Figure 4**). As shown in the picture, if the 3-fen water heading towards Mianzhu is excavated from the position indicated by the arrow, it should be more in line with the design concept of Li Bing's water conservancy project. From the on-site situation, the mountain is not very high, and the surface layer

of Quaternary deposits is covered with mudstone. From the perspective of lithology, it is not difficult to excavate the mountain at this location. The reason for not completing it may be that Li Bing has passed away.



Figure 4. Suspected unfinished work

3. Conclusion

From the comparison between the design concept and design form and the Dujiangyan Irrigation Project Water Conservancy Project, combined with the cultural relics around the water conservancy project Dawang Temple (for Li Bing), Erwang Temple (for Li Bing's son), Li Bing's tomb, etc., which is judged that the Luoshui water conservancy project is very likely to be built for Li Bing, and Li Bing is also very likely to die in Shifang. Li Bing's contributions to water management in Shifang and Mianzhu are invaluable, bringing blessings to future generations. In line with the Taoist ideology of "following nature" and "harmony between man and nature", he respects and conforms to nature, and focuses on "unblock and smooth" in water control. Like Dujiangyan Irrigation Project, he also makes full use of the terrain conditions to build diversion dikes without dams to divert water, effectively preventing floods from ravaging the Shifang Plain, promoting the development of agricultural civilization and urban construction of Shifang and Mianzhu, improving the ecological environment of Shifang, Mianzhu mountainous areas and plains, and making Shifang and Mianzhu become well-known rich and land of plenty.

Therefore, the Li Bing culture in Luoshui Town can deepen its historical and practical significance from the perspective of engineering design, enhance tourists' cultural confidence in ancient Chinese science, and strengthen national pride.

Disclosure statement

The authors declare no conflict of interest.

Funding

The Scientificity and Cultural Inheritance of Ancient Water Conservancy System Engineering Survey and Design: A Case Study of Li Bing's Water Control Historic Site in Shifang. (Project number: 2023RW01)

References

[1] Baidu Encyclopedia, 2024, Sichuan Basin. https://baike.baidu.com/item/%E5%9B%9B%E5%B7%9D%E7%9B%86

%E5%9C%B0/404637?fr=aladdin

[2] Baidu Encyclopedia, 2024, Shangshu Yugong. https://baike.baidu.com/item/%E5%B0%9A%E4%B9%A6%C2%B7%E7%A6%B9%E8%B4%A1/14094077?fr=aladdin

[3] Chang Q, 2010, Records of the Huayang Region. Qilu Publishing, Jinan.

[4] Shi MQ, 1959, Records of the Grand Historian: Book of Rivers and Canals. China Book Bureau, Beijing, 1407.

[5] Social Science Publishing Brochure Editing Committee, 2024, Li Bing and Shifang. Shifang Municipal Social Science Federation and Shifang Municipal Museum.

[6] Baidu Encyclopedia, 2024, Dujiangyan Irrigation Project. https://baike.baidu.com/item/%E9%83%BD%E6%B1%9F%E5%A0%B0/122963?fr=aladdin

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Group Psychological Emergency Management after Suicide-related Death of Organization Members

Yuxin Du*

School of Basic Military and Political Education, National University of Defense Technology, Changsha 410073, China

***Corresponding author:** Yuxin Du, du58@outlook.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: The occurrence of member suicide in various types of organizations can have adverse effects including physical and psychological stress reactions, social impact, and suicide contagion. The study considers organizational member suicide as an unexpected crisis event in organizations, and divides organizational members affected by different suicides Φ into four regions A, F, W, and O through two dimensions of spatial distance and social distance of psychological distance, and through four stages of emergency management work: prevention-response-disposal-assessment, to achieve the goals of curbing suicide contagion, restore the mental health level of the group, and reduce the negative impact.

Keywords: Organization member suicide; Suicide influence; Psychological emergency management; Psychological distance

Online publication: March 10, 2025

1. Introduction

The impact of suicide is widespread and far-reaching, with survey data from the United States showing that 1 person's death by suicide can affect, on average, 5 family members, 15 extended family members, 20 friends, and 20 classmates or coworkers, with some still experiencing intense emotional distress even 14 years later [1–2]. The rough all-age suicide rate in China in 2019 was 8.1 per 100,000 people (World Health Organization, 2021). A large organization with more than 10,000 employees should be self-conscious that the probability of one suicide within the organization in a year can be as high as 81%. This probability will increase in the event of a major infectious disease outbreak, and the severe negative impact of suicides makes emergency management essential. Relative to previous suicide research, this paper considers suicide as a crisis event in all types of organizations and focuses intervention on the psychological impact of the group due to suicide.

Suicide has an impact on groups. Hospitals are a high-prevalence area for suicidal events, and studies addressing

the impact of suicide have focused on the nurse population. In Belgium, 73% of nurses in psychiatric hospitals experienced at least 1 acute event, with suicide accounting for 64%, while 55% of nurses in Japanese psychiatric hospitals experienced a patient suicide, with 13.7% experiencing post-traumatic stress disorder [3]. A meta-analysis of 63 studies showed that nurses experienced significant physiological, psychological, and behavioral changes after experiencing patient suicide [4]. Physiological responses included headache, increased heart rate, sleep disturbances, hallucinations, decreased appetite, and gastrointestinal distress. Psychological reactions include shock, fear, grief, guilt, nervousness, anxiety, and even depressive symptoms. In terms of behavior, difficulties in concentration, hypervigilance, over-protectiveness, and avoidance are observed.

Those most affected by suicide are the friends and family of the deceased. Studies from the UK and Australia have shown that cold numbness and avoidance from coworkers have led those bereaved by suicide to experience more stigma and social isolation in the workplace, and as a result, have more strained relationships with coworkers [5–6]. This significantly impairs their social functioning, reduces job performance, and leads to more separations and dropouts. This effect does not only stop at family and friends but also spreads to the periphery. After a fifth-grade girl in a city committed suicide and died by jumping from the window of her room on April 22, 2018, her best friend and her boyfriend both took leave from school to stay home because they could not continue their studies, and some of their classmates cried in class as well, making it impossible for the class to function normally [7].

The biggest impact of suicide is suicide contagion, six suicides occurred at Foxconn between January and April 2010 and began to attract a lot of media attention in May, with a flurry of coverage. In May alone, there were seven consecutive suicides in January, all of which involved jumping from a building. The contagion effect is even more pronounced in the case of celebrity suicides [8]. A meta-analysis of 98 celebrity suicides found a 0.26 change in the local suicide rate in the month following a celebrity suicide. The increase was even greater in the case of entertainment stars, at 0.64 in North America, 0.68 in Europe, and 0.58 in Asia [9]. Following the suicide of the Japanese singer, Okada Yukiko, on April 8, 1986, Japan's suicide rate was 44% higher than at the same time in 1985.

2. Method

Individuals' judgments and responses to critical events are moderated by psychological distance, which has four dimensions: temporal distance, spatial distance, social distance, and probability distance [10]. Temporal distance measures the time interval between the event and the individual, and probability distance measures the probability that the event meets the individual. The probabilistic distance for the case where the suicide has already occurred was the same. Its temporal distance is equal for all individuals in the organization. Then the impact of the suicide event on the individual is only regulated by the two dimensions of spatial distance (distance from the suicide site) and social distance (social relationship with the deceased), and the farther the spatial distance and social distance are the less impacted. For a more intuitive and concise representation, let the impact of suicide be Φ, then:

$$\Phi \propto \frac{1}{Sp*So} \tag{1}$$

Due to individual differences (Individual difference, Id) in cognitive judgment, personality traits, suicide susceptibility, psychiatric history, etc., even with the same spatial and social distance, individuals are not affected in the same way. Introducing individual differences as correction constants in **Equation 1** is:

$$\Phi \propto \frac{Id}{Sp*So} \tag{2}$$

In the same organization, both spatial and social distances have their qualifying values, and here the maximum spatial distance is set as the general spatial boundary of the organization's activities and the maximum social distance is the shared organizational membership. Taking the suicidal person as the origin, the distribution of other people affected in the case of a member's suicide can be represented in **Figure 1** below.

The horizontal axis represents social distance, the vertical axis represents spatial distance, and the red line indicates that the physical-psychological stress caused by the effects of suicide has reached a level Φ_0 that requires rapid intervention, and the individuals under the red line are those who require urgent intervention. Area A near the horizontal axis indicates audience, with a large social distance and small spatial distance; Area F near the vertical axis indicates family members and friends, with a large spatial distance and small social distance (outside the dots indicate family members and friends who are not in the organization); Area W inside the circle indicates the people in the organization who are acquainted with the suicidal person, mostly the other worker of the same team, the social distance and spatial distance are closer than others; O area indicates other members of the organization who do not know the suicide victim, the social distance is far and the spatial distance is scattered. Below red line Φ_0, zones F, A and part of W are the main influence zones of physical and psychological stress reactions, while zone W indicates the main range of social influences, and the risk of suicide contagion is more insidious and has a wider distribution, and all four zones of AFWO need to be included in it.

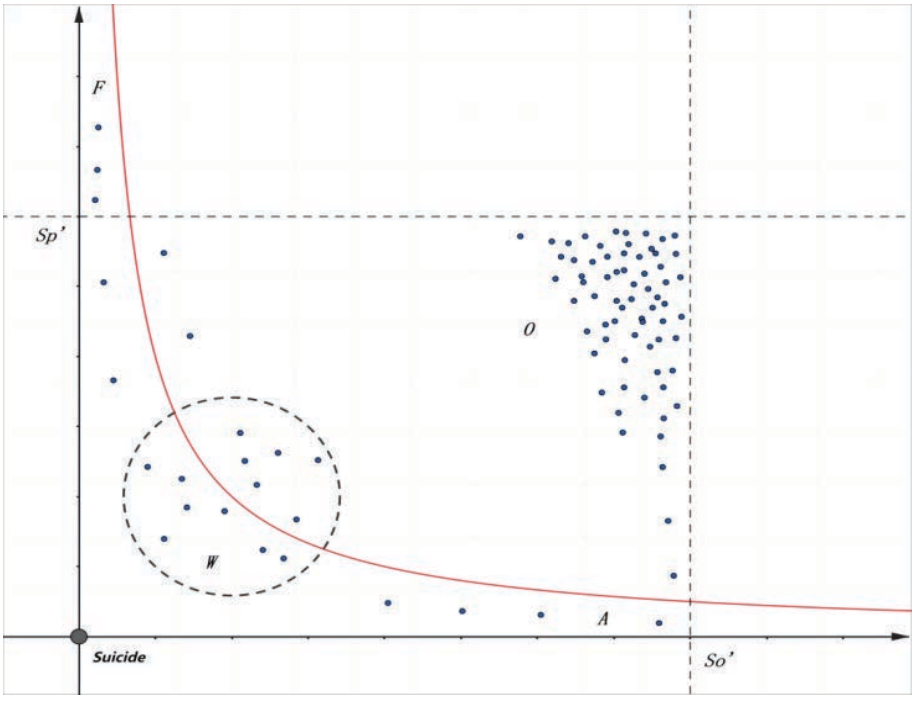


Figure 1. Distribution of organization members affected by suicide

3. Result: Emergency program

The Emergency Response Law of the People's Republic of China divides emergency management into four phases: prevention and preparedness, monitoring and early warning, emergency response and rescue, and post-event recovery and reconstruction. The psychological emergency management of groups affected by suicide is carried out under this system.

3.1. Phase 1: Prevention

3.1.1. Building psychological expectations

An anonymous survey involving 1120 people in India showed that people who had more awareness of the symptoms of COVID-19 were aware of nearby hospitals with emergency phone numbers, and paid regular attention to reports of COVID-19 had higher levels of mental health [11]. This reflects that mental preparation for possible emergencies is effective and necessary. Suicide prevention campaigns can be conducted within the organization to raise awareness of suicide among its members, equip them with certain methods of emotional processing and stress coping, and build up psychological expectations in advance.

3.1.2. Non-punitive organizational culture

The culture of "accountability" in an organization after suicide will undoubtedly increase the psychological burden of the responsible individuals, and the resulting blame-shifting and avoidance will lead to a breakdown in organizational trust. A survey of 731 nurses who experienced patient suicide in eight hospitals in Hubei Province found that the highest scores on support needs came not from family and friends, but from leaders, and were consistent both at home and abroad [12]. This shows that the establishment of a non-punitive organizational culture is then important, and may even to a certain extent play a role in suicide prevention.

3.1.3. Building socially supportive organizations

Social support is a protective factor for group mental health [13]. Interview surveys from the UK and Australia have demonstrated that social support has an important role in the recovery of the mental health of secondary victims of suicide, but due to feelings of guilt, self-blame, and the stigmatization of suicide, seeking social support is fraught with obstacles [14]. Employers show less sympathy when it comes to suicide than other difficulties, and most people also choose to avoid the topic in all types of work and social situations, resulting in more mistrust, social isolation, and withdrawal. To cope with this situation, an open and inclusive organizational culture, a cordial and honest communication environment, and an internal atmosphere of solidarity and mutual support should be constructed to promote a common organizational social identity, which in turn leads to the formation of social group psychological resilience in all kinds of emergencies [15].

3.2. Phase 2: Response

3.2.1. Reveal the distribution of people affected by suicide

The first step is to delimit Φ_0 the population affected by suicide within an organization, for which it is necessary to carry out a comprehensive psychological screening within the organization, looking for individuals who have already experienced intense physical and psychological stress and others who are at risk of suicide. On this basis, zones F and A are identified based on the dimensions of social and spatial distance, zone W is identified in relation to the deceased's work and social network within the organization, and zone O is identified for the rest of the population. Three screening tools are recommended as follows: The Patient Health Questionnaire Item (PHQ-9) adapted by Spitzer [16]. The Columbia Suicide Severity Rating Scale (C-SSRS) developed by Columbia University [17]. The suicidal behavior screening questionnaire developed by Tianjin University [18].

3.2.2. Blocking the media from spreading the effects of suicide

He and Qin examined 9,922 suicide reports on Weibo and found that these reports violated 9 of the 12 principles in the World Health Organization's Responsible Reporting of Suicide: A Quick Reference Guide [19]. As the main body

of emergency management, the organization of the suicidal person has the most truthful and accurate information and has the authority of the "official media" in suicide reporting. Concealment and shirking of responsibility is a breeding ground for rumors, and the best way to stop the fermentation of public opinion is for organizations to take the initiative to report suicide incidents in a truthful and responsible manner.

3.3. Phase 3: Disposition

3.3.1. Psychological first aid with individual counseling

After the psychological screening and delineation Φ_0, organizations can basically target the people who need emergency intervention, and the specific counseling or treatment plan needs to be formulated according to the specific situation of the interviewees, and here this study only recommends three commonly used methods of post-disaster psychological crisis intervention.

Post-disaster psychological first aid that is derived from the U.S. "Psychological First Aid Field Operation Guide." The content is comprehensive and systematic, highly structured, and has been used in emergencies such as the 9/11 incident in the United States as well as many terrorist attacks, hurricane disasters, and the Wenchuan earthquake in China, with remarkable results [20].

Eye movement desensitization reprocessing. It can effectively alleviate the effects of traumatic memories in a short period of time without the aid of medication and also has good efficacy in bereavement PTSD [21].

Cognitive behavioral therapy. Compared to eye-movement desensitization reprocessing, cognitive behavioral therapy has a lower rate of exposure to traumatic memories and a lower rate of shedding in interviewees [22].

3.3.2. Mitigating social influence adopt the Balint group

To reduce the impact of the suicide on the group (W-zone) in which the suicide is committed and to resume normal organizational activities as soon as possible, group psychological interventions are also needed after dealing with the physical and psychological stress of the second victim of suicide. The social effects of suicide are commonly manifested in the form of avoidance, stigmatization, impaired interpersonal communication and trust, and low team morale, which can be addressed by Balint groups. Founded in the 1950s by Hungarian psychiatrist Michael Balint, Balint's group was originally designed to train physicians to deal with the doctor-patient relationship and has been generalized to various group domains because of its clear steps and effectiveness.

The Balint group provides an outlet that allows people who are psychologically close to the suicidal person to open up about the deceased, express their emotions, answer their doubts, and bridge the gap, a process in which social support and empathy continue to derive, helping the team to get through and even further improve cohesion.

3.3.3. Enhancing group mental toughness with the Satir model

The negative impact of employee suicide on a large organization is huge, not only does it destroy the working atmosphere and performance of the deceased's team, but it is also a big blow to organizational morale. On the other hand, focusing only on localized areas (A, F, and W) does not eliminate the risk of suicide contagion. For example, in the Foxconn serial jumping incident, the suicides were relatively far from each other in terms of spatial and social distances, but the serial suicides still occurred. Therefore, attention should also be exerted on all team members including Zone O. The Satir model of group counseling can provide a solution.

The Satir Model of Therapy is a humanistic approach to family therapy founded by American psychotherapist Virginia Satir. Its most important feature is that it focuses on improving the individual's self-esteem and communication

rather than just eliminating the symptoms, and the ultimate goal of the treatment is for the individual to achieve "integration of mind and body, internal and external congruence" [23]. The Satir model can enhance members' sense of self-worth and self-esteem, which can not only reduce the impact of suicide among members of the organization, but also improve the psychological resilience of the group, playing a role in treating both symptoms and root causes, and can be used in group psychological emergency management to further reduce the risk of suicide contagion, or even play a role in preventing suicide.

3.4. Phase 4: Assessment

3.4.1. Tracking and evaluation of the effectiveness of disposition

Individual counseling and group interventions have a certain period of time, and a period of follow-up assessment is needed after the end of emergency psychological treatment [24]. After emergency psychological treatment, there is no guarantee that the effects of suicide can be completely eliminated, and regular follow-up is needed in at least three other areas: First, regular visits to those who are more seriously affected by suicide to observe whether their physical and psychological stress reactions have been eliminated and whether their social functioning has recovered; Second, to observe and determine whether the mental health and work performance of the suicide victim's team have been restored; and third, to follow up to determine whether the overall morale of the organization is no lower than before the suicide incident.

3.4.2. Summarize the psychological emergency management process

Finally, a review should be conducted to look for the reasons why members of the organization committed suicide, make targeted adjustments to the organization's construction, and strengthen prevention and preparedness. In addition, it is necessary to summarize and evaluate the emergency management of the incident, accumulate experience, improve the unit's emergency plan, and enhance the organization's ability to deal with similar emergencies. The entire psychological emergency management process is shown in **Figure 2**.

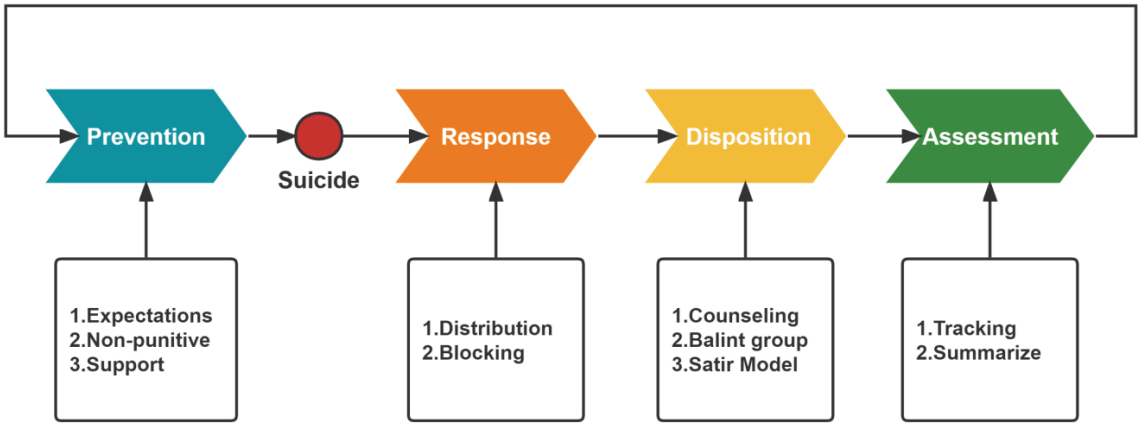


Figure 2. Flowchart for psychosocial emergency management of groups affected by suicide

4. Discussion

Does group psychosocial emergency management for suicides of members of an organization need to include the

families of the deceased? It is recommended that families should be included. There are two reasons for this: first, when it comes to the suicide of the deceased, the organization needs to deal with many aftermath issues with the family, which may have secondary effects if disputes arise. Secondly, family members, as the group of people who are socially closest to the deceased, are the most deeply affected and have the strongest need for intervention.

The three types of effects of suicide may overlap in different populations, and some members of Zones A, F, and W may need to receive more than one type of intervention, while many members of Zone O may not need intervention. In light of this, it is recommended that individual psychotherapy be delivered in an unsolicited manner, Balint groups be established by issuing invitations, and Satir group psychosocial interventions be conducted by open recruitment. Members of the organization affected by suicide can choose to accept or decline participation in one or more activities and can be informed about the process and content of the intervention and other members of the group intervention.

The main body of the group psychological emergency management of the suicide of the organization's members is the decision-making manager of the organization, but the main body does not have the qualifications and conditions for the implementation of emergency psychological treatment. In the whole psychological emergency management process, there is a need for an executive body with the qualification of psychological intervention to carry out various activities.

5. Conclusion

Member suicide is a major blow to any organization. If not handled well, it can damage the organization's image, undermine team trust, lower organizational morale, interfere with work performance, and lead to member turnover. However, if handled well, it can not only reduce the impact of suicide, but also provide social support to each other for other members who share the death of a teammate, improve personal empathy, self-esteem, and a sense of the meaning of life, and thus play a role in preventing suicide. Therefore, group psychological contingency management for organizational suicide is valuable and necessary.

Disclosure statement

The author declares no conflict of interest.

References

[1] Berman AL, 2011, Estimating the Population of Survivors of Suicide: Seeking an Evidence Base. Suicide and Life-Threatening Behavior, 41(1): 110–116.

[2] Feigelman W, Cerel J, McIntosh JL, et al., 2018, Suicide Exposures and Bereavement among American Adults: Evidence from the 2016 General Social Survey. Journal of Affective Disorders, 2018(227): 1–6.

[3] Takahashi C, Chida F, Nakamura H, et al., 2011, The Impact of Inpatient Suicide on Psychiatric Nurses and their Need for Support. BMC Psychiatry, 2011(11): 38.

[4] Wang M, Yan M, Gao Y, et al., 2022, Meta-integration of a Qualitative Study of Nurses' Authentic Experiences after Experiencing Patient Suicides. Journal of Nursing, 37(5): 65–69.

[5] Pitman A, De Souza T, Khrisna PA, et al., 2018, Support Needs and Experiences of People Bereaved by Suicide: Qualitative Findings from a Cross-Sectional British Study of Bereaved Young Adults. International Journal of Environmental Research and Public Health, 15(4): 666.

[6] Ross V, Kolves K, De Leo D, 2021, Exploring the Support Needs of People Bereaved by Suicide: A Qualitative

Study. Omega-Journal of Death and Dying, 82(4): 632–645.

[7] Hu M, Liang S, Xiao S, 2019, A Case Report of Crisis Intervention Following a Suicide Death among Elementary School Students. Chinese Journal of Mental Health, 33(7): 493–497.

[8] Stack S, 2000, Media Impacts on Suicide: A Quantitative Review of 293 Findings. Social Science Quarterly, 81(4): 957–971.

[9] Niederkrotenthaler T, Fu KW, Yip PS, et al., 2012, Changes in Suicide Rates Following Media Reports on Celebrity Suicide: A Meta-analysis. Journal of Epidemiol Community Health, 66(11): 1037–1042.

[10] Li YY, 2020, The Effect of Satir Group Psychological Intervention on the Enhancement of Interpersonal Relationship in the Dormitory of Public Security College Students. Chinese Journal of Health Psychology, 28(12): 1867–1872.

[11] Agarwal V, Sharma S, Gupta L, et al., 2020, COVID-19 and Psychological Disaster Preparedness — An Unmet Need. Disaster Medicine and Public Health Preparedness, 14(3): 387–390.

[12] Tan R, Hu D, Liu Y, et al., 2020, Analysis of 731 Second Victims' Experiences and Support Needs Levels in Hospital Patient Suicides. Journal of Nursing, 27(6): 29–34.

[13] Ortiz-Calvo E, Martinez-Ales G, Mediavilla R, et al., 2022, The Role of Social Support and Resilience in the Mental Health Impact of the COVID-19 Pandemic among Healthcare Workers in Spain. Journal of Psychiatric Research, 2022(148) 181–187.

[14] Pitman A, De Souza T, Khrisna PA, et al., 2018, Support Needs and Experiences of People Bereaved by Suicide: Qualitative Findings from a Cross-Sectional British Study of Bereaved Young Adults. International Journal of Environmental Research and Public Health, 15(4): 666.

[15] Drury J, Carter H, Cocking C, et al., 2019, Facilitating Collective Psychosocial Resilience in the Public in Emergencies: Twelve Recommendations Based on the Social Identity Approach. Frontiers in Public Health, 2019(7): 141.

[16] Spitzer RL, Kroenke K, Williams JB, 1999, Validation and Utility of a Self-report Version of PRIME-MD: The PHQ Primary Care Study. Primary Care Evaluation of Mental Disorders. Patient Health Questionnaire. The Journal of the American Medical Association, 282(18): 1737–1744.

[17] Viguera AC, Milano N, Laurel R, et al., 2015, Comparison of Electronic Screening for Suicidal Risk with the Patient Health Questionnaire Item 9 and the Columbia Suicide Severity Rating Scale in an Outpatient Psychiatric Clinic. Psychosomatics, 56(5): 460–469.

[18] Yang L, Hou XQ, Liu HL, 2021, Development and Reliability of a Screening Questionnaire for Suicidal Behavior. Chinese Journal of Clinical Psychology, 29(6): 1175–1181.

[19] He S, Qin M, 2022, Ethical Misconduct and Governance of Suicide Reporting in the Social Media Era: A Content Analysis of Suicide Reporting on Sina Weibo. Huxiang Forum, 35(6): 99–109.

[20] Luo Z, Guo C, 2015, Innovative Approaches to Disaster Mental Health Education — Interpretation and Implications of the U.S. Psychological First Aid Field Operations Guide. Medicine & Philosophy (A), 36(9): 58–60 + 70.

[21] Chen L, Zhang GQ, Hu M, et al., 2015, A Controlled Study of Eye Movement Desensitization and Reprocessing Therapy Versus Cognitive-behavioral Therapy in Patients with Bereavement Posttraumatic Stress Disorder. Chinese Family Medicine, 18(16): 1957–1960.

[22] Wang M, Yan M, Gao Y, et al., 2022, Meta-integration of a Qualitative Study of Nurses' Authentic Experiences after Experiencing Patient Suicides. Journal of Nursing, 37(5): 65–69.

[23] Satir V, 2007, Satir's Model of Family Therapy, translated by Nie Jing. World Book Publishing Company, Beijing, 34–50.

[24] Cheng D, Hu DY, Guo X, et al., 2020, Effects of a Balint Group on Anxiety, Depression and Self-efficacy of Nurses Experiencing Patient Suicide. Journal of Nursing, 27(15): 69–73.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on Balance Optimization of Garment Production Line Based on Industrial Engineering Methods

Qingjun Lu*

School of Management, Shandong University of Technology, Zibo 255049, Shandong, China

***Corresponding author:** Qingjun Lu, lqj001202@126.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: In the context of the garment manufacturing industry, there has been a continuous improvement in the requirements for production efficiency and resource utilization. Consequently, the optimization of production line balancing has become a key issue for enterprises to enhance their competitiveness. This paper investigates the shirt production line of a sewing workshop of a garment enterprise. It addresses the problems of uneven distribution of work processes, prominent bottleneck stations, and long production cycles. The paper applies the theory and method of traditional industrial engineering to optimize the workforce, production process, equipment management, and so on. Initially, standard working hours are determined through job measurement and time study; Industrial engineering methods are then used to optimize and balance the processes of the production line; and the production line balance rate and smoothness index are introduced to evaluate the improvement effect. The experimental results demonstrate that the optimized production line balance rate increases from 39.5% to 62.8%, and the production imbalance loss rate decreases from 60.5% to 37.2%. The method proposed in this study provides theoretical support and practical tools for the apparel manufacturing industry, and it has a significant reference value for realizing lean production.

Keywords: Apparel production line; Line balancing; Bottleneck process; Beats

Online publication: March 10, 2025

1. Introduction

In recent years, the global apparel market has seen a surge in competition, with consumers demanding greater variety and customization. This has created significant challenges for apparel manufacturing companies, who must respond by reducing production cycles, lowering operating costs, and enhancing flexibility. Given its status as a labor-intensive industry, the efficiency of apparel production is directly affected by the level of production line balancing. The objective of line balancing is to achieve a balanced and efficient production process through the rational allocation of work processes and the optimization of work station configuration. This is achieved by reducing idle time, lowering work-in-

process inventory, and increasing overall production capacity [1]. However, the production of apparel is characterized by complex processes, strong interdependencies between processes, and an increased demand for multi-species small-lot production. To date, scholars both domestically and internationally have conducted extensive research on the production line balancing problem, primarily concentrating on the modeling and resolution of the classical assembly line balancing problem, and progressively extending to the consideration of dynamic adjustment, multi-objective optimization, and other complex scenarios. In the domain of apparel manufacturing, the majority of research endeavors concentrate on the areas of process splitting, man-hour measurement, and workstation layout optimization [2]. This encompasses the application of action analysis by the MTM method or the integration of heuristic algorithms to enhance workstation allocation [3]. However, the extant research is inadequate in two respects. Firstly, the unique flexibility requirements of apparel production have not been fully incorporated into the model. Secondly, the traditional static balancing strategy is difficult to adapt to the dynamic perturbations, such as human fluctuations and equipment failures, in the production process. This results in the theoretical optimization deviating from the actual effect.

In this paper, the focus is on a shirt production line of an enterprise, which is selected as the research object. Through job determination, the bottleneck of the production line is identified, and industrial engineering techniques and methods are applied to analyze each process on the production line. The principles of ECRS (Elimination, Consolidation, Rescheduling, and Simplification) and the principle of economy of action are applied to reduce stagnation and waiting due to the difference in time, and ultimately to improve production efficiency. Concurrently, the efficacy of these enhancements is appraised through the utilization of indicators such as the production line balance rate, a paradigm shift from the conventional one-person, one-station fixed-person system. This paradigm shift facilitates enhanced productivity in response to fluctuations in demand without necessitating an increase in personnel. The study proffers solutions for the enhancement of production lines within analogous enterprises.

2. Industrial engineering-related methods

2.1. Methodological research

The methodology under scrutiny here is founded on the premise of meticulously documenting and analyzing prevailing production and processing methodologies with the objective of identifying and establishing more efficient and rational workflows. Adopting this methodology enables companies to optimize production processes and procedures, reduce superfluous handling waste, foster optimal human-machine collaboration, and institute standardized work practices, thereby achieving substantial enhancement in work efficiency. The methodology employs a systematic approach to analyze the production system comprehensively, with the objective of resolving various issues in production optimization. This systematic approach encompasses a wide range of levels, from macro to micro. Specifically, the methodology encompasses three key domains: process analysis, job analysis, and motion analysis. Through these detailed analyses, companies can identify bottlenecks and redundancies in the production process, providing a solid foundation for the development of improvement strategies [4].

The 5W1H analysis method is a systematic approach to problem exploration (**Table 1**). Its objective is to reveal the nature of a problem and find a solution by asking questions and analyzing the problem several times in a row from the six key dimensions: purpose, cause, time, place, people, and method [5]. This method focuses on asking in-depth questions about the work or problem under study. Through an exhaustive question-and-answer process, it pinpoints the problem and develops improvement measures accordingly. In instances where the initial analysis and proposed measures prove ineffective in achieving optimal outcomes, alternative methods or strategies may be considered for

further problem resolution. The following section details specific questioning methods employed in this analysis.

Table 1. 5W1H questioning method

Perspective	1st question	2nd question	3rd question
Goal	(What)	Necessity	Is there a more suitable match?
Rationale	(Why)	Why do you have to do it?	Is it not necessary to do
Timing	(When)	Why do it now?	Is there a more appropriate time elephant
Point	(Where)	Why do it here?	Is there a more suitable location
Officers	(Who)	Why this man?	Is there a more suitable candidate
Methodologies	(How)	Why it's necessary	Availability of more appropriate methods and tools

The "ECRS" principles are utilized in conjunction with the "5W1H" analysis to enhance the efficiency of the production process. The "ECRS" principles, which stand for "Eliminate, Combine, Rearrange and Simplify", are employed following the collection of comprehensive descriptions from the staff regarding the present status of the production line. The implementation of these principles, guided by the staff's detailed descriptions, enables the optimization of relevant processes, thereby enhancing production efficiency and reducing costs [6].

2.2. Operational measurement

Job measurement can be defined as the utilization of tools or methodologies for the estimation of the time required by skilled workers to execute a task in accordance with established job requirements. Prior to the implementation of this approach, a significant amount of idle time was observed, resulting in diminished productivity on the production line. This was attributable to the absence of a standard operating time for operators. The implementation of a standard operating time for a process provides operators with a reference point to motivate themselves to save time, effectively utilize the operating time, eliminate unnecessary time wastage, and enhance the output efficiency of the production line [7]. Among the numerous operation measurement methods, the stopwatch timing method is widely utilized for its high efficiency and good applicability. This method involves the utilization of a stopwatch timer and ancillary tools to directly and continuously time qualified operators according to the specified time, record the relevant parameters and working time, and set the relaxation rate according to the production situation, thereby arriving at the standard working time of the process. It should be noted that standard time includes normal time and relaxation time, i.e. standard time is equal to normal time plus relaxation time.

3. Theories related to production line equilibrium

3.1. Concept of line balancing

Production line balancing is predicated on the fundamental principles of industrial engineering, entailing the observation and analysis of the load degree of all processes on the entire production line. Through the process of adjustment and optimization of the workload of each process, the objective is to minimize the discrepancy between the work time of each process. The purpose of line balancing is to eradicate superfluous waiting time and enhance labor productivity. In the context of production line balancing, the establishment of constraints aimed at balancing the load of each process is paramount. This ensures that the total operating time of each process does not exceed its maximum capacity, thereby resolving the bottleneck time of the process experiencing congestion [8]. Moreover, the regulation of workload is

intricately linked to the issue of process sequencing. An optimal work order can significantly enhance the efficiency of the production line, thereby reducing costs. Consequently, the optimization of work processes and the mitigation of bottleneck periods can reduce the waiting time of all processes, thereby reducing working hours and conserving human resources, while concurrently lowering costs, enhancing productivity, and ultimately, improving the efficiency of the enterprise's products.

3.2. Production line balance optimization steps

The following steps are recommended when optimizing production line balance.

The content of the work process must be determined. Research must be conducted on the enterprise production line to understand the process flow and the work content of each station.

Working hours must be measured and recorded. The stopwatch method must be used to measure the time used in each process, and abnormal data must be excluded. The evaluation coefficient and relaxation time must then be determined, combined with the on-site data, and the standard time must be calculated through the formula.

The collected data are then processed to identify the bottleneck station. The data are counted, and the bottleneck workstation is found more intuitively in the form of charts.

The evaluation index is then determined. The effect of production line optimization before and after the quantitative analysis needs to be carried out, according to the formula to calculate the production line balance rate, balance loss rate, smoothness index, and so on.

Analyze the identified problems and determine the underlying causes by engaging in communication with the workers, utilizing quantitative data and other relevant methods to identify defects in the production line and investigate the root causes of the issues.

Develop an improvement program. After conducting a thorough analysis of the aforementioned problems, formulate an improvement plan that is tailored to the specific circumstances of the production line.

3.3. Production line balance evaluation indicators

The evaluation of production line balance is primarily informed by the following categories of indexes.

3.3.1. Production line balance rate

The production line balance rate is an index used to assess the degree of balance and efficiency of the production line [9]. This is typically expressed as a percentage, with a higher rate indicating a more balanced process and a faster and more efficient operation of the entire production line. Conversely, a low rate of production line balance indicates potential bottlenecks within the production line, prolonged process times, or suboptimal production line design, necessitating adjustments and optimizations to enhance the balance rate. The formula for calculating the production line balance rate is as follows:

$$P = \frac{W}{n \times C} \times 100\% \quad (1)$$

In this model, P denotes the production line balance rate, W signifies the total time of all processes, n represents the number of workstations, and C denotes the beat time of the production line.

3.3.2. Balance loss ratio

The Line Balance Loss Ratio is defined as the proportion of time expended on a production line due to the presence of

non-essential waiting time and unnecessary movements. It is a metric used to assess the efficiency of the production line and the amount of time wasted, typically expressed as a percentage. A higher Line Balance Loss Rate is indicative of a longer duration spent on the production line, and a less efficient overall production process. Conversely, a lower line balance loss ratio signifies a more efficient operation on the production line. The formula for calculating the line balance loss ratio is as follows:

$$d = \frac{n \times C - W}{n \times C} \times 100\% = 1 - P \quad (2)$$

The evaluation criteria for the production line balance loss rate are delineated in **Table 2**.

Table 2. Evaluation scale for balance loss ratio

Equilibrium loss rate d	d≤10%	10%≤d≤20%	d≥20%
Hierarchy	excellent	virtuous	bad

3.3.3. Smoothness index

The production line smoothness index is a metric employed to evaluate the degree of smoothness of a production line. It quantifies the degree of variation and fluctuation between workstations on a production line over a specified time period, with a lower index indicating reduced variation and fluctuation in the production process, thereby enhancing productivity [10]. Conversely, an elevated smoothing index signifies greater variation and fluctuation within the production line, potentially compromising production efficiency and quality. By undertaking systematic monitoring and optimization of the production line smoothness index, enterprises can enhance the efficacy and quality of production, thereby ensuring more effective management of production schedules and plans, and ultimately, enhancing market competitiveness. The calculation formula for the production line smoothness index is as follows:

$$SI = \sqrt{\frac{\sum_{i=1}^{n} (C - Ti)^2}{n}} \quad (3)$$

SI denotes the smoothing index of the production line, whilst C represents the production beat of the production line. In addition, n denotes the number of workstations and denotes the operating time of the ith process in the production line.

4. Apparel line overview

4.1. Analysis of the current situation of the shirt production line

This paper analyzes and improves the shirt production line as a research object. The company is a small and medium-sized apparel manufacturing enterprise, which consists of several apparel production lines. Shirt production is a highly standardized process in the clothing manufacturing category. Its core processes usually include: fabric cutting > parts sewing (collar, sleeves, front piece, back piece, etc.) > assembly sewing > ironing and shaping > quality inspection > packaging. In comparison with other apparel categories, the production of shirts demands a higher degree of process precision and a strong dependence between processes. For instance, the assembly of cuff grommets must be completed before the eyelet locking process. The conventional production line predominantly employs an assembly line mode of operation, with workstations arranged following the sequence of the process. However, the overall process remains susceptible to bottlenecks, attributable to the automation level of the equipment and the efficiency of manual operation.

4.2. Measurement of process operating time

In the course of optimizing the production process and enhancing the efficiency of a shirt production line, it is imperative to accurately measure the working time of each process. In this study, the stopwatch timing method was employed to evaluate the working time of each process on the shirt production line. To minimize the impact of random errors, temporary disturbances, and individual outliers on the measurement results, the triple standard deviation method was implemented for data screening. For the selected processes, the study performed several independent stopwatch measurements and used the example of process 1 doorstop sticky lining for detailed illustration. To ensure the accuracy of the data, the study performed 8 observed measurements for this process and recorded the results in **Table 1**. Initially, the results from the eight measurements were aggregated and then divided by the number of measurements to derive an average value, designated X. This average value is representative of the centralized trend of the results from multiple measurements and provides a more accurate reflection of the actual working hours. Following the determination of the mean value X, the deviation of each measurement from X was calculated. The sum of the squares of these deviations was then averaged, and the square root of this value was taken to obtain the standard deviation. The standard deviation is a measure of the dispersion of the measurement data, and according to the principle of triple standard deviation, measurements that are more than three times the standard deviation of X are considered outliers and should be eliminated. This step serves to minimize the impact of random errors and outliers on the final results. Subsequent to the elimination of outliers, the remaining measurements are aggregated and divided by the actual number of measurements (i.e., the number of measurements after removing the outliers) to obtain the screened average working hours. This average working time is more representative of actual working time and can provide a robust foundation for the optimization of the production line.

In summary, the employment of the stopwatch timing method, the triple standard deviation method, and multiple observation measurements have enabled the derivation of more accurate and reliable working hour data for the process. This, in turn, provides a strong guarantee for the optimization of the production line and the improvement of efficiency. The working hour measurement results of process 1 access control sticky lining are shown in **Table 3**.

Table 3. Process time measurement datasheet

Number of observations	1	2	3	4	5	6	7	8
Observation time (s)	11.1	10.3	9.8	10.1	9.7	9.6	10.2	10.8

Following the completion of the work-time measurement, the measured data must undergo scientific screening to ensure the subsequent execution of the work is conducted in an orderly manner, and to prevent inaccuracies in the measurement data arising from measurement errors and other factors. This paper employs the triple standard deviation method, which stipulates that the normal value range of a group of data should be within the interval of the arithmetic mean ±3σ of the group of data. In instances where the measured data deviates from this range, it necessitates the elimination of the data from further analysis. The specific calculation method is outlined as follows.

Assuming that the observation time for a particular operating unit is X_1, X_2, X_3……X_n, the average value of this set of data is:

$$\overline{X} = \frac{\sum_{i=1}^{n} Xi}{n} \tag{4}$$

The standard deviation is:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(Xi-\overline{X})^2}{n-1}} \quad (5)$$

Set the upper limit of deviation to $\overline{X}$ + 3σ, the lower limit of deviation is $\overline{X}$ + 3σ, and the remaining values are considered outliers and should be eliminated. Following the elimination of these aberrant values, the mean time measurement results of each process are determined using the standardized formula: standard time = observation time x assessment factor x (1 + relaxation rate). The standard working hours for each process are presented in **Table 4**.

Table 4. Operational standard time

Process number	Job element content	Standard working hours/s
1	Access control adhesive lining	10.6
2	Folding iron access control	21.9
3	Receive the front piece of the province	24.8
4	Receive the back piece of the province	16.2
5	Labeling (Close)	5.6
6	Shoulder seams and side seams (Lock)	27.2
7	Shoulder seams and side seams (Inverted)	28.8
8	Ironing (Saving) seams, folding, and Ironing (Hemmed)	34.2
9	Collars sticky lining hooked	9.6
10	Collars clean sample	24.8
11	Trimming turning ironing	26.5
12	Collar corner shaping	16.1
13	Sole collar	54.9
14	Sleeves closed side seams	7.6
15	Locking side seams	10.5
16	Inverted ironing side seams, folding ironing cuffs	18.1
17	Cuffs plain line	24.2
18	Sole sleeves	66.3
19	Locking sleeve cages	27.5
20	Body hem plain line	20.9
21	Locking eyelets	46.2
22	Buttons	45.5
23	Ironing whole	34.6

4.3. Analysis of production line balance

The standard operating time calculated according to the above steps shows that the number of stations n = 23; the bottleneck time c = 66.3 seconds and W = 602.6 seconds, which gives the line balancing rate of the shirt production line:

$$P = \frac{602.6}{66.3 \times 23} = 39.5\%$$

Shirt line equilibrium loss rate:

$$d = 1 - P = 1 - 39.5\% = 60.5\%$$

Shirt production line smoothness index:

$$SI = v42.83$$

The relevant data collected during the on-site research indicates that the balance rate of the shirt production line is 39.5%, while the balance loss rate is 60.5%. This suggests that the discrepancy in operating time between workstations has resulted in significant waiting and inventory waste. The calculation of the smoothing index of the production line yielded a result of 42.83, which is indicative of significant dispersion in the total time allocated to each workstation. This finding suggests that the time deviation between workstations is substantial, and the workload between different workstations is imbalanced. In conclusion, the overall balance of the shirt production line is suboptimal, with a considerable loss in operating time and scope for enhancement.

4.4. Analysis of production line problems

It is evident that process 18, which is identified as the key bottleneck process in the shirt production line, exhibits a production beat of 66.3 seconds, which is considerably longer than the production cycle of other processes. This has a substantial impact on the balance of the production line, leading to a considerable decline in overall efficiency. To meet the resource demands of this bottleneck process, the production line often needs to allocate additional resources, but this may lead to an imbalanced distribution of resources across different processes, with some processes being idle due to excess resources and others being limited due to a lack of resources. This results in inappropriate consumption of resources and unnecessary increase in production costs, and constitutes a significant negative impact on the overall resource utilization efficiency of the production line. This has been shown to result in excessive consumption of resources and unnecessary escalation in production costs, which in turn negatively impacts the overall resource utilization efficiency of production lines. Moreover, Process 18 is characterized by a high workload and high-intensity work pressure, which pose a significant challenge to the physical and mental health of employees and can easily lead to employee fatigue and overwork. Prolonged exposure to such a high-pressure working environment may have a detrimental effect on the accuracy and efficiency of employees' work, which in turn poses a potential threat to product quality. Consequently, the timely optimization and enhancement of Process 18 has become a pivotal concern, with the objective of enhancing the overall efficiency of the production line, ensuring product quality, and promoting the rational utilization of resources.

The division of workstations is not reasonable. The configuration of the shirt production line workstations gives rise to a significant non-equilibrium problem, which is reflected in the considerable differences in the operational elements covered by the workstations, as well as the substantial fluctuations in the required operating time. These factors directly lead to an imbalance of the task load between the workstations. When a workstation is overloaded with tasks, workers are compelled to complete substantial workloads within a constrained timeframe. This can lead to the exacerbation of physical and mental fatigue, as well as a decline in product quality due to the rush to achieve results. Moreover, it can result in the onset of health problems, which can further increase the unplanned downtime of the workstations and hinder the implementation of the established production plan. Conversely, if the quantity of tasks at a workstation is inadequate or the tasks are unduly elementary, workers may perceive the work as unchallenging, which can engender a sense of burnout. This, in turn, can diminish job satisfaction and engagement, as well as compromise the

overall operational efficiency of the production line. This, in turn, can result in the underutilization of resources and the occurrence of superfluous losses. The implementation of a refined workstation division strategy is therefore proposed as a means to optimize the allocation of resources and reduce unnecessary resource wastage. This strategy encompasses but is not limited to, the reduction of material wastage, labor costs, and equipment idling and downtime. The process of workstation segmentation necessitates meticulous consideration of the characteristics inherent in each work element, the judicious estimation of work time, and the alignment of worker capacity with workload. This is undertaken to achieve a balanced distribution of workload among workstations, thereby enhancing the overall efficiency and economic benefits of the production line.

5. Optimization analysis of shirt production line

5.1. Optimization of bottleneck processes

The bottleneck process imposes a limitation on the capacity of the entire production line and frequently necessitates additional resource investment, such as supplementary equipment and manpower. A detailed examination of the bottleneck process in the shirt production line, designated Process 18, which requires 66.3 seconds, utilizing the 5W1H analysis and integrating the ECRS principles (Eliminate, Consolidate, Reorder, and Simplify), revealed that Process 18 could not be eliminated nor further simplified. Consequently, measures were implemented to optimize this bottleneck process by introducing specialized equipment and an operator. However, subsequent improvements to Process 18 led to Process 13 emerging as a new capacity bottleneck, exhibiting a comparable operational pattern to Process 18. Consequently, a decision was made to implement the same strategy employed for the enhancement of Process 18, namely the incorporation of a dedicated machine and an operator into Process 13, with the objective of reducing its operational duration.

5.2. Improvement of workstation division

The current configuration of the workstation arrangement for shirt production exhibits a state of evident chaos, characterized by a disproportionate distribution of workload across workstations. This imbalance exerts a detrimental influence on the equilibrium of the production line. To address this issue, this study employs the 5W1H analysis method and the ECRS principle, with the objective of re-planning and optimizing each process within the shirt production line. The 5W1H analysis method was employed to guide the investigation, with a series of key questions being posed for each process of the shirt production line. These included inquiries into the necessity of process consolidation, the specific implementation of the merger, the integration of the merged process into the overall production process, the operator responsible for the merged process, the timing of the combined process, and the specifics of the combined process. The subsequent in-depth analysis of these questions resulted in the formulation of the following merging schemes: the merging of processes 4 and 5, with a combined operating time of 21.8 seconds; the merging of processes 9 and 10, with a combined operating time of 34.4 seconds; and the merging of processes 15 and 16, with a combined operating time of 28.6 seconds. Following the implementation of these measures, the operating time of each merged process became more uniform with the operating times of the neighboring processes, both before and after it. This effectively balanced the workload of workers and reduced the number of workstations, thereby significantly improving the balancing rate between workstations.

The present study has demonstrated that there was a significant improvement in the production balance rate, which increased from 39.5% to 62.8%. Furthermore, the production imbalance loss rate decreased from 60.5% to 37.2%, and the smoothing index decreased from 42.83 to 18.78. These significant improvements in the key indexes prove the

effectiveness and necessity of the optimization measures.

6. Conclusion

In this paper, the authors employed the stopwatch timing method to accurately measure the processing time of the shirt production line, subsequently analyzing the data using 5W1H and ECRS principles. They then proposed an optimization strategy for the original production line, which was characterized by long time-consuming bottleneck processes, inefficient use of equipment, and uneven distribution of workstations. The optimization of the production line layout resulted in a substantial enhancement of the balance rate, a reduction in the balance loss rate, and an improvement in the smoothness index, thereby providing a comprehensive evaluation of the efficacy of the implemented improvements. Following the execution of this enhancement program, there was a notable augmentation in production efficiency and a substantial enhancement in the economic efficiency of the enterprise, thereby providing unequivocal validation of the efficacy of the industrial engineering methodology. In the current market environment, characterized by a proliferation of product varieties and intensified customer demand fluctuations, the utilization of industrial engineering methodologies to achieve efficient production and material turnover of multi-species, small-batch, multi-frequency products has emerged as a pivotal issue that necessitates resolution. This will be the focal point of the subsequent research endeavors.

Disclosure statement

The author declares no conflict of interest.

Reference

[1] Sun X, Guo SS, Guo J, et al., 2024, A Pareto-based Hybrid Genetic Simulated Annealing Algorithm for Multi-objective Hybrid Production Line Balancing Problem Considering Disassembly and Assembly. International Journal of Production Research, 2024(13): 4809–4830.

[2] Prakoso I, Priyanto D, Asyari H, et al., 2024, Improvement of Bottlenecks in Printed Brown Sugar Production Using Line Balancing and Simulation. Engineering Headway, 2024(6), 331–339.

[3] Jiang L, Duan JJ, Zheng RP, et al., 2023, Optimization and Simulation of Garment Production Line Balance Based on Improved GA. International Journal of Simulation Modeling, 2023(2): 303–314.

[4] Sordan JE, Oprime PC, Pimenta ML, et al., 2022, Symbiotic Relationship between Robotics and Lean Manufacturing: A Case Study Involving Line Balancing. The TQM Journal, 2022(5): 1076–1095.

[5] Sawal A, Hamzah AJ, 2020, Application of Line Balancing using the Heuristic Method to Equalize the Production Line at PT. IOP Conference Series: Materials Science and Engineering, 2020(1): 12035.

[6] Radha H, Rajesh SM, Reena YA, 2017, Enhancing Productivity Improvement by Line Balancing Techniques. International Journal of Engineering and Management Research (IJEMR), 2017(3): 28–33.

[7] Srisawat Supsomboon, 2019, Simulation for Jewelry Production Process Improvement Using Line Balancing: A Case Study. Management Systems in Production Engineering, 2019(3): 127–137.

[8] Cui XY, Shi X, 2020, Research on the Balance of Assembly Line in an Automobile Manufacture Enterprise. American Journal of Industrial Engineering, 2020(1): 10–13.

[9] Lijalem M, 2020, Productivity Improvement through Lean Manufacturing Tools in Ethiopian Garment Manufacturing

Company. Materials Today: Proceedings, 37(2): 1432–1436.

[10] Nithish KR, Mohan R, Gobinath N, 2021, Improvement in Production Line Efficiency of Hemming Unit Using Line Balancing Techniques. Materials Today: Proceedings, 2021(2): 1459–1463.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Research on Layout Optimization of Auto Seat Assembly Workshop based on SLP

Kaixin Zhao*

School of Management, Shandong University of Technology, Zibo 255049, Shandong, China

***Corresponding author:** Kaixin Zhao, zkx1101924@126.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: With the continuous advancement of intelligent manufacturing, the focus of enterprises in the production process has gradually shifted to the direction of more intelligent and automated. Under this background, each company gradually carries on the intelligent transformation and upgrading of the workshop, and the layout planning of the workshop facilities is an important step. Reasonable workshop layout is helpful to improve the handling efficiency of workshop materials and reduce workshop cost effectively. By analyzing the current situation and existing problems of the facility layout of a car seat assembly workshop, the SLP method is used to optimize the overall layout of the workshop, and the effect of the proposed optimization scheme is verified to be effective.

Keywords: Workshop layout; SLP method; Intelligent manufacturing

Online publication: March 10, 2025

1. Introduction

With the “Industry 4.0” and “Made in China 2025” strategy, China has set off a new wave of revolution in the manufacturing industry, and the automobile manufacturing industry has also developed rapidly and changed, which puts forward higher requirements for the production and operation of automobile enterprises. In this context, most of the automobile manufacturing enterprises have been transformed and upgraded, and the production system of enterprises is becoming more and more important. As the core of the enterprise production system, the layout design of the workshop is particularly important. Workshop layout is one of the most considered, complex, and core issues in manufacturing system design, and its main idea is how to effectively organize and arrange various manufacturing resources to achieve optimal design objectives in a given environment [1]. A good workshop layout can ensure product quality while minimizing production costs, making the production process continuous and reducing annual cost savings by 10%–30% [2]. It can be seen that a reasonable workshop layout is of great significance for improving logistics efficiency, reducing production costs, and enhancing the competitiveness of enterprises [3].

Systematic Layout Planning (SLP), as an important method in the study of workshop layout, has been widely

used in domestic and foreign research. Through continuous analysis and summary of workshop layout problems, scholars around the world have made the content of workshop layout research more accurate, systematic, and constantly refined. Based on the SLP method, Ji et al. successfully realized the dynamic planning and layout of the site by dividing the construction phase and classifying the state of the site [4]. Khariwal et al. adopted the SLP method to carry out layout optimization design of enterprise logistics parks, which further improved the rationality of relevant layout planning [5]. Gao improved the SLP method and applied it to the layout transformation project of the company's production workshop to verify the effectiveness of the layout transformation scheme [6]. Wang et al. analyzed and improved the layout of the production workshop of a steel structure company by using the SLP theory, which ultimately reduced material redirection, reduced handling time, improved production efficiency, and ensured production safety [7]. Haryanto et al. designed the optimal location of each unit structure of the logistics center in combination with SLP to solve the positioning problem of the structural units and proposed the facility layout scheme of each unit to carry out effective production activities [8].

To sum up, scholars have conducted a lot of research and practice on layout optimization problems in various fields by using the SLP method, but through combing literature, it is found that the SLP method is rarely applied in the layout of car seat manufacturing workshops. Given this, this paper selects a seat assembly workshop of an automobile company as the research object. By analyzing the current layout of the workshop and existing problems, the SLP facility layout planning method is adopted to optimize the layout of the workshop, providing a reference scheme for the improvement of the workshop layout.

2. Current situation of car seat assembly workshop

The automobile company selected in this paper is the leading automobile seat supplier in China, which is committed to the design, research, and development of automobile seats. The company's car seat assembly workshop is set up in a huge rectangular factory, the main operating units include a raw material area, a skeleton preassembly area, a plastic ironing area, a plastic parts installation area, a functional check area, a finished product staging area, etc. The layout diagram of the workshop at this stage is shown in **Figure 1**.

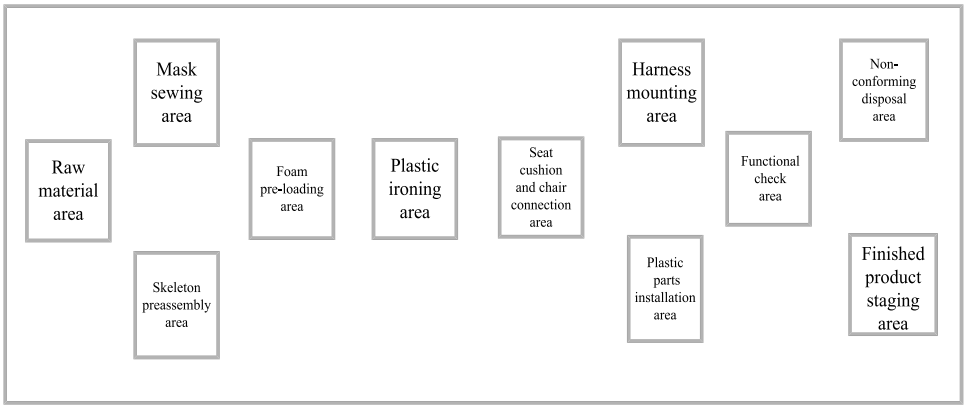


Figure 1. Initial workshop facility layout

Given the main research on the layout of the car seat assembly workshop, the whole chair process of the car seat assembly workshop is analyzed, which aims to provide a reliable basis for the subsequent layout of the workshop facilities. In the seat assembly process, the quality inspection of the product and the transportation of various materials

is essential, so the assembly process also includes inspection engineering. The specific workshop process flow is shown in **Figure 2**.

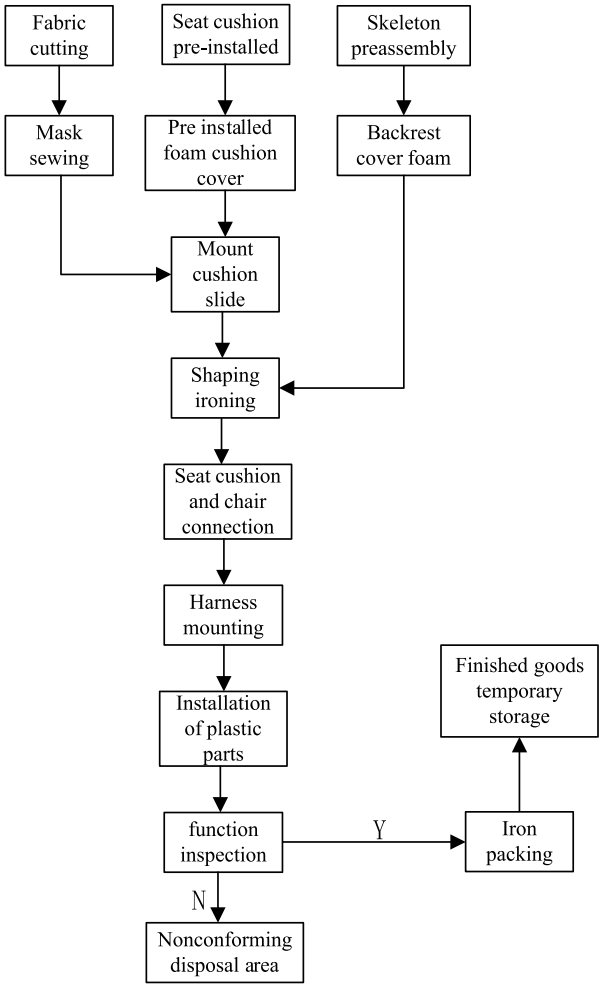


Figure 2. Process flow diagram

3. Problems and analysis of car seat assembly workshop

To fully understand the main problems existing in the layout of the assembly workshop, this paper analyzes and studies the current workshop from the perspective of F-D quantitative analysis. In the process of car seat assembly, many process links cannot be concentrated in the same position, so the scope of operation of the workshop needs to be divided, as shown in **Table 1**.

Table 1. Summary of workshop units

Serial number	Operating unit	Feature	Area (m^2)
1	Raw material area	Incoming inspection, temporary storage of raw materials	15*35
2	Mask sewing area	Cover material production	18*30
3	Skeleton preassembly	Backrest, cushion skeleton preassembly	18*30

Table 1 (Continued)

Serial number	Operating unit	Feature	Area (m^2)
4	Foam re-loading area	Foam cover connection, installation bayonet, etc.	15*35
5	Plastic ironing area	Back shaping, guide sleeve ironing, etc.	15*35
6	Seat cushion and chair connection area	Back seat cushion connection, seat belt installation, etc.	15*35
7	Harness mounting	Airbag, heating module wiring harness installation, etc.	18*30
8	Plastic parts installation area	Switch button, support wire installation	18*30
9	Functional check area	Functional and visual inspection	15*35
10	Finished product staging area	Storage of finished products	24*30
11	Non-conforming disposal area	Temporarily store non-conforming products	24*30

D analysis is a quantitative logistics analysis method. Firstly, the material handling paths of different operating units in the car seat assembly workshop were determined, as shown in **Figure 3**. It can be seen that the layout of the workshop still has the problem of unreasonable arrangement of facilities, such as the cross confusion of material handling routes and the distance gap between raw materials and various operating units, which makes the assembly process appear discontinuous phenomenon, resulting in certain losses in time and cost.

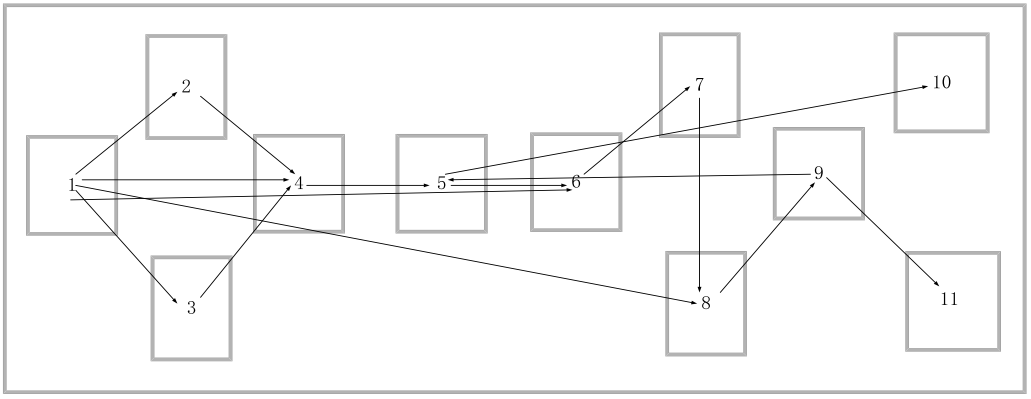


Figure 3. Material handling road map

By using European distance to calculate the distance relationship between various operating units, and applying statistics to the average material flow of each operating unit in the workshop, the workshop F–D diagram is drawn by calculating the material flow relationship and distance relationship between various operating units in the assembly process of car seats in the assembly workshop. The material flow (F) is the vertical axis and the distance (D) is the horizontal axis (**Figure 4**).

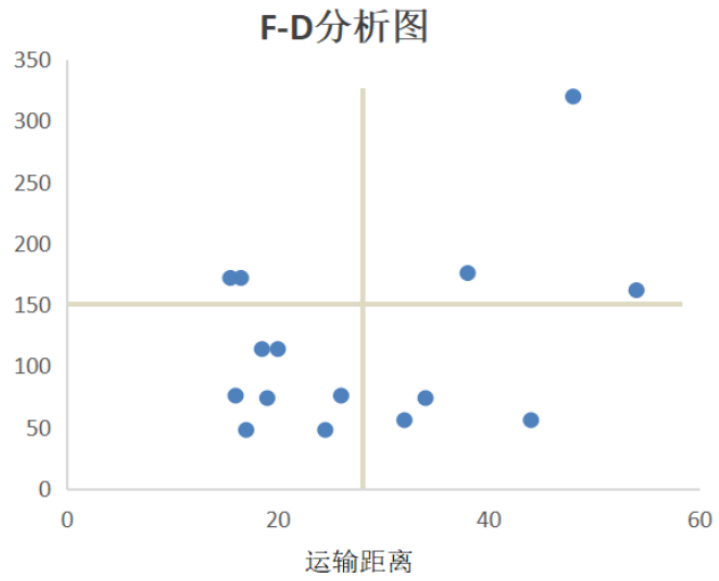


Figure 4. F–D analysis chart

In the Cartesian coordinate system, the workshop operation units are divided into four regions: A represents the workshop operation units with large logistics volume but close handling distance; B represents the workshop operation unit with large logistics volume and transportation distance, which is the area that needs the most improvement; C represents workshop operation units with small logistics volume and close transportation distance. This area is an ideal layout for workshop equipment operation units, which is in line with reality; D represents workshop operation units with a small logistics volume but a long transportation distance and the transportation distance needs to be shortened in this area. When planning the layout, it is necessary to consider the characteristics and impacts of different areas, and reasonably arrange high material flow and long-distance workshop operation units.

From the above, it can be seen that there are still problems with the layout of the car seat assembly workshop, such as insufficient scientific division of operating units and repeated handling between operating units. In addition, through research, we found that the workshop did not take into account the adverse effects of machine noise on human health when arranging the layout. Therefore, it is necessary to optimize the layout of the car seat assembly workshop to improve workshop efficiency.

4. Layout optimization of car seat assembly workshop based on SLP

The design of the workshop layout using the SLP method generally involves the analysis of logistics relationships, non-logistics relationships, and comprehensive relationships among various operating units [9]. The current situation of the workshop layout can be understood through the above content, and the relationship between operating units can be further analyzed through these materials. The optimization scheme of the workshop layout based on SLP is obtained.

4.1. Logistics relationship analysis

In the process of logistics relationship analysis, five symbols A, E, I, O, and U are usually used to divide the intensity of logistics data between workshop equipment, and the intensity of logistics decreases from A to U in turn. The specific representative meanings and symbols of different levels are shown in **Table 2**.

Table 2. Classification of logistics intensity

Rank symbol	Logistics intensity	Volume ratio	Proportion of logistics routes
A	Ultra	40%	10%
E	high	30%	20%
I	larger	20%	30%
O	normal	10%	40%
U	negligible	—	—

There are 15 job pairs in the production workshop with logistics relationships. Based on the distance, material flow, and material handling path between each job unit, the volume distance product between each job pair with the logistics relationship is further calculated [10]. This data can be used to represent the logistics intensity relationship between each job pair. The logistics intensity of the workshop is sorted from large to small, and the logistics intensity of the workshop and its level are summarized according to the logistics intensity level in **Table 2**, as shown in **Table 3**.

Table 3. Summary of logistics intensity of each operation unit

Serial number	Work unit pair	distance	Logistics quantity	Logistics intensity	Logistics intensity level
1	5-10	66	1000	66000	A
2	9-5	48	1000	48000	A
3	8-9	24	1160	27800	A
4	4-5	18	1300	23400	E
5	1-8	84	240	20160	E
6	6-7	21	786	16560	E
7	1-6	66	220	14520	E
8	5-6	18	720	12960	I
9	7-8	30	410	12300	I
10	3-4	21	490	10290	I
11	1-2	21	480	10080	I
12	1-3	24	400	9600	O
13	2-4	18	486	8748	O
14	1-4	30	290	8700	O
15	9-11	24	270	6480	O

According to the summary table of logistics intensity, the logistics relationship diagram of the workshop can be obtained, which makes the logistics relationship between each operation unit more intuitive. For workshop equipment without a material handling relationship, the logistics intensity will be treated in accordance with the U level. The specific physical relationship is shown in **Figure 5**.

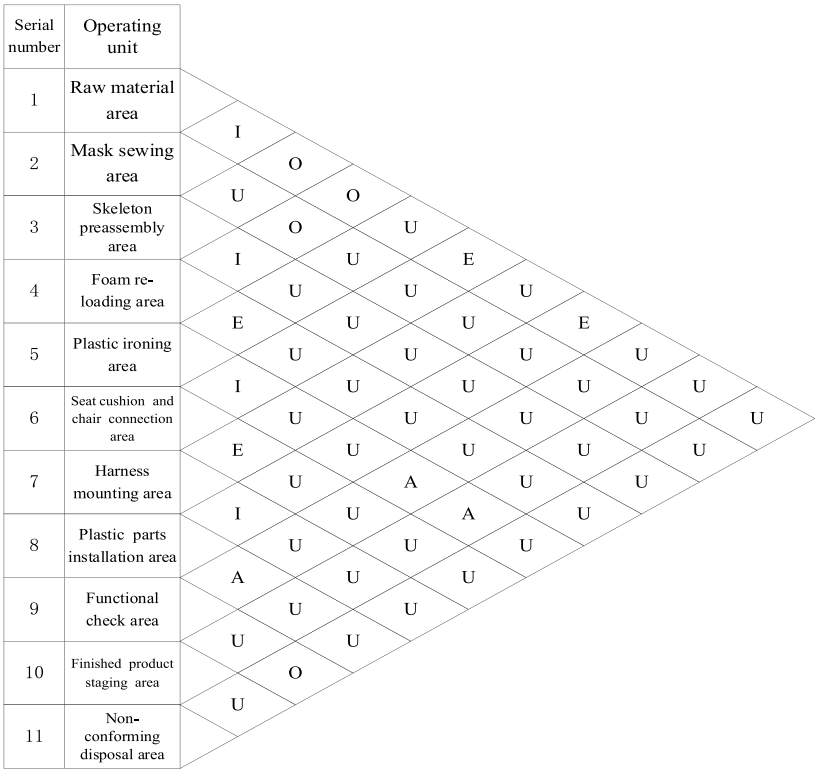


Figure 5. Logistics relationship diagram

4.2. Analysis of non-logistics relations

In addition to the analysis of logistics relations, the analysis of non-logistics relations is equally important. In the layout of the workshop, based on the actual investigation of the workshop and communication with the workshop staff, combined with the product process, the following determinants of non-logistic interaction were sorted out from different angles, as shown in **Table 4**.

Table 4. Determinants of non-logistics interrelationships

Serial number	Determining factor
1	Continuity of the production process
2	Material handling strength
3	Frequency of information exchange
4	Safe operating environment

According to the determinants of the closeness of workshop non-logistics relationship, the non-logistics relationship of workshop operation units is judged one by one, as shown in Table 5. The non-logistics relationship diagram is shown in **Figure 6**.

Table 5. Non-logistics relationship level table for each homework unit

Rank symbol	Homework unit	Relationship determinant
A	8-9, 4-5, 9-11	1,2,3,4
E	3-4, 2-4, 6-7, 5-6, 7-8	1,2,4
I	5-10, 9-5, 1-8, 1-6, 1-2, 1-3, 1-4	1,2,3
O	9-10, 2-3, 10-11, 1-5	3,4
U	……	Closeness does not matter

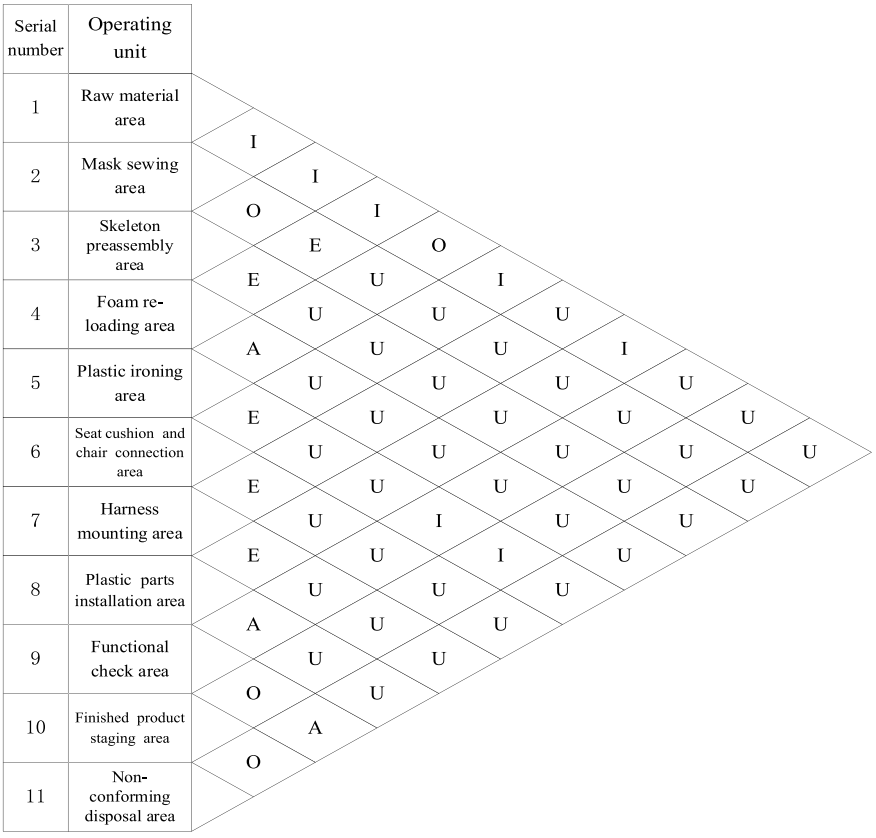


Figure 6. Non-logistics interrelationship diagram

4.3. Comprehensive correlation analysis

According to the actual situation of the automobile seat assembly workshop, the impact of logistics relations and non-logistics relations on the layout of the workshop is considered. To reduce the logistics crossover phenomenon of the workshop and the material handling cost, the logistics factors of the workshop should be taken into account when calculating the comprehensive relationship between various operating units. Therefore, the weight ratio of logistics relations and non-logistics relations in this paper is determined to be 2:1. To carry out a comprehensive correlation analysis, it is necessary to quantify the levels of logistics relations and non-logistics relations. Generally, A=4, E=3, I=2, O=1, U=0, and X=-1 are assigned to the relationship levels. The calculated comprehensive relationship analysis table is shown in **Table 6**, and the comprehensive relationship diagram is shown in **Figure 7**.

Table 6. Comprehensive relationship closeness table

Serial number	Job pair	Logistics relationship		Non-logistics relationship		Comprehensive relationship	
		Grade	Quantizer	Grade	Quantizer	Quantizer	Grade
1	8-9	A	4	A	4	12	A
2	5-10	A	4	I	2	10	A
3	9-5	A	4	I	2	10	A
4	4-5	E	3	A	4	10	A
5	6-7	E	3	E	3	9	E
6	1-8	E	3	I	2	8	E
7	1-6	E	3	I	2	8	E
8	5-6	I	2	E	3	7	E
9	7-8	I	2	E	3	7	E
10	3-4	I	2	E	3	7	E
11	9-11	O	1	A	4	6	I
12	1-2	I	2	I	2	6	I
13	1-3	O	1	I	2	4	I
14	2-4	O	1	I	2	4	I
15	1-4	O	1	I	2	4	I
16	9-10	U	0	O	1	1	O
17	2-3	U	0	O	1	1	O
18	10-11	U	0	O	1	1	O
19	1-5	U	0	O	1	1	O

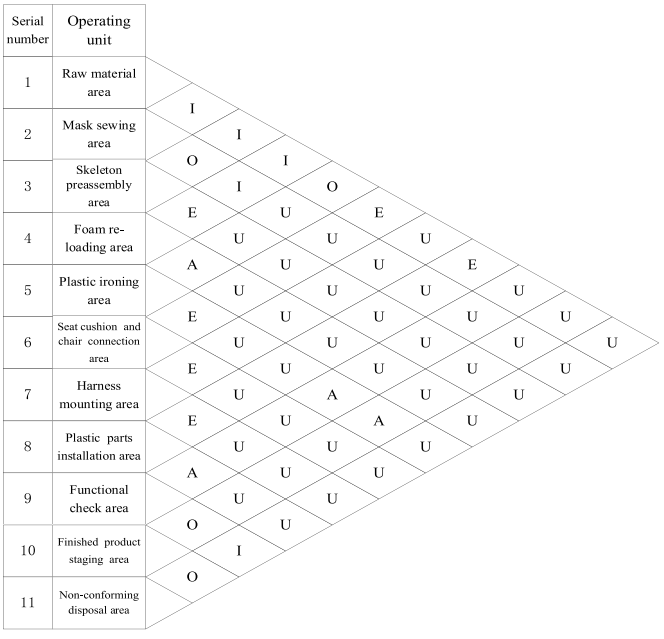


Figure 7. Comprehensive correlation diagram

5. Determine the workshop layout optimization scheme

5.1. Drawing up the workshop layout

When the SLP method is used to optimize the layout of the workshop, to further accurately derive the relative position of each work unit area in the workshop, the comprehensive quantization value between each work unit should be sorted to calculate the comprehensive proximity between the work units [11]. The quantized value of comprehensive proximity determines the position of the corresponding work unit in the layout planning of the whole workshop facility. The larger the value, the closer to the center layout. On the contrary, the smaller the value, the more it should be away from the central arrangement. Details are shown in **Table 7**.

Then draw a correlation chart of the position of the working area according to the above table, and use legend symbols to arrange their relative positions, usually using a “triangle” to represent the inventory area and a “circle” to represent the processing area. The proximity between operating units is usually indicated by a different number of solid lines, and the more the number, the closer the arrangement should be. An absolute necessity, special importance, importance, and general closeness are indicated by four, three, two, and one solid line, respectively. The location correlation diagram of the specific workshop operation area is shown in **Figure 8**. Among them, class A is 1 distance unit with the strongest degree of closeness, so it is preferentially placed; Class E is 2 distance units, the closeness is inferior to A, and the placement order is located after A; Level I consists of 3 distance units, placed after E; Level O is 4 distance units, placed after I; There is no close relationship between U-level operating units and can be placed at will.

Table 7. Comprehensive relationship closeness table

Activity	1	2	3	4	5	6	7	8	9	10	11
1		I/2	I/2	I/2	O/1	E/3	U/0	E/3	U/0	U/0	U/0
2	I/2		O/1	I/2	U/0	U/0	U/0	U/0	U/0	U/0	U/0
3	I/2	O/1		E/3	U/0	U/0	U/0	U/0	U/0	U/0	U/0
4	I/2	I/2	E/3		A/4	U/0	U/0	U/0	U/0	U/0	U/0
5	O/1	U/0	U/0	A/4		E/3	U/0	U/0	A/4	A/4	U/0
6	E/3	U/0	U/0	U/0	E/3		E/3	U/0	U/0	U/0	U/0
7	U/0	U/0	U/0	U/0	U/0	E/3		I/2	U/0	U/0	U/0
8	E/3	U/0	U/0	U/0	U/0	U/0	I/2		A/4	U/0	U/0
9	U/0	U/0	U/0	U/0	A/4	U/0	U/0	A/4		O/1	I/2
10	U/0	U/0	U/0	U/0	A/4	U/0	U/0	U/0	O/1		O/1
11	U/0	U/0	U/0	U/0	U/0	U/0	U/0	U/0	I/2	O/1	
Comprehensive degree	13	5	6	11	16	9	5	9	10	6	3
sort	2	9	8	3	1	5	10	6	4	7	11

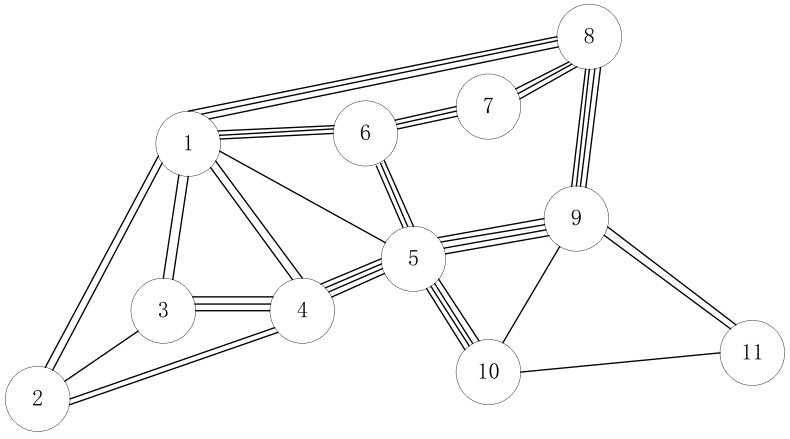


Figure 8. Location-related diagram of the workshop operation area

The diagram reflects the closeness of the working units in the workshop, but this is only the relative position of the working units under ideal circumstances. Combined with the actual situation, considering the actual constraints such as the actual reserved workshop channels, and keeping the rectangular working area distribution of the workshop as neat as possible, the initial layout optimization plan of the workshop was developed after repeated correction and adjustment, as shown in **Figure 9**.

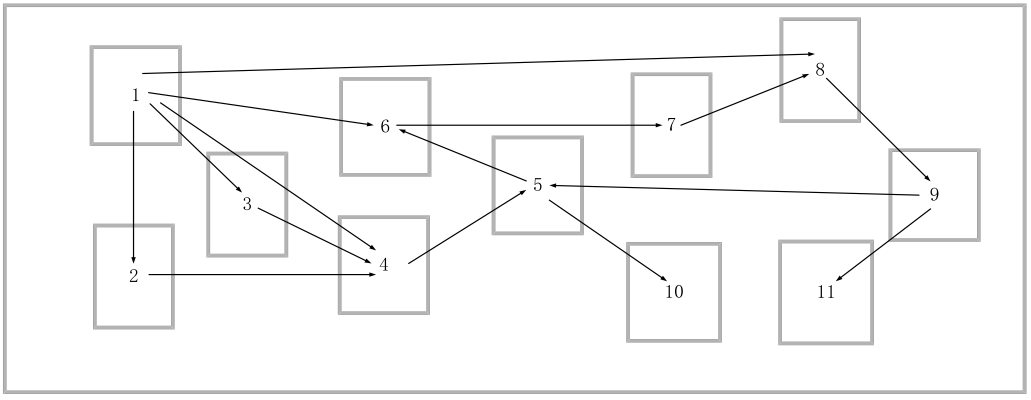


Figure 9. Workshop layout after SLP optimization

5.2. Optimization layout effect analysis

The optimized layout scheme of the workshop obtained by SLP can obtain the change of distance between each operation position of the workshop and the change of total logistics intensity, as shown in **Table 8**.

Table 8. Comparison and changes of various homework units

Serial number	Job pair	Distance	Optimized distance	Total logistics intensity	Optimized total logistics intensity
1	5-10	66	21	66000	21000
2	9-5	48	51	48000	51000
3	8-9	24	21	27800	24360
4	4-5	18	21	23400	27300

Table 8 (Continued)

Serial number	Job pair	Distance	Optimized distance	Total logistics intensity	Optimized total logistics intensity
5	6-7	84	36	20160	8640
6	1-8	21	87	16560	68382
7	1-6	66	33	14520	7260
8	5-6	18	21	12960	15120
9	7-8	30	21	12300	8610
10	3-4	21	18	10290	8820
11	1-2	21	24	10080	11520
12	1-3	24	18	9600	7200
13	2-4	18	33	8748	16038
14	1-4	30	42	8700	12180
15	9-11	24	18	6480	4860
Total		513	465	329982	292290

Through the data, the study can find that the total distance has decreased by 9.3% from 513 to 489, and the total logistics intensity has changed from 295598 to 292290. Moreover, through the comparison of the layout diagram before and after the workshop layout optimization, it can be seen that the crossing of material handling routes has been effectively reduced. It can be seen that the optimized workshop layout can effectively shorten the material handling distance, reduce the material handling intensity, reduce the handling waste, and improve the assembly efficiency of the workshop to a certain extent [12].

6. Conclusion

This paper takes the seat assembly workshop of an automobile enterprise as the research object. Through the F-D analysis of the layout status of the workshop, it is found that the layout of the workshop still has some problems, such as unscientific division of working units, repeated handling of materials, and crossing of lines. To solve the above problems, the SLP method was selected to optimize the overall layout of the workshop, and the effect of the workshop layout optimization scheme was analyzed from the three aspects of logistics handling distance, logistics intensity, and handling route, and the feasibility of the production line layout optimization scheme was verified.

Disclosure statement

The author declares no conflict of interest.

References

[1] Li S, 2017, Optimization and Simulation Research on Workshop Layout of H Company, thesis, Anhui University of Technology.

[2] Li H, Huang GW, Qi ES, 2014, Research on Dynamic Facility Planning System Based on Hybrid Ant Colony

Algorithm. Journal of Management Engineering, 28(1): 110–118.

[3] Wang ZY, Liu DJ, 2012, Research on the Supply Method of Direct Distribution Materials by Zhengzhou Nissan Motor Company. Proceedings of the 9th Henan Province Automotive Engineering Technology Symposium.

[4] Ji HQ, Zhou JQ, Li L, et al., 2017, Research on Planning and Layout of Subway Station Construction Site Based on Dynamic Layout Method. Journal of Railway Science and Engineering, 2017(7): 1865–1873.

[5] Khariwal S, Kumar P, Bhandari M, 2021, Layout Improvement of Railway Workshop using Systematic Layout Planning (SLP): A Case Study. Materials Today: Proceedings, 2021(44): 4065–4071.

[6] Gao JC, 2019, Research on Optimization and Simulation of Production Workshop Facility Layout Based on Improved SLP. Internal Combustion Engine and Accessories, 2019(1): 189–191.

[7] Wang YR, 2019, Research on Optimization of Production Workshop Layout of a Steel Structure Company based on SLP. Modern Manufacturing Engineering, 2019(3): 31–37.

[8] Chen C, Tran HD, Tong LK, et al., 2019, Optimal Facility Layout Planning for AGV-based Modular Prefabricated Manufacturing System. Automation in Construction, 2019(98): 310–321.

[9] Shi XF, DCT Dual-Clutch Transmission Workshop Layout Design and Simulation Optimization, thesis, East China Jiaotong University.

[10] Hu JQ, 2018, Optimization Design of Clutch Workshop Layout Based on SLP and AHP. Value Engineering, 2018(20): 144–146.

[11] Zhou JJ, 2016, Research on Optimization of Workshop Layout Based on Job Fatigue, thesis, Chongqing University.

[12] Leng HJ, Yan WQ, 2019, Research on Workshop Layout based on SLP and Genetic Algorithm. Value Engineering, 2019(16): 63–66.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Confucian Governance by Virtue: A Study on the Benevolent Rule as the Core Political Model

Guizhen Liu [1], Yuanlongyu Li[2]*

[1]Lyceum of the Philippines University, Batangas 4200, Philippines

[2]School of Computer Science, Beijing University of Technology, Beijing 100124, China

***Corresponding author:** Yuanlongyu Li, 24080307@emails.bjut.edu.cn

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: Confucianism emphasizes governance by virtue (De Zhi), advocating the ethicalization of politics and the politicization of ethics. This paper explores the concept of benevolent rule (Ren Zheng) as the core of Confucian political philosophy, tracing its development from Confucius to later Confucian scholars such as Mencius, Xunzi, and Dong Zhongshu. Confucius regarded benevolence (Ren) as the highest moral standard for rulers, believing that a virtuous ruler serves as a moral exemplar for the people, fostering social harmony and political stability. Mencius further developed this theory, asserting that a ruler's moral cultivation directly influences national governance and that only a ruler who embodies benevolence and righteousness can ensure lasting peace and stability. Xunzi emphasized the systematic implementation of moral governance through policies that benefit the people, moral guidance, and ritual norms. Later Confucian scholars reinforced the idea that political legitimacy depends on the ruler's moral integrity, which limits autocratic power and promotes ethical leadership. This study highlights the enduring influence of Confucian virtue-based governance on Chinese political thought and its implications for contemporary governance.

Keywords: Confucianism; Governance by virtue; Benevolent rule; Political ethics; Moral leadership

Online publication: March 10, 2025

1. Introduction

Confucian moral governance, rooted in the ethical teachings of Confucius and his followers, has played a pivotal role in shaping political philosophy and governance in China and beyond. Emerging during the tumultuous Spring and Autumn and Warring States periods, this thought system sought to address the challenges of social disorder and political instability by advocating governance based on virtue, ethical leadership, and the cultivation of moral character [1]. Unlike legalist approaches that prioritized strict laws and punitive measures, Confucian moral governance emphasized the ruler's personal virtue as the foundation of a harmonious and stable society [2].

The development of this doctrine was significantly influenced by Confucius, who championed the principles of "ren" (benevolence) and "li" (ritual propriety), Mencius, who advanced ideas of "people-oriented governance" and the innate goodness of human nature, and Xunzi, who integrated moral cultivation with institutional structures. Over time, Confucian moral governance was institutionalized, particularly during the Han dynasty, and remained a dominant political ideology in China for centuries. It not only shaped the administrative systems of successive Chinese dynasties but also influenced governance models in East Asian countries such as Korea, Japan, and Vietnam.

Despite the transformations in modern political structures, the ethical dimensions of Confucian governance continue to provide valuable insights into leadership, social responsibility, and civic morality. The enduring legacy of Confucian moral governance reflects its ability to bridge ancient philosophical ideals with contemporary governance challenges, emphasizing the importance of moral integrity in political leadership and societal harmony.

2. The formation and development of Confucian moral governance thought

The thought of Confucian moral governance emerged during the Spring and Autumn and Warring States periods, a time of profound political and social transformation in ancient China. The collapse of the Zhou dynasty's feudal system, coupled with incessant warfare among states, fostered an environment of intellectual ferment known as the "Hundred Schools of Thought." This period saw the rise of various philosophical traditions, among which Confucianism played a defining role in shaping the ideals of ethical governance. The increasing disillusionment with supernatural explanations for political stability and disorder led to a growing emphasis on moral principles and human responsibility in governance.

Confucius (551–479 BCE) established the foundational principles of Confucian ethical governance, advocating for the central tenets of "Ren" (benevolence) and "Li" (ritual propriety). He proposed that rulers should lead by moral example, emphasizing that a virtuous ruler who embodies Ren and Li would inspire the people to follow moral conduct voluntarily. His advocacy for "benevolent governance" (Ren Zheng) opposed tyranny and underscored the necessity of ethical leadership in achieving social harmony. Although his ideas were not widely implemented during his lifetime, they laid the groundwork for future Confucian thought.

Mencius (372–289 BCE) expanded upon Confucius' doctrines, reinforcing the role of moral virtue in governance. He introduced the concept of "Yi" (righteousness) as complementary to Ren, emphasizing the unity of benevolence and righteousness in state administration. Mencius championed "people-oriented governance" (Min Ben Si Xiang), asserting that "the people are more important than the ruler", a principle that prioritized the welfare of the populace over authoritarian rule. His belief in the "innate goodness of human nature" (Xing Shan Lun) further highlighted the role of moral education in cultivating ethical leadership and fostering social stability [3].

Xunzi (c. 310–235 BCE) contributed a contrasting yet influential perspective by asserting that human nature is inherently inclined toward self-interest and requires guidance through education and rituals. His philosophy integrated moral cultivation with institutional governance, advocating a balance between "ritual governance" (Li Zhi) and "legal governance" (Fa Zhi). His emphasis on the coexistence of ethical norms and legal structures later influenced the synthesis of Confucianism and Legalism, shaping governance models in the Han dynasty and beyond.

The institutionalization of Confucian moral governance occurred during the Han dynasty, particularly

under Emperor Wu (r. 141–87 BCE), who endorsed Confucianism as the state ideology. The policy of "excluding all other schools and honoring Confucianism alone" (Ba Chu Bai Jia, Du Zun Ru Shu) ensured the dominance of Confucian ethical governance principles in Chinese political thought. Over successive dynasties, Confucian moral governance evolved, influencing not only China's administrative system but also those of neighboring East Asian countries such as Korea, Japan, and Vietnam.

In contemporary society, the principles of Confucian moral governance continue to offer insights into ethical leadership and social stability. While modern governance relies on legal frameworks, the integration of moral education and ethical leadership remains essential in promoting civic responsibility and social cohesion. The legacy of Confucian moral governance thought thus persists as a significant intellectual and cultural heritage, bridging ancient philosophy with modern governance challenges.

3. The evolution of Confucian ethical governance

The Spring and Autumn and Warring States periods were critical stages in the initial establishment of Confucian ethical governance thought [4]. This era was marked by frequent social turmoil and the transition from a slave-based society to a feudal system. The flourishing of intellectual and cultural diversity, known as the "Hundred Schools of Thought", provided fertile ground for the formation and development of Confucianism. The chaotic political landscape, characterized by incessant warfare among feudal states, led to a growing skepticism regarding the absolute role of deities in national governance and stimulated new reflections on moral principles. By the late Spring and Autumn period, certain feudal states sought to replace traditional moral indoctrination with legal governance, as exemplified by the casting of criminal codes in bronze by Zichan of Zheng and Zhao Yang of Jin [5]. This marked the initial debate between the principles of ritual governance (Li Zhi) and legal governance (Fa Zhi), further facilitating the emergence of Confucian ethical governance thought [6].

Confucius laid the foundation for Confucian ethical governance, with "Ren" (benevolence) and "Li" (ritual propriety) as its core tenets. He regarded ren as the highest virtue for rulers, advocating that "a benevolent person loves others" and integrating this principle into political life. Concurrently, Li functioned as an external behavioral norm aimed at maintaining social order [6]. Confucius emphasized that rulers should possess noble moral character and implement "benevolent governance" (Ren Zheng), upholding the principle of "virtue before punishment" while opposing tyranny. He believed that a state governed by ritual and moral education could ultimately realize the ideal of Ren.

Although Confucius' ideas were not widely adopted during his time, the Confucian school gradually expanded in influence over time. Mencius inherited and further developed Confucius' theories, advancing the doctrine of benevolent governance. He not only upheld Ren as the core principle but also introduced "Yi" (righteousness), emphasizing the unity of Ren and Yi. Mencius asserted that a ruler must possess moral integrity and govern through Ren and yi rather than military force. He distinguished between "kingly governance" (Wang Dao), which is based on virtue, and "hegemonic governance" (Ba Dao), which relies on power and coercion. He underscored the critical role of a ruler's moral cultivation in national stability and the well-being of the people.

Mencius' concept of "people-oriented governance" (Min Ben Si Xiang) was also a significant component of Confucian ethical thought. He proposed the principle of "the people are more important than the ruler", advocating that "the ruler is of lesser importance, the state is secondary, and the people are paramount." Additionally, he developed the "theory of innate human goodness" (Xing Shan Lun), arguing that human nature is inherently good, with moral development being shaped by education and environment. Consequently,

he emphasized the necessity for rulers to implement benevolent governance and educate the people to achieve social harmony and stability.

Xunzi, another key figure in Confucian thought, further expanded upon the ideas of Confucius and Mencius, emphasizing the paramount role of ritual in governance. He advocated the principle of "exalting rituals and emphasizing laws" (Long Li Zhong Fa), asserting that both moral cultivation and institutional regulation were essential for effective state governance. Unlike Mencius, Xunzi proposed the "theory of innate human evil" (Xing E Lun), contending that human nature is inherently inclined toward selfish desires and requires education and ritual constraints to be properly guided. His ideas significantly influenced the later integration of Confucianism and Legalism, laying the theoretical groundwork for the Confucian dominance in the Han Dynasty [7].

The ethical governance thought of Pre-Qin Confucianism not only shaped the political and social structures of its time but also provided a foundational theoretical framework for future governance [8]. Confucius' advocacy of "benevolence as the foundation, ritual as the practice" (Ren Ben Li Yong) and Mencius' development of the "unity of benevolence and righteousness" (Ren Yi Xiang He) became crucial theoretical pillars for state administration in later periods. The Han Emperor Wu's policy of "excluding all other schools and honoring Confucianism alone" (Ba Chu Bai Jia, Du Zun Ru Shu) established Confucianism as the dominant ideology in ancient Chinese society [9]. Over successive dynasties, Confucian ethical governance thought continued to evolve and profoundly shaped traditional Chinese culture and institutional structures [10].

Moreover, Confucian ethical governance thought extended beyond China, influencing East Asian countries such as Korea, Japan, and Vietnam. These nations integrated Confucian principles into their political and cultural systems, developing localized Confucian traditions. The Confucian emphasis on moral cultivation, social harmony, and governance by virtue had a profound impact on the political institutions, social ethics, and cultural values of East Asia.

In conclusion, the Spring and Autumn and Warring States periods were pivotal in the initial establishment of Confucian ethical governance thought. The theoretical contributions of Confucius, Mencius, and Xunzi constructed the core framework of this ideology. Confucianism emphasized the moral cultivation of rulers, centered on benevolent governance, and advocated a governance model that integrated ritual and legal principles. These ideas not only shaped ancient Chinese political culture but also influenced the governance models of East Asian nations, becoming a vital intellectual heritage of Chinese civilization.

3.1. The fundamental connotations of Confucian moral governance

The Chinese character " 德 " (De) carries a profound and multifaceted meaning in ancient Chinese culture. Its earliest forms can be traced back to oracle bone script and bronze inscriptions, though its presence in the Shang dynasty was not particularly prominent. Scholar Xu Zhongshu suggested that the " 彳 直 " symbol found in oracle bone script represents an early form of "De." Subsequent research has indicated that in its early usage, "De" encompassed meanings related to conduct and intention, gradually evolving into a concept associated with morality. The notions of "De" appear in the Canon of Yao (Yao Dian) and Canon of Shun (Shun Dian), which emphasize that a ruler must possess moral qualities to govern the world effectively. In these early texts, "De" refers both to general behavior and virtue. The Zhou dynasty's ideology of "revering De" (Jing De) established morality as the foundation of political legitimacy, an idea that had already manifested in the early abdication system and the divine right of kingship in the Xia and Shang dynasties.

3.2. The development of De-based governance (De Zhi)

The concept of governing through virtue, or De-based governance (De Zhi), emerged in the early Western Zhou period. To consolidate political authority, the Duke of Zhou proposed the principles of "revering De to protect the people" (Jing De Bao Min) and "aligning with Heaven through virtue" (Yi De Pei Tian), laying the foundation for the De-based political system [11]. Later, Guan Zhong identified rituals, propriety, integrity, and a sense of shame as the four essential pillars of a state, warning that the decline of ritual propriety would lead to national collapse. Similarly, Zichan asserted that governance must be rooted in De, regarding morality as the fundamental principle of state administration [12].

3.3. Confucius's theory of De-based governance

Confucius further refined the theory of De-based governance, formulating a threefold framework of rule by ritual (Li Zhi), rule by virtue (De Zhi), and rule by humane leadership (Ren Zhi). He argued that relying solely on administrative orders and penal codes might compel people to obey out of fear, but it would not lead to true moral transformation. Instead, through moral guidance and ritual education, people would internalize ethical norms and voluntarily adhere to them, achieving the ultimate goal of governance. He emphasized "governing by De" (Wei Zheng Yi De), insisting that rulers should lead by moral example, inspiring the populace through their own virtue to ensure long-term social stability [13].

3.4. Mencius and the ethical foundations of governance

Mencius, like Confucius, underscored the centrality of morality in governance. He asserted that good governance must be built upon moral education, advocating that ruling through virtue (Yi De Fu Ren) fosters genuine public allegiance, as opposed to mere coercion through force. His theory of benevolent governance (Ren Zheng) posited that compassion and morality are the cornerstones of state administration. He emphasized that rulers must prioritize the welfare of the people, alleviate their burdens, and implement lenient policies to secure public support [14]. Furthermore, he introduced the concept of "vast, unyielding moral force" (Hao Ran Zhi Qi), which refers to an inner strength derived from moral conviction, asserting that only through such moral confidence could a ruler effectively govern by virtue.

3.5. Xunzi: Integrating ritual and law in governance

Xunzi advanced the discourse on De-based governance by emphasizing the role of ritual (Li) in state administration. Unlike Mencius, he argued that human nature is inherently flawed and requires external education and regulation. Consequently, he advocated for a synthesis of ritual and law (Li Fa Bing Zhong), asserting that while morality inspires, legal frameworks are indispensable for maintaining social order. His doctrine of "exalting ritual and enforcing law" (Long Li Zhong Fa) proposed that effective governance should combine moral influence with rational legal structures to ensure a stable and orderly society.

3.6. The three dimensions of Pre-Qin Confucian De-based governance

The Confucian theory of De-based governance before the Qin dynasty can be categorized into three main aspects: People-centered governance (Min Ben Zhi Zhi): This doctrine asserts that the people's interests take precedence over the ruler's authority. Mencius' famous proposition, "The people are the most important, the state comes next, and the ruler is the least important" (Min Wei Gui, She Ji Ci Zhi, Jun Wei Qing), exemplifies this principle. Benevolent governance (Ren Min Zhi Zhi): This aspect stresses that rulers must

possess a compassionate heart and implement moral education to cultivate ethical conduct among the populace. Rule by virtuous elites (Xian Ren Zhi Zhi): This principle holds that only individuals of exceptional moral integrity and capability should govern, ensuring a meritocratic and ethically guided administration [15].

3.7. Later developments: Han Dynasty to Ming-Qing Neo-Confucianism

Xu Fuguan identified Confucian moral idealism as one of the most influential intellectual resources in Chinese culture, emphasizing self-cultivation as the pathway to moral governance. Confucianism prioritized righteousness (Yi) over profit (Li) and upheld benevolence (Ren) as the highest moral principle, advocating a governance model centered on De-based rule (De Zhi) [16]. Confucian De-based governance integrates self-cultivation and public administration, requiring rulers to cultivate their own virtue first before governing the nation—a principle encapsulated in the Confucian maxim "cultivate oneself, regulate the family, govern the state, and bring peace to the world" (Xiu Shen Qi Jia Zhi Guo Ping Tian Xia) [17].

3.8. The contemporary relevance of Confucian De-based governance

Examining Confucian De-based governance provides valuable insights into its historical influence and modern relevance [6]. As scholar Qian Xun pointed out, the Confucian emphasis on ethical responsibility and social duty continues to offer solutions to modern moral crises and interpersonal challenges. Although the rule of law has become the cornerstone of contemporary governance, moral governance remains essential in areas such as family education, social management, and leadership development [18].

For example, in corporate management, a leader's moral integrity directly impacts team cohesion and execution efficiency. In public administration, moral education plays a crucial role in enhancing civic awareness and reducing social conflicts.

4. Conclusion

Confucian moral governance, rooted in ethical cultivation and virtue-based leadership, has played a profound role in shaping governance models in China and beyond. From the formative ideas of Confucius, Mencius, and Xunzi to its institutionalization during the Han dynasty and its later evolution in East Asian societies, this tradition has left an enduring legacy. Emphasizing benevolence, righteousness, and the integration of ritual and law, Confucian governance sought to create a harmonious and ethically driven society.

Although modern political systems rely primarily on legal frameworks, the principles of Confucian moral governance remain relevant in contemporary discussions on ethical leadership, civic responsibility, and social harmony. Its emphasis on moral education, people-centered governance, and virtuous leadership continues to offer insights for addressing contemporary challenges in politics, business, and social management. By bridging ancient wisdom with modern governance, Confucian moral thought provides a valuable ethical foundation for fostering integrity, stability, and societal well-being in an ever-changing world.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zuo J, 2013, The Contribution of Confucian and Mohist Education to the Dissemination of "Ritual" During the Hundred Schools of Thought in the Spring and Autumn and Warring States Periods. Journal of Nanyang Normal University, 2013(11): 65.

[2] Wang CY, 2016, A Study on the Relationship Between Confucian "Rule by Virtue" Thought and the Contemporary Policy of "Governing the Country by Virtue", thesis, Liaoning University of Technology.

[3] Ding DJ, 2008, Mencius' People-Oriented Thought and Its Comparison with Contemporary Democratic Thought. Journal of Beijing University of Technology (Social Science Edition), 2008(4): 42.

[4] Gao ZQ, Bao DN, 2007, On the Formation of Ancient China's Pragmatic Design Thought—With a Discussion on the Design Culture of the Spring and Autumn and Warring States Periods. Journal of Jiangsu Institute of Technology (Social Science Edition), 2007(1): 55.

[5] Chen ZY, 2008, The Alliances and Oaths Between the State of Lu and Other States During the Spring and Autumn Period and Their Characteristics. Journal of Henan University of Science and Technology (Social Science Edition), 2008(5): 23.

[6] Zhang MY, 2016, A Study on Confucian Moral Governance Thought and Its Modern Value, thesis, Heilongjiang University.

[7] Yang K, 2015, Research on the Pre-Qin Confucian Moral Governance Management Thought and Modern Enterprise Humanistic Management, thesis, Liaoning University of Science and Technology.

[8] Ma Y, 2011, The Thought of Moral Governance in Pre-Qin Confucianism and Its Modern Value, thesis, Xi'an Polytechnic University.

[9] Zhang LY, 2011, A Study on the Translation of Classical Texts from the Perspective of Cultural Globalization. Overseas English, 2011(11): 220.

[10] Ma SL, 2014, Using "Attire" to Convey the Dao—A Study on the Cultural Connotations of Hanfu, thesis, Hunan University of Technology.

[11] Xue XP, 2009, A Study on Pre-Qin Confucian Moral Value Thought and Its Modern Implications, thesis, Hebei Normal University.

[12] Lang XX, 2003, On Confucian Thought of Moral Governance and Its Practical Significance. Gansu Higher Education Journal, 8(4): 42.

[13] Chen HS, 2011, The Management Philosophy in The Analects. New Western Region, 2011(9): 126.

[14] Yang L, Yan LJ, 2014, Gu Hongming's Domestication Translation Strategy of The Analects. Journal of University of Science and Technology Beijing (Social Science Edition), 2014(1): 16.

[15] Feng L, 2009, An Exploration of Pre-Qin Confucian Moral Governance Thought, thesis, Xiangtan University.

[16] Xu FG, 2005, A History of Chinese Theories on Human Nature. East China Normal University Press, Shanghai, 99–100.

[17] Xue LF, 2012, A Brief Discussion on the Relationship between Confucian Rites and Music Culture and the Concepts of Self-Cultivation, Family Regulation, State Governance, and World Peace. Hubei Social Sciences, 2012(4): 113.

[18] Qian X, 1991, Pre-Qin Confucianism. Liaoning Education Press, Shenyang, 241.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Innovative Paths and Cultural Identity Research in Folk Art Education in Guangzhou Universities Enabled by Digital Technology

Ruiji Shengchuan[1]*, Yichun Zhangluo[2]

[1]School of Music and Dance, Guangzhou University, Guangzhou 510006, Guangdong, China

[2]Tianjin Chengjian University, Tianjin 300380, China

Corresponding author: Ruiji Shengchuan, S33c99rj-4@gzhu.edu.cn

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: This paper focuses on folk art education in Guangzhou universities empowered by digital technology. Using a combination of questionnaire surveys, interviews, classroom observations, and case studies, it deeply explores its innovative paths and the impact on students' cultural identity. Research has found that digital technology, through its application in Guangzhou university folk art education, enables innovative teaching methods, effectively enhancing students' sense of identity with Chinese traditional culture. Simultaneously, the study reveals current issues and proposes targeted development suggestions, providing references for promoting the digital transformation of folk art education in Guangzhou universities and related education in universities across the country.

Keywords: Digital technology; Guangzhou universities; Folk art education; Cultural identity

Online publication: March 10, 2025

1. Introduction

Amidst the global wave of digitization, the education sector is undergoing profound changes, and digital transformation has become an inevitable trend in higher education development [1]. As a treasure of Chinese traditional culture, folk art carries rich historical memories and cultural connotations. Guangzhou, as the core region of Lingnan culture, possesses diverse and unique folk art resources, such as Cantonese opera and Guangfu boat lights [2]. Integrating digital technology into folk art education in Guangzhou universities not only conforms to the trend of education modernization but also represents an important measure to inherit and promote Chinese excellent traditional culture and enhance students' cultural identity.

However, the current research on the application of digital technology in folk art education in Guangzhou universities is still in the exploratory stage. Domestic research mainly focuses on education digitization and innovation

and entrepreneurship education, with few systematic studies on the digital transformation of folk art education and inadequate practical application and empirical research [3–5]. Although foreign research focuses on technology applications and digital communication, it lacks an in-depth exploration of folk art education in different regions, especially in Guangzhou [6–9]. In this context, it is of great practical significance to deeply study the innovative paths and cultural identity of folk art education in Guangzhou universities enabled by digital technology.

This study aims to fill this research gap. Through a systematic analysis of the current application, innovative practices of digital technology in folk art education in Guangzhou universities, and its impact on students' cultural identity, it provides theoretical support and practical guidance for the digital transformation of folk art education in Guangzhou universities. It also offers references for folk art education in universities across the country, facilitating the inheritance and development of Chinese excellent traditional culture.

2. Theoretical framework

2.1. Digital enablement theory

Digital enablement theory emphasizes the innovative role of digital technology in traditional education models. In folk art education, digital technology breaks time and space limitations and achieves an efficient allocation of educational resources by providing diversified teaching tools and resources [10]. Digital technology can create an immersive learning environment for students, making them feel like they are in a real scene of folk art, thus enhancing the intuitive experience of learning. Artificial intelligence (AI) technology can tailor personalized learning paths for students based on their learning progress and interests, improving learning effectiveness [11]. The application of these technologies fundamentally changes the teaching methods and learning experiences of traditional folk art education, injecting new vitality into education and teaching.

2.2. Cultural identity theory

Cultural identity refers to an individual's sense of belonging and identification with their cultural group, which is an important psychological foundation for cultural inheritance and development [12]. In a digital learning environment, students participate in folk art education courses and access rich folk art resources through digital platforms. They deeply understand the history, culture, and values behind folk art. This interactive and experiential learning process helps students establish emotional connections with traditional culture, enhancing their identification with Chinese traditional culture, especially Guangzhou folk art. Students can experience the atmosphere of traditional festivals in virtual folk scenes or understand the inheritance of folk art through digital resources, enabling them to more deeply understand and identify with local culture.

2.3. Contemporary transformation of folk art education

In the contemporary education system, folk art education has irreplaceable value [13]. It is not only an important way to inherit and promote Chinese excellent traditional culture but also cultivates students' aesthetic ability, innovative spirit, and cultural literacy. Guangzhou's folk art, such as Cantonese opera, integrates various art forms such as music, dance, and literature, and Guangfu boat lights contain unique waterside culture. These rich resources provide quality materials for folk art education in universities. However, the traditional folk art education model faces issues such as limited teaching resources and a single teaching method. Digital transformation brings new opportunities, allowing folk art education to break through the limitations of traditional teaching. It can be presented to students in a more vivid and intuitive way, achieving innovative development of folk art education in the contemporary era.

3. Research methods

3.1. Questionnaire survey

A questionnaire survey was designed for students from multiple universities in Guangzhou regarding digital folk art courses. The survey covered aspects such as student satisfaction with the courses, changes in cultural identity, and artistic literacy before and after learning. A total of 800 questionnaires were distributed, and 720 valid questionnaires were collected, with an effective recovery rate of 90%. Through statistical analysis of the questionnaire data, student feedback on digital folk art courses was obtained, providing quantitative data support for the study.

3.2. Interview method

In-depth interviews were conducted with teachers and course designers involved in folk art education in Guangzhou universities. The interviews focused on their views on digital teaching, practical experiences, difficulties faced, and suggestions for improvement. A total of 20 teachers and 10 course designers were interviewed. Through the collation and analysis of the interview content, valuable experiences and insights from their teaching practices were obtained, providing a deep understanding of the application of digital teaching in folk art education from the perspective of teachers and course designers.

3.3. Classroom observation

Observations were made in folk art education classrooms in Guangzhou universities to observe the application of digital technology in practical teaching. Aspects such as classroom interaction, student engagement, and the use of teaching resources were recorded to evaluate the impact of digital technology on classroom teaching effectiveness. A total of 15 different types of folk art courses were observed, providing a direct understanding of the practical application effects and existing problems of digital technology in the teaching process.

3.4. Case analysis

Representative digital folk art courses in Guangzhou universities, such as the digital Guangdong Han Opera course, were selected for detailed analysis. Starting from course design, teaching implementation process, and student learning outcomes, the specific application and implementation effects of digital technology in the innovation path of folk art education were demonstrated, providing practical cases for other universities to learn from.

4. Research content and analysis

4.1. Exploring innovative paths of digital technology in folk art education

Application of Digital Technology: Some universities in Guangzhou have introduced digital technology into folk art education to create immersive learning scenarios. In digital courses, students can use digital technology to “place themselves” in performance scenes, watch actors’ costumes, makeup, and performance movements online, and experience the stage atmosphere. Digital technology overlays virtual folk elements on real scenes, allowing students to see folk art displayed in real scenes without spatial or geographical restrictions through digital applications, understanding its structure and production process. This immersive experience greatly enhances students’ interest in learning and makes them more actively involved in learning.

Artificial intelligence and adaptive learning: Based on AI technology, some universities have developed personalized learning platforms. The platform analyzes students’ learning progress and interest preferences based on data such as answer performance, study duration, and enthusiasm for participation in interactions during the learning process. It then

recommends personalized learning content. For example, in folk art history courses, students interested in traditional theater will be recommended more traditional theater-related materials, including classic repertoire appreciation and actor interviews. Students interested in intangible cultural heritage crafts will receive related craftsmanship tutorials and historical and cultural background introductions. This personalized learning path design meets students' differentiated learning needs and improves learning effects.

Cross-platform digital resource integration: Guangzhou universities are actively integrating folk art digital resources and establishing digital folk art resource libraries. These resource libraries cover various forms of information such as text, images, audio, and video, including historical documents, performance videos, and artistic works of folk art. Through multi-platform sharing, students can access the resource library on different platforms such as campus networks and mobile terminals, enabling anytime, anywhere learning. Additionally, the resource library provides interactive functions, allowing students to exchange learning experiences and share their own works on the platform, promoting interaction and cooperation between students.

4.2. The impact of digital empowerment on students' cultural identity

Design of cultural identity measurement indicators: Through questionnaires and interviews, a set of cultural identity measurement indicator systems has been designed, including dimensions such as cognition of Guangzhou folk art, emotional identity with Chinese traditional culture, and willingness to inherit folk art. The questionnaire adopts the Likert scale form, allowing students to score their degree of agreement with each dimension. By comparing and analyzing the questionnaire data before and after student learning, changes in students' cultural identity are evaluated.

Case analysis: Taking the digital course of Guangdong Han Opera as an example, before the course was implemented, some students only had a superficial understanding of Guangdong Han Opera, and their cultural identity was low. After the course was implemented, a questionnaire survey found that 85% of students had a deeper understanding of the history, singing style, and performance form of the Guangdong Han Opera. 78% of students expressed an enhanced sense of identity with Chinese traditional culture, and 60% of students expressed willingness to participate in the inheritance activities of Guangdong Han Opera. This indicates that the digital course has effectively enhanced students' identity with Guangdong Han Opera and Chinese traditional culture.

Student feedback and classroom interaction analysis: Through statistical analysis of student classroom feedback and interaction data, it is found that digital teaching stimulates students' active learning awareness. In digital classrooms, the number of times students participate in discussions and ask questions has increased significantly. They share their understanding and feelings about folk art through online platforms, forming a good learning atmosphere. This interactive learning not only deepens students' understanding of knowledge but also promotes their cultural identity, allowing them to understand the connotation of folk art more deeply through communication.

5. Research results

5.1. Feasibility and effectiveness of innovative paths

Research findings indicate that the innovative application of digital technology in folklore art education at Guangzhou universities has high feasibility and significant effectiveness. The application of AI technology has increased students' interest in learning by 70%. The design of personalized learning paths through artificial intelligence has improved students' academic performance by an average of 15 points (out of 100). Cross-platform digital resource integration has facilitated communication and cooperation among students, enhancing their autonomy in learning. These innovative paths have promotional value in universities at different levels and majors, effectively improving the quality of folklore

art education.

5.2. Improvement effect of cultural identity

Through quantitative and qualitative research, it has been found that digital folklore art education significantly enhances students' cultural identity. After studying digital courses, students' awareness of Guangzhou folklore art has increased by an average of 40%, and their emotional identification with traditional Chinese culture has increased by 35%. Qualitatively, students have demonstrated a stronger interest in folklore art during interviews and classroom interactions, actively participating in the inheritance and promotion of folklore art. Some students have even spontaneously organized folklore art clubs to carry out related activities.

5.3. Suggestions for optimizing teaching models

Based on the research results, the following suggestions for optimizing teaching models are proposed: further develop digital teaching resources to enrich teaching content; strengthen teachers' digital literacy training to improve their ability to use digital technology; enhance the interactivity and personalized services of the digital teaching platform by improving its functionalities; establish a diversified teaching evaluation system that comprehensively considers students' learning processes and outcomes.

6. Discussion and suggestions

6.1. Experience summary of the digital transformation of folklore art education in Guangzhou universities

Guangzhou universities have gained some experience in the digital transformation of folklore art education [14]. Firstly, they focus on the deep integration of technology and teaching content, selecting appropriate digital technologies based on the characteristics of folklore art to enhance teaching effectiveness. Secondly, they actively integrate multiple resources, including on-campus teachers, external experts, and social cultural institutions, to jointly promote the construction of digital courses. Thirdly, they emphasize students' subjectivity, designing courses and teaching activities oriented towards students' needs to stimulate their learning enthusiasm.

6.2. Challenges and countermeasures

The application of digital technology requires certain hardware devices and software support, which can be costly. The countermeasure is to seek financial support from the government and schools and collaborate with enterprises to reduce technical costs through industry-university-research cooperation. For example, partnering with technology companies to develop low-cost VR equipment suitable for folklore art education.

Some teachers have limited mastery of digital technology, affecting teaching effectiveness. Teacher training should be continuously strengthened, and teachers should be regularly organized to participate in digital teaching skills training courses. Encourage teachers to conduct digital teaching research and practice to enhance their digital literacy.

The quality of digital resources for folklore art on the internet varies. Universities should establish strict resource screening and review mechanisms to ensure the accuracy and authority of teaching resources. Simultaneously, encourage teachers to independently develop high-quality teaching resources to enrich teaching content.

6.3. Reference significance for national universities

The practices of Guangzhou universities provide valuable experience for national universities. In terms of course design,

other universities can learn from the way Guangzhou universities combine digital technology with local folklore art to develop folklore art courses with local characteristics. Promote personalized learning and immersive teaching models to improve teaching effectiveness. Regarding resource integration, establish a cross-school and cross-regional digital resource sharing platform for folklore art to achieve optimal resource allocation.

6.4. Suggestions for international exchange and promotion

Utilize digital platforms to promote Guangzhou folklore art internationally. Spread traditional Chinese culture overseas by producing multilingual versions of digital courses and hosting online international folklore art exchange activities. Collaborate with international universities to study the digital transformation of folklore art education and enhance the influence of Chinese universities in the field of international folklore art education.

7. Conclusion

Through an in-depth exploration of digital technology-enabled folklore art education in Guangzhou universities, the study systematically analyzes its innovative paths and impacts on students' cultural identity. The research results indicate that digital technology brings new development opportunities to folklore art education in Guangzhou universities. By innovating teaching methods and integrating teaching resources, it effectively improves teaching quality and students' cultural identity.

However, there are still some issues in applying digital technology to folklore art education in Guangzhou universities, requiring further improvement in technical cost control, teacher digital literacy enhancement, and teaching resource optimization. In the future, we should continuously monitor the development trend of digital technology, constantly explore its new applications in folklore art education, and provide strong support for inheriting and promoting excellent traditional Chinese culture.

Simultaneously, it is hoped that the research results can provide valuable references for the digital transformation of university folklore art education, promote the further development of Chinese university folklore art education, and facilitate the global dissemination and exchange of excellent traditional Chinese culture.

Funding

Guangzhou Municipal Bureau of Education 2024 College Research Project: Phase I Research Results of the Innovative Research on Folk Art Education in Guangzhou Colleges and Universities under the Background of Digital Transformation (Project No. 2024312462)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Song J, 2024, Facilitating Deep Learning in College English through Cooperative Learning in the Context of Educational Digital Transformation. Textile and Garment Education, 39(1): 85–90. https://doi.org/10.13915/j.2095-3860.2023.0345.

[2] Liao WX, 2024, Construction of Innovation and Entrepreneurship Education System in Vocational Colleges in the Digital Economy Era. Continuing Education Research, 2024(8): 52–56.

[3] Gong SJ, 2024, The Importance and Dimensions of Innovation in Higher Education Teaching Management — A Review of "Research on Innovation in Higher Education Teaching Management". Theory and Practice of Education, 44(18): 2.

[4] Bin MR, 2024, A Review of the Integration of Ideological and Political Education and Innovation and Entrepreneurship Education in Colleges and Universities. Higher Education Forum, 2024(5): 1–4.

[5] Meng XL, Yu LY, Chen RQ, 2024, Research on the Path of Promoting Practical Education through Innovation and Entrepreneurship Education in Colleges and Universities. China Employment, 2024(6): 97–98. https://doi.org/10.16622/j.cnki.11-3709/d.2024.06.049

[6] Jiang XY, Ma ZL, 2023, Exploring the Dissemination Path of Traditional Folk Art in the Media Convergence Era. Art Education, 2023(2): 43–46.

[7] Zhang YG, 2022, Research on the Dissemination and Preservation of Folk Art in the New Media Environment. Art Research, 2022(2): 141–143. https://doi.org/10.13944/j.cnki.ysyj.2022.0079

[8] Wang S, 2022, Digital Protection and Utilization of Folk Art Resources using Virtual Reality Technology. Mobile Information Systems, 2022(1): 8198830.

[9] Wei Y, 2021, Digital Inheritance Application of Chinese Traditional Folk Art in Art Teaching in Colleges and Universities. Forest Chemicals Review, 2021(Jan–Feb): 103–109.

[10] Liu H, 2024, Optimization of Digital Inheritance Pathway of Folk Art in Information Age. Archives Des Sciences, 74(2): 168–179.

[11] Zhang X, 2023, Digital Communication of Folk Music in Social Music Culture. Frontiers in Art Research, 5(14): 30–34.

[12] Wang ZL, 2011, New Constructivism: Learning Theory in the Internet Age. Distance Education Journal, 2011(2): 11–18.

[13] Zhu ZT, He B, 2012, Smart Education: A New Realm of Educational Informatization. Audio-Visual Education Research, 2012(12): 5–13.

[14] Huang RH, Zhang JB, Hu YB, et al., 2012, The Triple Realm of Smart Education: From Environment, Model to System. Modern Distance Education Research, 2012(4): 3–11.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Scientific and Social Research, 2025, Volume 7, Issue 2
https://ojs.bbwpublisher.com/index.php/SSR
Online ISSN: 2981-9946
Print ISSN: 2661-4332

Constructing a Data Security and Sharing Mechanism for Smart Cities Based on Blockchain Technology

Yu Wu*

Guangxi City Vocational University, Nanning, Guangxi, China

Corresponding author: Yu Wu, y1u2@hotmail.com

Copyright: © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

Abstract: With the rapid advancement of smart city construction, data has become a core element of urban development. However, traditional data management models face numerous challenges in ensuring data security and promoting data sharing. Blockchain technology, with its decentralized, tamper-proof, and traceable characteristics, provides a new approach to address data security and sharing issues in smart cities. This article elaborates on the principles and features of blockchain technology, deeply analyzes the current status and dilemmas of data management in smart cities, and focuses on exploring specific schemes for constructing a data security and sharing mechanism based on blockchain technology. The article also demonstrates the application effects through practical cases and concludes with an outlook on the technology's application prospects in smart cities, aiming to provide theoretical support and practical reference for promoting the healthy development of smart cities.

Keywords: Smart city; Blockchain technology; Data security; Data sharing

Online publication: March 10, 2025

1. Introduction

In today's digital era, the construction of smart cities is in full swing. According to relevant data, more than half of the global population already lives in cities, and this proportion is expected to reach 70% by 2050. The rapid development of cities has brought massive amounts of data, covering various fields such as transportation, healthcare, energy, and the environment. For example, in the transportation sector, intelligent transportation systems collect data on vehicle speed, location, and traffic flow through sensors. In the healthcare sector, hospital electronic health record systems store large amounts of data such as patient information, diagnosis results, and treatment records. This data holds significant value and can provide powerful support for city planning, management, and services.

However, issues of data security and sharing are also increasingly prominent. On the one hand, frequent data breaches have caused severe losses to individuals and society. For instance, in 2023, a well-known e-commerce platform experienced a data breach, exposing the personal information and shopping records of millions of users and sparking widespread social concern. On the other hand, the phenomenon of data islands is severe, and data sharing and circulation between different departments and institutions are difficult, resulting in wasted data resources and hindering the coordinated development of smart cities. For example, the difficulty of sharing data between the healthcare and insurance sectors leads to patients providing a large amount of duplicate information during the claims process, increasing costs and time [1].

This study aims to explore how to utilize blockchain technology to build a secure and efficient data-sharing mechanism, addressing the challenges of data security and sharing in smart city construction. This not only helps improve city management efficiency and service quality but also promotes sustainable city development. In terms of theoretical significance, this study enriches the application research of blockchain technology in the field of smart cities, providing new ideas and methods for the development of related disciplines. In terms of practical significance, the research results can provide valuable references for city managers, technology developers, and related enterprises, driving the progress of smart city construction.

2. Analysis of smart city data security status

2.1. The importance of smart city data

Data plays a crucial role in the construction and development of smart cities. It is not only the link connecting various intelligent systems but also the core driving force for achieving intelligent city management. The operation of smart cities relies on the collection, transmission, storage, and analysis of massive amounts of data, covering various aspects of city management, including traffic flow monitoring, environmental quality analysis, energy consumption statistics, public safety monitoring, and resident life services. Through deep mining and analysis of this data, city managers can achieve optimal resource allocation, precise public service provision, and significant improvements in city operation efficiency [2].

For example, in traffic management, real-time traffic flow data can help traffic departments optimize signal light control and alleviate congestion. In environmental monitoring, air quality data can provide a scientific basis for pollution control. In public safety, the analysis of surveillance data can prevent crime and quickly respond to emergencies. It can be said that the security and integrity of data are directly related to the normal operation of cities and the quality of life of residents. Any problems with the data can affect intelligent city management and may lead to severe social and economic consequences.

2.2. Challenges faced by data security

Despite the irreplaceable importance of data in smart cities, data security issues are increasingly prominent with the continuous increase in data volume and the growing complexity of the technological environment. As the level of city intelligence increases, more and more devices and systems are connected to the network, and data collection and transmission links are constantly increasing, which significantly raises the risk of data breaches. For example, vehicle driving data in intelligent transportation systems, surveillance video data in intelligent security systems, and personal medical data in resident health management systems may all be leaked due to network attacks, system vulnerabilities, or human error [3]. Once this sensitive data falls into the hands of

lawbreakers, it not only violates residents' privacy but may also lead to identity theft, financial fraud, and other criminal activities, causing huge losses to residents and society.

Smart city data security faces not only technical challenges but also management constraints. From a technical perspective, although encryption technology, access control technology, and data backup technology can ensure data security to a certain extent, the protective capabilities of existing technologies are still insufficient as attack methods continue to evolve. For example, the development of quantum computing technology may pose a threat to traditional encryption algorithms, while the low-security protection capabilities of IoT devices also bring new hidden dangers to data security. From a management perspective, issues such as incomplete data security management systems, weak personnel security awareness, and missing emergency response mechanisms also affect data security to some extent. For example, many city government departments and enterprises lack clear data security responsibility divisions, making it difficult to implement data security management responsibilities. In the event of a data security incident, it is difficult to handle it effectively and timely [4].

3. The application of blockchain technology in smart city data security

Blockchain technology is a data storage and transmission technology based on decentralization and distributed ledgers, featuring tamper-proof data, high transparency, and strong security. Its application scope has far exceeded the financial field, gradually expanding into multiple areas such as smart cities, supply chain management, and the Internet of Things. The core advantage of blockchain lies in its decentralized architecture. Data is no longer centrally stored in a single server or institution but is distributed across multiple nodes, each storing a complete ledger copy. This distributed storage approach significantly enhances data security and reliability because any attempt to tamper with the data requires simultaneous modification of the ledgers on all nodes, which is technically almost impossible. Another important feature of blockchain is the tamper-proof nature of data. Once data is written to the blockchain, it cannot be modified or deleted, providing a powerful guarantee for data authenticity and integrity. Simultaneously, the transparency of the blockchain also offers significant advantages for its application in data security [5]. All transaction records and data changes are transparent to participants, facilitating supervision and auditing and effectively preventing data abuse and fraud. These characteristics make blockchain technology an ideal choice for addressing data security issues in smart cities.

3.1. Applications of blockchain in data security

3.1.1. Encrypted data storage

In smart cities, secure data storage is fundamental to ensuring data security. Blockchain technology encrypts data using encryption algorithms and stores it in a distributed ledger. Each data block generates a unique hash value through a hash function and is linked to the previous data block, forming an immutable chain structure. This encrypted storage method not only ensures data confidentiality but also enhances data integrity and reliability through the redundant storage mechanism of the distributed ledger. For example, in a smart healthcare system, patients' personal health data can be encrypted and stored using blockchain technology. Only authorized medical staff and the patients themselves can access and use this data, effectively protecting patients' privacy.

3.1.2. Data access control

Data access control is a critical aspect of data security management in smart cities. By utilizing the smart contract function of blockchain, fine-grained control over data access can be achieved. Smart contracts are automatically executed contract terms deployed on the blockchain in code form. When preset conditions are met, the contract automatically executes corresponding operations. In smart cities, smart contracts can set permissions and rules for data access, ensuring that only authorized users can access specific data. For example, in a smart transportation system, traffic management departments can set access permissions through smart contracts, allowing only certified traffic management personnel and related technical staff to access traffic flow data and surveillance video data. This blockchain-based access control mechanism not only improves data security but also reduces human intervention and management costs [6].

3.1.3. Data traceability and verification

Data traceability and verification are essential for data security management in smart cities. Blockchain technology can record the source and change history of data. Each data block includes a timestamp of data generation, data content, and data source information. Through the distributed ledger of the blockchain, users can easily trace the source and change process of data, verifying its authenticity and integrity. For example, in the energy management system of a smart city, blockchain technology can record the generation, transmission, and usage of energy consumption data, ensuring data accuracy and reliability. Once data abnormalities are detected, the source of the problem can be quickly located through the blockchain's traceability function, and measures can be taken promptly. This data traceability and verification mechanism not only helps prevent data tampering but also provides strong support for data auditing and regulation.

3.2. Practical cases of blockchain technology in smart cities

Shenzhen, as one of the leading cities in China's smart city construction, actively explores the application of blockchain technology in the field of data security. In the field of smart government services, the Shenzhen government has built an electronic license sharing platform using blockchain technology, storing residents' ID cards, driver's licenses, business licenses, and other electronic license information on the blockchain. Through smart contracts, different departments can share and verify license information safely and efficiently, greatly improving the efficiency and transparency of government services [7]. Simultaneously, blockchain technology is also applied to the smart transportation system, ensuring the security and integrity of traffic flow data and surveillance video data through encrypted storage and data traceability functions. These applications not only enhance the intelligence level of city management but also effectively protect residents' privacy and data security.

Amsterdam is one of the global models for smart city construction. The city has introduced blockchain technology in the field of energy management. Through the blockchain platform, Amsterdam has achieved distributed energy trading and management. Residents and businesses can buy, sell, and exchange energy through the blockchain platform. All transaction records are encrypted and stored on the blockchain, ensuring transaction transparency and security. Simultaneously, blockchain technology can monitor energy production, transmission, and consumption processes in real time, providing accurate data support for energy management. This blockchain-based energy management system not only improves energy utilization efficiency but also promotes the development of renewable energy, providing strong support for the sustainable development of the city [8].

4. Constructing a data-sharing mechanism for smart cities based on blockchain

4.1. Demands and challenges of data sharing

In the construction of smart cities, data sharing is a key link to achieve efficient city management and services. Various departments need to share and exchange data to break information islands and improve the city's operational efficiency and collaborative abilities. For example, traffic management departments need to share data with meteorological departments to optimize traffic signal control, and the medical system needs to share data with social security departments to provide precise medical services. However, traditional data-sharing methods face many challenges, limiting the efficiency and security of data sharing.

Firstly, the problem of data islands is a prominent contradiction in smart city construction. Different departments have difficulties in data circulation and sharing due to differences in system architecture, data format, and management mechanisms. For example, public security department monitoring data, environmental monitoring data from environmental protection departments, and traffic flow data from transportation departments are often stored independently, making it difficult to integrate and collaboratively analyze them [9].

Secondly, data inconsistency seriously affects the effectiveness of data sharing. Due to different data update frequencies, data formats, and standards among departments, there are significant discrepancies in the accuracy and consistency of shared data. For example, different departments may have different descriptions of the same location's geographic information, leading to misunderstandings and errors when data is used across departments.

Finally, the risk of data leakage is a non-negligible security hazard in the data-sharing process. In the traditional data-sharing model, data is often transmitted and stored through centralized servers, making it a target for network attacks. Once data is leaked, it can damage residents' privacy and may cause serious social and economic problems.

4.2. Data sharing mechanism based on blockchain

To solve the aforementioned problems in data sharing, a data-sharing mechanism based on blockchain technology has emerged. The decentralization, immutability, and transparency of blockchain provide a new solution for efficient data sharing in smart cities.

4.2.1. Establishing a distributed data-sharing platform

Utilizing blockchain technology to establish a distributed data-sharing platform can effectively solve the problem of data islands. On this platform, data from various departments is no longer centrally stored on a single server but is distributed across multiple nodes, with each node storing a complete data copy. This distributed architecture not only enhances data security but also increases the system's fault tolerance. For example, when one node fails, other nodes can still operate normally, ensuring data availability. Additionally, the consensus mechanism of the blockchain ensures data consistency and integrity across different nodes, preventing data tampering or loss.

4.2.2. Developing data sharing standards and protocols

To ensure data accuracy and consistency, it is essential to establish unified data-sharing standards and protocols. In smart city construction, differences in data formats and standards among departments can pose significant difficulties for data sharing. Through blockchain technology, data sharing standards and protocols can be embedded in smart contracts, ensuring that data follows unified rules during the sharing process. For instance,

the transportation and environmental protection departments can negotiate and develop a common data format and standard, encoding it into a smart contract. When data is shared between the two departments, the smart contract automatically verifies the data format and content, guaranteeing accuracy and consistency.

4.2.3. Utilizing smart contracts for automated data exchange

Smart contracts are a core function of blockchain technology, capable of automatically executing preset contract terms without human intervention. In data sharing for smart cities, smart contracts enable automated data exchange and verification among departments, improving the efficiency and security of data sharing. For example, when the transportation management department needs real-time meteorological data from the meteorological department, a smart contract can automatically trigger the data exchange process based on preset rules. The meteorological department's server sends data to the blockchain platform. After the smart contract verifies the data's integrity and accuracy, it automatically transmits the data to the transportation management department. The entire process requires no manual operation, saving time and labor costs while reducing the possibility of human error.

5. Conclusion and outlook

This article explores the construction of a data security and sharing mechanism for smart cities based on blockchain technology. By establishing a distributed data-sharing platform, developing data-sharing standards and protocols, and utilizing smart contracts for automated data exchange, this mechanism offers significant advantages in improving data security and sharing efficiency. Experimental results demonstrate that the data-sharing mechanism based on blockchain can effectively address issues such as data islands, data inconsistency, and data leakage present in traditional data-sharing models. This provides strong support for efficient management and collaborative services in smart cities [10].

Disclosure statement

The author declares no conflict of interest.

References

[1] Zhang QH, Gao Q, 2024, Exploring the Application of Big Data and Blockchain Technology in Smart City Data Security Management. Information Recording Materials, 25(11): 117–119 + 123. https://doi.org/10.16009/j.cnki.cn13-1295/tq.2024.11.051

[2] Zhou Y, 2024, Research on Data Storage and Sharing Scheme Based on Blockchain Supporting Fair Payment, thesis, Xi'an University of Technology. https://doi.org/10.27398/d.cnki.gxalu.2024.000316

[3] Guo J, 2023, Smart City Communication Data Security Sharing Method Based on Blockchain Attribute Encryption. Proceedings of the 2023 Third International Academic Conference on Innovative Talent Training and Sustainable Development. https://doi.org/10.26914/c.cnkihy.2023.014404

[4] Zhao WJ, 2022, Blockchain Has Huge Potential in Smart City Applications. China Information World, 2022(3): 62–65.

[5] Zeng HX, 2022, Decentralized Ciphertext Data Security Sharing Based on Blockchain in Smart Cities, thesis, Xidian

University. https://doi.org/10.27389/d.cnki.gxadu.2022.002877

[6] Li CF, Shi MY, 2021, Introduction to Big Data Technology. Communication University of China Press, Beijing.

[7] Lu J, 2022, Blockchain Engineering Practice. Machinery Industry Press, Beijing.

[8] Han YS, 2021, Exploring the Application of Government Big Data in Smart City Construction — Taking the Construction of "Cloud Yangzhou" as an Example. New Industrialization, 11(10): 38–44. https://doi.org/10.19335/j.cnki.2095-6649.2021.10.005

[9] Li Y, 2019, Winning the Financial Security 3.0 Era — New Finance + New Technology + New Security. Posts and Telecommunications Press, Beijing.

[10] Rao ZH, 2020, Internet of Things Network Security and Applications. Electronic Industry Press, Beijing.

Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Integrated Services Platform of International Scientific Cooperation

Innoscience Research (Malaysia), which is global market oriented, was founded in 2016.Innoscience Research focuses on services based on scientific research. By cooperating with universities and scientific institutes all over the world, it performs medical researches to benefit human beings and promotes the interdisciplinary and international exchanges among researchers.

Innoscience Research covers biology, chemistry, physics and many other disciplines. It mainly focuses on the improvement of human health. It aims to promote the cooperation, exploration and exchange among researchers from different countries. By establishing platforms, Innoscience integrates the demands from different fields to realize the combination of clinical research and basic research and to accelerate and deepen the international scientific cooperation.

Cooperation Mode



Clinical Workers



In-service Doctors





Foreign Researchers





Hospital



University



Scientific institutions

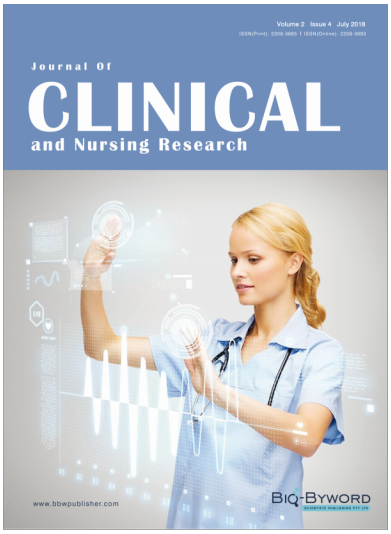
Our Journals



The *Journal of Architectural Research and Development* is an international peer-reviewed and open access journal which is devoted to establish a bridge between theory and practice in the fields of architectural and design research, urban planning and built environment research.

Topics covered but not limited to:

- Architectural design
- Architectural technology, including new technologies and energy saving technologies
- Architectural practice
- Urban planning
- Impacts of architecture on environment



Journal of Clinical and Nursing Research (JCNR) is an international, peer reviewed and open access journal that seeks to promote the development and exchange of knowledge which is directly relevant to all clinical and nursing research and practice. Articles which explore the meaning, prevention, treatment, outcome and impact of a high standard clinical and nursing practice and discipline are encouraged to be submitted as original article, review, case report, short communication and letters.

Topics covered by not limited to:

- Development of clinical and nursing research, evaluation, evidence-based practice and scientific enquiry
- Patients and family experiences of health care
- Clinical and nursing research to enhance patient safety and reduce harm to patients
- Ethics
- Clinical and Nursing history
- Medicine



Journal of Electronic Research and Application is an international, peer-reviewed and open access journal which publishes original articles, reviews, short communications, case studies and letters in the field of electronic research and application.

Topics covered but not limited to:

- Automation
- Circuit Analysis and Application
- Electric and Electronic Measurement Systems
- Electrical Engineering
- Electronic Materials
- Electronics and Communications Engineering
- Power Systems and Power Electronics
- Signal Processing
- Telecommunications Engineering
- Wireless and Mobile Communication